Investigating the integration of drone management systems to create an enabling remote piloted aircraft regulatory environment in South Africa

Submitted in partial fulfilment for the
Master of Arts in the field of ICT Policy and Regulation

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Abstract

The emerging technology of remote piloted aircraft is touted as an innovative device with potential to transform various industries. It is important for South Africa to create an enabling regulatory environment for commercial remote piloted aircraft to succeed and contribute positively to the economy of the country. However, commercial remote piloted aircraft are heavily regulated in South Africa with inefficient compliance processes and poor enforcement mechanisms.

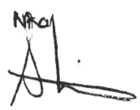
The study interrogates the South African remote piloted aircraft regulatory environment, juxtaposing it with global regulatory trends to better understand existing gaps and opportunities that can be capitalised. To address gaps, this study investigated drone management systems as tools that can be used to facilitate a friendly remote piloted aircraft regulatory environment. The deterrence model is extended in this study to form a theoretical and conceptual framework to regulate remote piloted aircraft. The researcher used an interpretivism case study methodology, collecting qualitative data from published documents such as policies, legislation, regulations and professionals working in the remote piloted aircraft regulatory environment.

The findings of this study support the belief that the South African remote piloted aircraft regulatory environment is cumbersome and unfriendly. Even though South Africa has an effective remote piloted aircraft regulatory environment, it is negatively impacted by efficiency challenges. The South African remote piloted aircraft regulations replicated the manned aircraft regulations resulting in remote piloted aircrafts being over-regulated and stifled as a technology. Furthermore, the South African remote piloted aircraft regulatory environment has weak enforcement mechanisms which opens room for fraudulent activities.

The study recommends the integration of drone management systems in the South African remote piloted aircraft regulatory environment. At a fundamental level, drone management systems can be used to facilitate a friendly licensing and enforcement environment. One vital feature that needs to be developed for drone management systems to be highly effective for all stakeholders is the inclusion of flight information management. The availability of this feature could potentially lead to the relaxation of the requirements to attain a licence for beyond visual line of sight operations and services.

Declaration

I declare that this report is my own, unaided work. It is submitted in partial fulfilment of the requirements for the degree of Master of Arts in the field of ICT Policy and Regulation at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any other degree or examination in any other university.



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Siyanda Nkamisa

18 August 2021

Dedication

I dedicate this achievement to my kids Qhama Luyolo Nkamisa and Imani Nande Nkamisa. I acknowledge your sacrifice and thank you for affording me time to travel this journey. To KS. Monyetsane and L. Nwashe, thank you for the support and belief in my abilities.

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I would like to acknowledge Dr Lucienne Abrahams for her support and confidence in me completing this journey. Your firm and direct approach helped me overcome mental barriers. I would also like to acknowledge Mr. Thabiso Thukani, my co-supervisor, for the guidance and support throughout this journey. You allowed me space to make mistakes and grow without any judgements but gently nudged me towards the correct path and for that, I am forever grateful. I am eternally grateful to all the respondents who sacrificed their time to assist me in this journey. Your invaluable sacrifice and inputs have shaped me as a person.

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List of Acronyms

ANO	Air Navigation Order
ASMS	Automated Spectrum Management System
ATNS	Air Traffic and Navigation Services Company
BVLOS	Beyond Visual Line of Sight
CAA	Civil Aviation Authority
CAQDAS	computer aided qualitative data analysis software
CAR	Civil Aviation regulations of 2011
CCC	Complaints and Compliance Committee
CCTV	closed-circuit television
CKTS	convergence of knowledge and technology for the benefit of society
DCDT	Department of Communications and Digital Technologies
DMS	Drone Management System
DoT	Department of Transport
DSRC	Dedicated Short-Range Communications
ECA	Electronic Communications Act, (Act No. 36 of 2005) as amended
EMC	electromagnetic compatibility
EU	European Union
E-VLOS	Extended Visual Line of Sight
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FIMS	Flight Information Management System
GPS	Global Positioning System
ICAO	The International Civil Aviation Organization
ICASA	Independent Communications Authority of South Africa
ICT	Information Communication and Technologies
IMS	Information Management Systems
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
MTMS	Manned Traffic Management Systems
OEM	Original Equipment Manufacturer
POPIA	Protection of Personal Information Act 4 of 2013
PwC	PricewaterhouseCoopers
RAASA	Recreation Aviation Administration South Africa
RLA	Director's letter of approval
ROC	Remote Piloted Aircraft Operator's Certificate
RPA	Remote Piloted Aircraft
RPAS	Remotely Piloted Aircraft Systems
RPL	Remote Pilot License
SA	South Africa
SACAA	South African Civil Aviation Authority
SA-CATS 101	South African Civil Aviation Technical Standards
SANBS	South African National Blood Service

SANDF	South African National Defence Force
SAPS	South African Police Services
SASREA	Safety at Sports and Recreational Events Act (Act No. 2 of 2010)
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
USA	United States of America
UTM	Unmanned Traffic Management
UTMS	Unmanned Traffic Management System
VLOS	Visual Line of Sight

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Chapter 1: The state of the South African remote piloted aircraft regulatory environment

1.1 Introduction

The digital era has seen a rise in the need for data management and analytics, and Information Management Systems (IMS) have become important tools in managing big data to support organizations to create knowledge. An IMS comprises technical layers that collate raw data and interpret it into information and knowledge. The development of IMSs has evolved into customisation that tailor-makes solutions to suit specific requirements (Cummings, 2020). This study investigated an IMS known as a Drone Management System (DMS) to explore if it can create a conducive regulatory environment for effective compliance with South African Remote Piloted Aircraft (RPA) regulations. The study focused on the regulation of commercial RPAs, corporate RPAs and non-profit RPAs as these categories are required to be licensed by the South African Civil Aviation Authority (SACAA). Private RPAs are not considered for this study as they are exempted from licensing but are only required to observe the SACAA rules, general guidelines and limitations. A DMS offers a centralised database to effectively and efficiently manage RPA operations and compliance with RPA regulations. Institutions involved in the RPA regulatory chain can benefit from using DMSs to improve the management of regulatory processes and enforcement (Haeberlé, 2018).

1.2 Research Problem Statement

Remote piloted aircraft are innovative devices with potential to transform various industries (van Vuuren, 2018). It is important for South Africa to create an enabling regulatory environment for commercial RPAs to succeed and contribute positively to the economy of the country. However, commercial RPAs are heavily regulated in South Africa with some sections of industry equating the PART 101 regulations to a technical ban as they are hard to comply with (African Union, 2018). The SACAA compliance processes are seen as inefficient and cumbersome leading to despondency in relation to compliance (van Vuuren, 2018). Furthermore, the PART 101 regulations are not clear on enforcement mechanisms making it difficult to deter non-compliance. Civil society on the other hand has sociocultural concerns relating to RPA usage in South Africa (Emma-Iwuoha, 2018). The inefficient processes and stringent PART 101 regulations potentially contribute to stagnation, non-adoption, illegal use and non-compliance in relation to RPA usage in South Africa. This study therefore investigated drone management systems as systems that can be used to create an enabling regulatory environment for RPA use in South Africa.

1.3 Research Purpose Statement

The purpose of this study was to investigate an alternative tool that can be used to create an enabling regulatory environment for remote piloted aircrafts to succeed as an emerging technology in South Africa. Drone management systems are explored as systems that can assist with creating an enabling regulatory environment for remote piloted aircrafts in South Africa.

1.4 Research Questions

Main research question:

How can drone management systems be used to facilitate an enabling regulatory environment for commercial remote piloted aircraft usage in South Africa?

The following sub-questions will be used to further explore the main research question:

(1) How can drone management systems contribute towards the implementation of different regulatory approaches.

(2) To what extent can drone management systems alleviate sociocultural concerns associated with remote piloted aircraft usage in South Africa?

(3) How can drone management systems promote compliance with remote piloted aircraft requirements stipulated in the SACAA PART 101 regulations and enforcement challenges related to remote piloted aircraft usage in South Africa?

1.5 An overview of the remote piloted aircraft technology

The International Civil Aviation Organization (ICAO) defines an RPA as an Unmanned Aircraft System (UAS) which is a more comprehensive term that describes the system which comprises of an Unmanned Aerial Vehicle (UAV), ground control stations and data links. This research uses the SACAA's term "RPA" interchangeably with the commonly used term which is "drone". According to the SACAA, RPAs are small aircraft with no onboard pilots that operate through a remote control or the use of on-board computers piloted from a remote pilot station. The SACAA differentiates RPA from toy aircraft and model aircraft based on usage. The SACAA suggests that small aircrafts used solely for recreational or sports purposes should be governed by Recreation Aviation Administration South Africa (RAASA) and the aircraft would most likely be regarded as a toy and its use would be legal. However, if the aircraft is used for private, commercial or corporate purposes, then it is classified as an RPA and would have to be regulated by the SACAA (Emma-Iwuoha, 2018).

The concept of RPA operations has the potential to disrupt a lot of industries and the lives of the public as seen from their use in events such as sports, music concerts, political rallies etc. Recent years have seen massive innovation in RPA technology with various applications which make this device (African Union, 2018).

1.5.1 Types of remote piloted aircrafts

RPAs are classified as having multi-rotors, single rotors, fixed-wing and Fixed-Wing Hybrid shown in Figure 1 (Flynt, 2017). The size of an RPA ranges from very small, small, medium and large RPAs.

Figure 1

Different Kinds of RPAs

Note. Adapted from “21 Types of drones” by J. Flynt, 2017 (*http://3dinsider.com/types-of-drones/*). Copyright 2020 by 3DINSIDER.

Range of flight refers to the distance the RPA is capable of flying measured from the pilot and these range from very close, close, short-range and mid-range (Flynt, 2017).

Table 1 gives the advantages and disadvantages of the different types of RPAs categorised according to rotors while Table 2 (Chapman, 2016) stipulates the size, range and capabilities of RPAs.

Table 1

Classification of RPAs by Rotor

	Pros	Cons	Typical Uses
Multi-Rotor	• Accessibility • Ease of use • Vertical takeoff and landing (VTOL) and hover flight • Good camera control • Can operate in a confined area	• Short flight times • Small payload capacity	Aerial Photography and Video Aerial Inspection
Fixed-Wing	• Long endurance • Large area coverage • Fast flight speed	• Launch and recovery needs a lot of space • no VTOL/hover • Harder to fly, more training needed • Expensive	Aerial Mapping, Pipeline and Power line inspection
Single-Rotor	• VTOL and hover flight • Long endurance (with gas power) • Heavier payload capability	• More dangerous • Harder to fly, more training needed • Expensive	Aerial LIDAR laser scanning
Fixed-Wing Hybrid	• VTOL and long-endurance flight	• Not perfect at either hovering or forward flight • Still in development	RPA Delivery

Note. Adapted from “Types of Drones: Multi-Rotor vs Fixed-Wing vs Single Rotor vs Hybrid VTOL” by A. Chapman, 2016 (https://www.auav.com.au/articles/drone-types).

Table 2

Categories of RPAs

Categories of RPAs								
Size				**Range**				**Capability**
Very Small	Small	Medium	Large	Very Close	Close	Short	Mid	
Up to 50cm in length.	They do not exceed 2 meters in length and usually have fixed wings	Smaller than light aircrafts, but still quite large	These types of RPAs are as large as a small aircraft	Have a range of around 5km	These can be controlled from up to 50km away from the pilot	Can be controlled from 150km away	Can be controlled from as far away as 650km	GPS capability
Can be used for conducting biological warfare or to spy on people.	high powered	They usually need to be carried by two people, and can weigh up to 200kgs.	The military frequently makes use of these RPAs and sends them to areas of high risk in place of fighter jets containing officers.	They can stay in the air for 20 minutes or longer, up to an hour.	A powerful battery allows them to stay in the air for up to 6 hours.	Can stay airborne for up to 12 hours	Popular choice for collection of scientific data relating to the weather, and geology of a particular region.	Trick RPAs
					The military uses these RPAs often.			Delivery RPAs Photography RPAs Racing RPAs Alternative-powered RPAs

Note. Adapted from "21 Types of drones" by J. Flynt, 2017 (http://3dinsider.com/types-of-drones/). Copyright 2020 by 3DINSIDER.

1.5.2 General application of remote piloted aircrafts

RPAs are efficient and innovative low-cost devices with the potential to positively contribute to the economy by transforming traditional industries and a lot of organisations will benefit immensely from deploying them in their operations (Zinn, 2018). RPAs will revolutionise industries such as civil engineering, mining, transport and agriculture among others by enabling cost-effective mapping, remote sensing, inspection and surveying which will lead to improved decision making; RPAs are also used for plant and wildlife preservation and conservation, or any kind of first-responder crisis activities e.g. accidents, fire and natural disasters (van Vuuren, 2018). These devices simplify remote sensing and reporting as fewer resources are used than normally required. Organisations will improve their turnaround times for problem-solving as evidenced by the deployment of RPAs in the agricultural sector to survey storm damage, monitoring crop progress, and making sure that crops and herds are safe and healthy (van Vuuren, 2018).

Editorials and media reports in South Africa indicate that RPAs are being used in the country. An example is Drone Guards which is venturing into the use of RPAs in security services focusing on residential estates with plans to expand to mines, farms and other sectors (Martin, 2019). Sowetan Live reported on Lebohang Lebogo who is planned to conduct RPA operations on behalf of the South African National Blood Service (SANBS), supplying blood to remote rural areas in the country (Ledwaba, 2019). The City of Cape Town is also planning to use RPAs to manage fires in non-accessible areas, searching for blocked waterways and ducts that are hard to get to, inspecting pylons and bridges, providing information on traffic accidents, adding live intelligence during police raids, increasing security in informal settlements and gathering data during emergencies such as veld fires and flooding. The City of Cape Town has reported an expenditure of R500,000 on RPAs and they have trained six pilots to conduct these operations (Caboz, 2019a). South African farming communities have been introduced to a crop spraying RPA after the SACAA approved the RPA on behalf of DC Geomatics to provide this service subject to commercial licence terms and conditions. This application will help reduce the cost of crop spraying especially for up and coming farmers (Caboz, 2019b).

However, RPAs have a negative reputation to contest as they were initially used by the military to conduct covert operations and at the same time they have to address socio-cultural concerns of safety, security, liability, privacy and behavioural concerns among others (Luppicini & So, 2016). The regulatory regime also poses a threat to the use of RPAs as it is modelled from the traditional manned aircraft form and hasn't changed in the last decade (Vacca & Onishi, 2017). Furthermore, RPAs are vulnerable to external and environmental factors such as animal attacks (e.g. bird strike) during flight operations. Law enforcement agencies need to be equipped to deal with RPA hijackings as hackers can easily take control of the RPA without the knowledge of the RPA operator (GrindDrone, 2017). All these factors could potentially stall the global uptake of RPAs and reduce them to minor roles. Considering the potential of these devices, governments need to create a conducive environment for them to be adopted.

1.6 Global remote piloted aircraft regulatory influences

The worldwide proliferation of RPAs has presented challenges for governments and society at large as it disrupted the transportation industry, more so the aviation sector. Core to the regulation of aviation is safety and security and this has resulted in legacy aviation regulatory approaches being adopted to govern RPAs which has limited the innovative potential of these devices. Traditionally the governance of aviation focuses on developing regulations and standards for air safety and security (Wolf, 2018). Formal regulation as depicted in Table 3 (Clarke & Moses, 2014) is mostly preferred in the governance of RPAs with the ICAO as the global body and regional and national bodies being members or affiliates to this structure (Clarke & Moses, 2014).

Table 3

Regulatory Forms and Regulatory Actors

Forms	Formal regulation (Government)	Co-regulation	Industry self-regulation	Organisational self-regulation
The state	Determines what and how	Negotiates what and how	Influences what	Has limited influence
Industry	Influences what and how	Negotiates what and how	Determines what and how	Influences what and how
Corporations	Contribute to Industry Association	Contribute to Industry Association	Contribute to Industry Association	Determine What and How
Other stakeholders	May or May Not Have Some Influence	May or May Not Have Some Influence	May or May Not Have Some Influence	May or May Not Have Some Influence

Note. Adapted from “The regulation of civilian drones’ impacts on public safety” by R. Clarke. And BL. Moses, 2014, ScienceDirect.

The RAND Science, Technology and Policy program compiled a global report on international commercial RPA regulation and RPA delivery services. The report indicates that the global trend to RPA regulation is the adoption of formal regulation shown in Table 3, focusing on pilot licensing, RPA registration, restricted zones and insurance requirement; most countries prioritise parameters such as RPA mass, population density, altitude of flight, and use cases in their regulatory frameworks (Jones, 2017). To enable the penetration of RPAs in the economy, several countries such as Australia, China, Canada and some members of the European Union (EU) exempt commercial RPAs of a certain class from licensing requirements based on mass, height of flight operations and other factors. These RPAs are however subjected to rules, limits and guidelines for operations (Levush, 2016). The exemptions take a form of co-regulation, industry regulation or organisational self-regulation as shown in Table 3 depending on the type of operation. In these forms, commercial operators collaborate to manage RPA operations looking at safety and security aspects (Clarke, 2016). Challenges presented by RPAs cut across international and national regulators as RPAs require concurrent regulatory jurisdiction from different ministries for effective management (Levush, 2016). Regulators often place public interest as a core objective thereby making privacy, safety and security among other mandatory metrics in the regulatory making processes. For regulators to create an enabling environment for RPA use, they need to balance public interest with air safety and security concerns. As a result of this outlook, the RAND Science, Technology and Policy report identifies six approaches adopted globally to regulate RPAs shown in Table 4 with a list of countries per approach (Jones, 2017).

Table 4

RPA Legislation Approaches, by Country

Approach	Definition	Countries
Outright ban	Countries do not allow RPAs at all for commercial use.	Argentina, Barbados, Cuba, India, Morocco, Saudi Arabia, Slovenia, Uzbekistan
Effective ban	Countries have a formal process for commercial RPA licensing, but requirements are either impossible to meet or licenses do not appear to have been approved	Algeria, Belarus, Chile, Colombia, Egypt, Kenya, Nicaragua, Nigeria
VLOS required	RPAs must be operated within VLOS of the pilot, thus limiting their potential range	Belgium, Bermuda, Bhutan, Botswana, Croatia, Ecuador, Jamaica, Latvia, Lithuania, Luxembourg, Nepal, Netherlands, Slovakia, South Africa, South Korea, Switzerland, Thailand
Experimental BVLOS	Exceptions to the constant VLOS requirement are possible with certain restrictions and pilot ratings.	Australia, Austria, Brazil, Canada, China, Czech Republic, Denmark, Finland, France, Germany, Greece, Guyana, Ireland, Japan, New Zealand, Panama, Poland, Rwanda, Singapore, South Africa, Sri Lanka, Russia, Trinidad and Tobago, Uganda, United Kingdom, United States
Permissive	Countries have enacted relatively unrestricted legislation on commercial RPA use. These countries have a body of regulation that may give operational guidelines or require licensing, registration, and insurance, but upon following proper procedures it is straightforward to operate a commercial	Costa Rica, Iceland, Italy, Norway, Sweden, United Arab Emirates, South Africa.

Note. Adapted from “International Commercial Drone Regulation and Drone Delivery Service” by T. Jones, 2017, RAND Corporation. Copyright 2017 by RAND Corporation

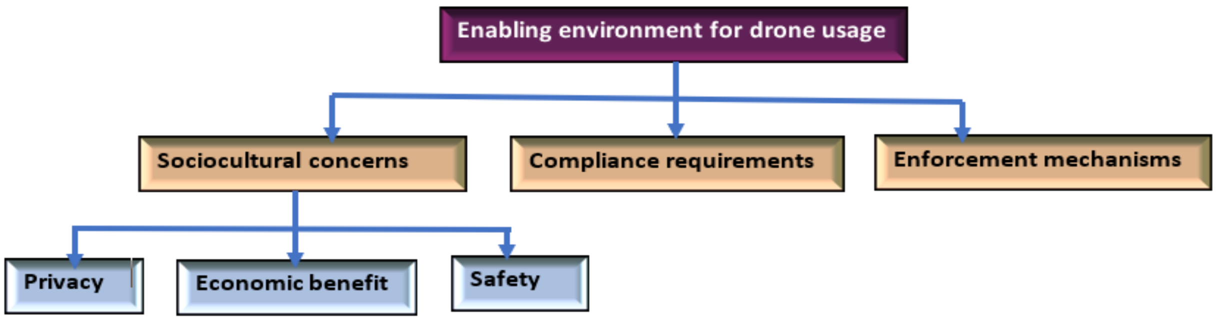
A strong culture of compliance motivates Civil Aviation Authorities (CAA) to consider lite touch regulatory approaches such as co-regulation and industry self-regulation with relevant stakeholders contributing as evidenced by the EU and Federal Communications Commission (FCC) which have provisions for commercial RPAs of a certain class to be reclassified as exempted (Levush, 2016). The UK CAA uses a permissions and exemptions scheme to manage RPA operations that have a scope that goes beyond the prescripts of the Air Navigation Order (ANO) regulations. To be considered in the permissions and exemptions scheme, applicants need to provide satisfaction to the CAA that the proposed operations can be conducted in a safe manner (United Kingdom Civil Aviation Authority, 2015). RPA industry analysts, Drone II, have conceptualised six key elements of a good RPA law which are used to measure a country's readiness for RPAs. CAAs across the globe can use these elements among others to assess the efficacy of their RPA regulations for readiness to leverage RPA technology. Drone II states that RPA laws need to: provide legislative certainty that is up to date with current RPA needs and innovations; reduce RPA operational limitations by enabling ease of procedural requirements for special circumstances e.g. Extended Visual Line of Sight (E-VLOS); promote highly skilled RPA pilots by offering competency-based examinations and licensing; offer administrative efficiency through e-procedures for certification; leverage on Unmanned Traffic Management (UTM) systems for airspace integration of RPAs (McNabb, 2019). Unfortunately, the RAND Science, Technology and Policy report indicate that globally RPA regulation is technically hard to comply with as most countries have adopted the effective ban approach with a mix of restrictions on the visual line of sight operation as shown in Table 4 (Jones, 2017). This approach has contributed to the slow uptake of RPA technology in the commercial sector and potentially opens a window for non-compliance and illegal use of RPAs. This trend can be seen in South Africa as well, as only 62 commercial RPA operators have been licensed since the enactment of the SA RPA regulations in 2015 while the UK had licensed over 4530 RPA operators in 2018 (SACAA, 2017). Interviewed RPA operators raised concerns about the increased illegal RPA use in South Africa. The researcher could not find information on progressive mechanisms to enforce compliance with RPA regulations and this could further exacerbate the culture of non-compliance.

1.7 A remote piloted aircraft enabling regulatory environment

The section above summarised the use of RPAs and also highlighted concerns that contribute to a negative perception of this technology. It is therefore important for South Africa to create an enabling regulatory environment for RPA use. There are multitudes of factors to be considered in an enabling regulatory environment for RPA use (Clarke, 2016). Therefore, this study only focused on the following elements: efficient compliance with RPA regulations, effective enforcement mechanisms to deter non-compliance and illegal use of RPAs; and socio-cultural concerns emanating from privacy, safety and economic benefit that need to be addressed to create trust and acceptance of the technology by the public (Clarke & Moses, 2014). A summary of these elements is shown in Figure 2 (Researcher, 2021). The section below outlines these elements by framing the South African RPA regulatory framework and its challenges to understand the integration of DMS in this environment.

Figure 2

Elements of an enabling environment



Note. Researcher (2021)

1.7.1 The South African remote piloted aircraft regulatory requirements and challenges

The South African RPA regulatory infrastructure is composed of the following institutions: SACAA, Independent Communications Authority of South Africa (ICASA) and the Air Traffic and Navigation Services Company (ATNS) empowered through their respective legislation and regulations. To regulate RPAs, the SACAA developed PART 101 regulations[1] supported by the South African Civil Aviation Technical Standards[2] (SA-CATS 101) and technical guidelines. The SACAA PART 101 regulations focus on air safety and security and they set out requirements for user registration, RPA registration, RPA operations and stipulate rules, general guidelines and limitations for RPA usage. The SACAA circumscribes four categories of RPA operations i.e. a) commercial RPAs; b) corporate RPAs; c) non-profit RPAs; and d) private RPAs. For effective management of RPAs, the SACAA works with other government and regulatory institutions; for

[1] PART 101 regulations, published in government gazette No. 38830 on 27 May 2015,
[2] SA-CATS 101 amended by the Director of Civil Aviation through SA-CATS 1/2017 w.e.f. 1 June 2017

instance, RPA operations in public spaces require collaboration with either national, provincial or municipal institutions to obtain necessary permits (Goitom, 2016). ICASA[3] is also involved in the regulation of RPAs with a different mandate to that of the SACAA. ICASA focuses on the quality of production of Information Communication and Technologies (ICT) devices to ensure efficient use of the radio frequency spectrum without causing harmful interference, adherence to electromagnetic compatibility requirements and electrical safety. ICASA uses technical standards[4] developed through international and national standards development bodies to manage conformity of ICT devices for use in South Africa. Manufacturers are required to produce their products in line with these technical standards[4]. However, ICASA's mandate touches on some aspects of socio-cultural concerns presented by RPAs but does not address concerns of privacy and safety emanating from RPA flight operations. The SACAA and ICASA use a command and control approach to regulation, stipulating specific rules and requirements for compliance. Penalties or sanctions among others are used as a form of deterrence for non-compliance and illegal use of ICT devices. The Air Traffic and Navigation Services Company Act, 1993 (Act No. 45 of 1993)[5] ("ATNS Act") empowers the ATNS to provide air traffic management solutions in South Africa. Considering that RPAs use the airspace, the ATNS is expected to be part of the RPA regulatory framework. However, the ATNS Act is silent on RPA operations and indication from the ATNS corporate plan, 2020 are that the ATNS is yet to incorporate RPA operations in their air traffic management solutions. One can therefore deduce that there is currently no RPA Flight Information Management System (FIMS) in South Africa which poses danger for traditional airspace users and

[3] Type Approval regulations, 2013 published in government gazette notice 871, No. 36785 on 26 August 2013
[4] Official List of Regulated Standards for Technical Equipment and Electronic Communications Facilities Amendment Regulations of 2020, published in government gazette notice 357, No. 43132 on 24 March 2020
[5] The Air Traffic and Navigation Services Company Act, 1993 (Act No. 45 of 1993), published in government gazette No. 39568 on 31 December 2015

the public. The lack of FIMS potentially creates uncertainty and resistance with regards to the adoption of RPAs in South Africa.

The benchmark report on international commercial RPA regulation and RPA delivery services by Jones (2017) shows that a lot of countries have adopted a risk-based approach in the development of RPA regulations with the SACAA following suit with the PART 101 regulations. This regulatory approach attempts to address the six elements mentioned by Drone II analysts in Section 1.3.1 above with few shortfalls. In as much as the Part 101 regulations provide legislative certainty, they are too restrictive and come across as a technical ban (African Union, 2018). An interview with an industry consultant highlighted the need for RPA operators to conduct Beyond Visual Line of Sight (BVLOS) operations but this is hindered by PART 101 draconian requirements. A summary of the licensing and certification requirements of RPAs by the SACAA is shown in Table 5 (SACAA, 2021). The SACAA developed a five-phased process to meet all the requirements in Table 5. Industry experts are frustrated by this structure claiming that the five-phased process is not streamlined and that it is inefficient (van Vuuren, 2018). The SACAA structural and departmental setup grouped the operations of the five phases in silos making the application process unorganised as one cannot seamlessly move from one stage to the next. Applicants are required to submit new applications at each stage with turnaround times that go over four to six months per phase.

An inefficient process can discredit good regulations, creating disillusionment and potentially contribute to non-compliance (African Union, 2018). A gap is also identified in the enforcement of RPA regulations as there is no clarity on available mechanisms used by the regulatory bodies. ICASA’s mandate for an example goes as far as confirming that devices are authorised to be used in the country through inspections and market surveillance and responding to radio frequency spectrum interference related complaints but they do not enforce matters related to airspace use. The SACAA in collaboration with ATNS manage airspace operations and the researcher could not find mechanisms used by these institutions to enforce RPA regulations, especially for in-flight operations. There is no information or evidence of how non-compliance and illegal use of RPAs is managed in South Africa and interviews with industry experts highlighted this concern as well. The command and control regulations are an instrumental deterrence tool used by institutions to enforce the law and they heavily rely on effective compliance and enforcement processes (Drahos, 2017). The perceived inefficient compliance and ineffective enforcement processes therefore potentially contribute to non-compliance and illegal use of RPAs in South Africa while they also fail to address socio-cultural concerns.

1.7.2 Socio-cultural concerns related to remote piloted aircraft use in South Africa

Hattingh (2013) paints South Africa as a diverse multi-cultural country with eleven official languages leading the researcher of this study to deduce that there are numerous sociocultural concerns that would need to be explored as contributors to an RPA enabling environment. This study therefore only focused on economic benefit, privacy and safety sociocultural concerns based on research conducted that highlights these as major concerns that need to be addressed to create an enabling regulatory environment for RPA usage (Clarke & Moses, 2014).

1.7.2.1 Economic Benefit from remote piloted aircraft integration. Economic benefit encompasses economic opportunities to be realised from RPAs looking at the efficacy of the RPA regulatory framework in promoting RPA use. RPAs present the following economic benefits for business: cost reduction and improved productivity levels resulting in accessible and affordable products/services for consumers (Whyte, 2019). A PricewaterhouseCoopers (PwC) report shows varying levels of cost savings in the United Kingdom's technology, media and telecoms sector, with major cost reductions of £4.8bn by 2030 as a result of integrating RPAs in this sector (Whyte, 2019). On 26 October 2016, the United States of America (USA) announced $2.2 million in grants to support the Virginia Emerging Drone Industry Cluster Project in which Mountain Empire Community College was to offer courses to train students, including former coal industry workers, to fly RPAs. This initiative demonstrates the USA's belief in the contribution of RPAs to the economy (The White House Press Secretary, 2016). While there is no doubt on the economic benefits to be realised from RPAs, this study also looked at the cost of compliance to determine its impact as a socio-cultural concern. South Africa is a developing country that needs technological innovation for economic stimulation. It is imperative for South Africa to enable small and medium enterprises to provide innovative and cost-effective solutions. RPAs present a lot of economic opportunities for these enterprises and the previously disadvantaged groups (van Vuuren, 2018). The approach of the SACAA to model the RPA regulations similar to the conventional aviation regulations offsets this potential. The posture of the regulations currently favours well-established organisations in the aviation sector skewing the economic potential towards these organisations. The overall cost of compliance can be achieved in just under R20 000 as shown in Table 5 depending on the size of the envisioned service or operations but in reality, this cost can rise to as much as R300 000 based on training needs and pre-licensing requirements one needs to fulfil for compliance purposes. These costs relate to flight school fees and consultancy fees to prepare the documentation needed by the SACAA (Donnelly, 2016). The regulations in this form pose a threat of non-compliance and illegal use of RPAs emanating from the need of a certain sector of society to be active participants in their economy.

Table 5

SACAA Requirements and General Rules on the use of Commercial RPAs

Licensing requirements	**Licence fees (all costs included)**	**General Rules**	**Restrictions to flying RPAs**
RPA Letter of Approval (RLA)	R340/RPA	It is the full responsibility of the remote pilot of the RPAS to fly his/her aircraft safely and not endanger safety of another aircraft, any person or property	Do not fly RPAs near manned aircraft
RPA Operator's Certificate (ROC)	R10 130	The remote pilot must observe all statutory requirements relating to liability, privacy and any other laws enforceable by any other authorities.	Do not fly RPAs 10 km or closer to an aerodrome (airport, helipad or airfield)
Remote Pilot Licence (RPL)	R1500		Do not fly RPAs in controlled, restricted or prohibited
Certificate of Registration/Marking	R800/RPA		Do not fly RPA 50m or closer from any person or group of persons (like sport fields, road races, stadiums, schools, social events, etc.)
			Do not fly RPA 50m or closer from Public road
			Do not fly RPA 50m or closer from any property without permission from property owner
			Only fly RPA in daylight and clear weather conditions

Note. Adapted from "Remotely Piloted Aircraft Systems" by South African Civil Aviation Authority, 2021 (http://www.caa.co.za/Pages/RPAS/Private%20Operations.aspx). Copyright 2017 by South African Civil Aviation Authority.

1.7.2.2 Privacy concerns. RPAs have a capability to capture big data thereby posing a threat to privacy if used irresponsibly. Clarke (2014) lists the following areas of focus relating to privacy: a) collection, storage, use and disclosure of personal information; b) behavioural privacy concerned with the right of an individual to act as they wish, free from unauthorised surveillance; and c) interception of private and personal communications. According to Michalsons (2018), South Africa legislatively provisioned the right and protection of privacy through section 14 of the Constitution of South Africa, 1996 and common law. Case law has also been used to deal with personal privacy, privacy of communications, and territorial privacy cases (Michalsons, 2018). Furthermore, the information Regulator of South Africa is mandated through section 39 of the Protection of Personal Information Act 4 of 2013 (POPIA) to provide data privacy and data protection for South African citizens (Michalsons, 2018). The South African regulatory institutions, however, need to have mechanisms in place to identify and respond to cases related to privacy concerns.

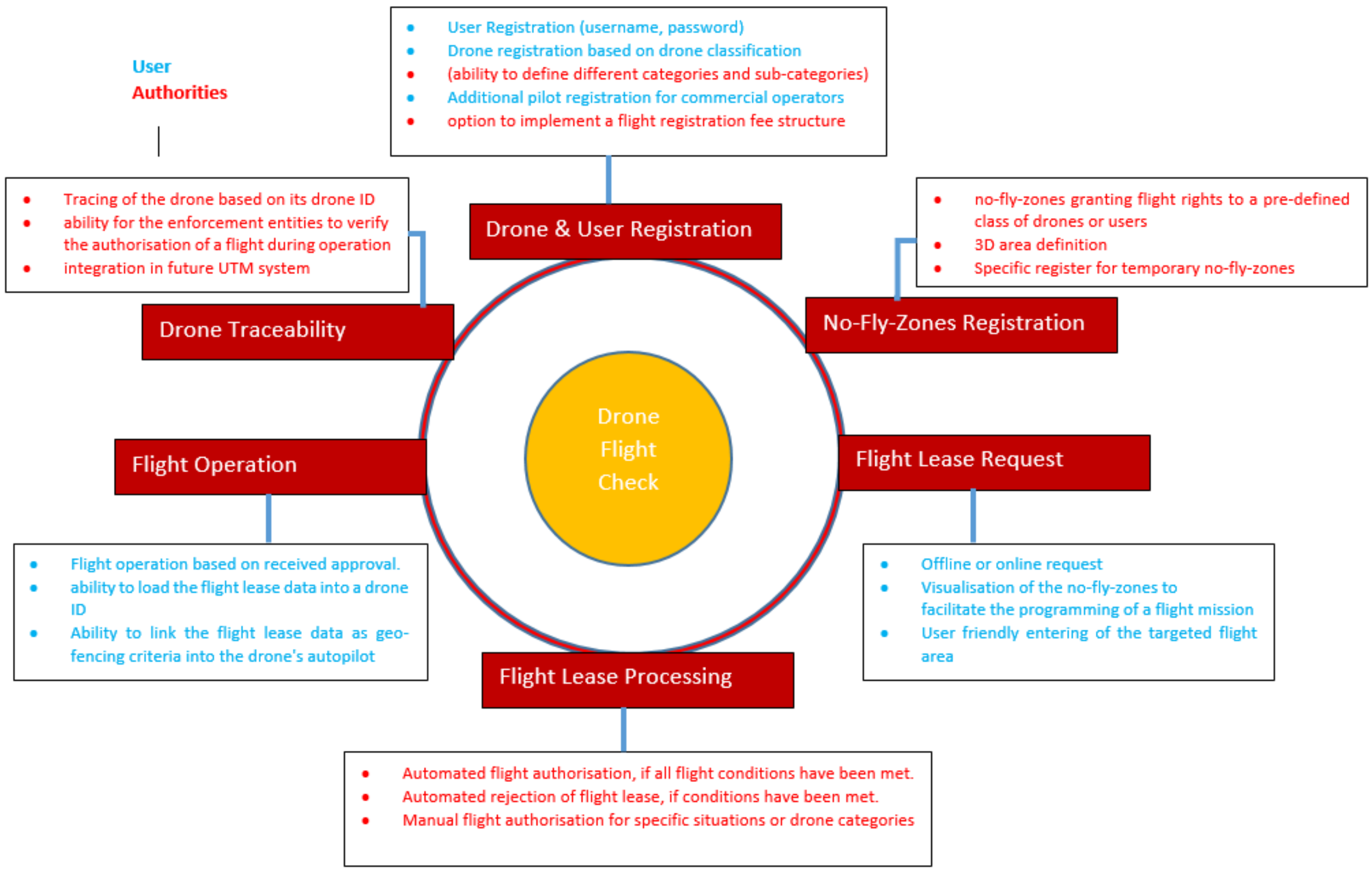
1.7.2.3 Safety concerns. The safety element entails the safety of the payload on board the RPA and public safety due to the following scenarios: RPA malfunction, RPA being hijacked, an accidental drop of payload and loss of payload during delivery (Clarke & Moses, 2014). Chapter 4 of the South African Civil Aviation Act, 2009 ("Aviation Act") read with Section 101.05.4, 101.05.5 & 101.05.6 of PART 101 regulations outline provisions for accident and incident notification that RPA operators need to adhere to at all times. Safety of the public is of paramount importance and therefore these provisions empower the SACAA to manage safety-related concerns. The SA – CATS 101 prescribes requirements to manage the safety of the payload onboard an RPA and manage any accidents that might impact the public.

1.8 Drone management systems in the South African remote piloted aircraft regulatory environment

DMS is an IMS that centralises the processing of RPA regulatory requirements and ensures adherence and effective implementation of the RPA regulatory requirements shown in Figure 3 (Haeberlé, 2018). The main features of a DMS are in line with the following regulatory requirements: RPA and user licensing, no-fly zones designation, RPA flight plans and management of flight operations similar to the SACAA requirements. The SACAA's five-phased compliance process consists of all the requirements mentioned above and these processes are performed in different departments and systems. The unavailability of an efficient system such as DMS and e-service platforms creates bottlenecks in the SACAA regulatory processes which leads to frustration and disillusionment about the SACAA's reputation to manage RPAs. DMS offer administrative efficiency through e-procedures for certification which can improve the efficiency of the SACAA compliance processes. DMS maps RPAs into a connected network known as "internet of drones" that can be used by SACAA, RPA communities such as recreational RPA associations/groups, agricultural communities, gated communities, social events and in indoor environments such as manufacturing plants etc. (Pereira, Espada, Crespo, & Aguilar, 2018). DMS are web-based applications that can interface with agencies such as the SACAA and ATNS for effective management of RPAs (Jiang et al., 2017). Haeberlé (2018) states that DMS offer safety through effective online flight plans, authorisations and tracking. The lack of RPA traffic management in South Africa compromises other airspace operations and creates uncertainty with regards to enforcement and further intensifies sociocultural concerns (Katzenellenbogen, 2017). An improved and efficient process will encourage RPA operators to comply thereby creating trust in the technology. Enforcement of RPA regulations requires the integration of all institutions involved in the chain for information sharing and effective management of RPAs. Enforcement is an element that needs to be improved in South Africa as this will aid to deter non-compliance and illegal use of RPAs. DMS can be used in this instance as they have a feature to manage in-flight operations (Hazon Solutions, 2018). Tracking of RPA operations can assist in addressing privacy and safety concerns as there is readily available information of all RPAs conducting operations at any given area. This would empower the SACAA to resolve any complaints related to RPA operations from members of society. The DMS can enable the SACAA to implement an adaptive regulatory approach based on use cases in collaboration with industry. This can facilitate a responsive approach to assist the SACAA to move between formal regulation, co-regulation and industry self-regulation which would greatly improve the uptake of RPAs in South Africa. The SACAA would still have management oversight on all RPA related matters as DMSs provide access to CAAs (Hazon Solutions, 2018).

Figure 3

Drone Management System



Note. Adapted from "Smart Solutions in Drone Management" by L. Haeberlé, 2018 (https://www.lstelcom.com/en/solutions-in/drone-management/). Copyright 2021 by Ls Telcom AG.

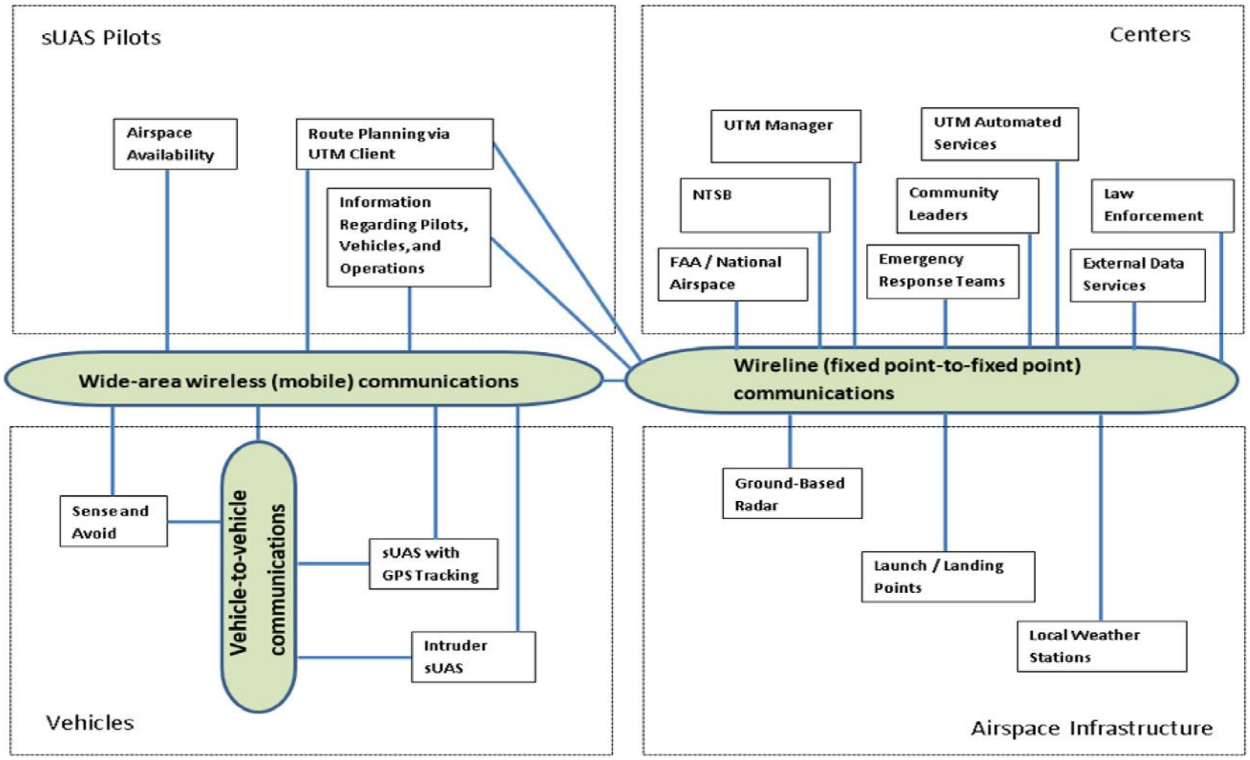
There are various organisations venturing into the development of DMSs due to business opportunity created by social and legislative challenges that are inherent with RPAs (Hazon Solutions, 2018). Most companies interested in using RPAs in their operations do not necessarily have the competence and knowledge to meet all the requirements that come with owning an RPA and DMS can assist such companies by providing a user-friendly solution that ensures ease of compliance with regulatory and operational requirements (van Vuuren, 2018). Hazon Solutions is one of the companies that develop DMS with their system capable of managing flight logs and air traffic management for RPAs and regulatory authorities can actively access Hazon Solutions' DMS for compliance and enforcement purposes. Haeberlé (2018) lists the following key features and advantages for authorities using DMS: 1) centralised database with all registered RPAs and users; 2) full control of no-fly zones establishment and management; 3) ability to define varying categories and sub-categories of flight rights and 4) authorizing flight operations.

1.8.1 Technical Architecture of drone management systems

The CAA remains the body that establishes and enforces regulations involving airspace safety, RPA registration, authorisation, and pilot licensing (Jiang et al., 2017).

Figure 4

DMS System Concept of Operations



Note. Adapted from "Unmanned Aircraft System traffic management: Concept of operation and system architecture" by T. Jiang, J. Geller, N. Daiheng and J. Collura, 2017, International Journal of Transportation Science and Technology.

The technical architecture for DMS consists of RPA pilots, control centres, RPAs, and airspace infrastructure as shown in Figure 4 (Jiang, Geller, Ni, & Collura, 2017). These elements are interconnected by some type of communication system ranging from wide-area networks, local-area networks, and RPA-to-RPA connections. Wide-area networks and local-area networks consist of wireless or fixed internet connections, satellite connections, and cellular connections. RPA-to-RPA connections could use Dedicated Short-Range Communications (DSRC) which is an open-source protocol for wireless communication similar to Wi-Fi, GPS, automated services, or a combination of all to synchronize RPAs sharing airspace. DMS must be registered and approved by the CAA, thereafter RPA communities can have ownership and management of DMS at a local level where they manage RPA registrations and operations (Jiang et al., 2017).

1.9 Limitations

Epistemology is concerned with the objective foundations of knowledge to discern the authenticity and adequacy of all possible knowledge relating to a subject (Ahmed, 2008). The researcher is an employee of ICASA which is one of the core institutions in the RPA regulatory environment and this poses a risk of objectivity when assessing the efficacy of the RPA regulatory environment while at the same time presents advantages where the researcher has valuable experience in this industry to understand the different nuances that define the regulatory environment. There were also challenges with regards to time constraints which impacted access to a wide pool of respondents and therefore the study focused on purposive sampling, using subject matter experts from RPA regulatory institutions and randomly selected members of society. This means that the outcomes of the study do not generally represent the overall population of South Africa.

1.10 Significance

This research examined the South African RPA regulatory environment looking at ways to create an RPA friendly environment. DMS are explored to understand their value proposition and use in South Africa. Proper integration of this system can provide value in the RPA regulatory environment by enabling regulatory institutions to consider adaptive and responsive approaches to regulation. The study contributes to the knowledge economy of RPA regulation, mapping the functional construction of the RPA regulatory environment, thereby providing cogitation to policy makers, regulators and industry players when developing future-proof RPA regulatory strategies.

1.11 Chapter Outline

Chapter 1 provided a background on RPA technology and its applications nationally and internationally. The chapter then frames the current South African RPA regulatory environment, outlining the vital regulations which detail compliance requirements to use RPAs in South Africa. Drone management systems are presented highlighting the high-level elements that form the topology of this system. The chapter concludes with the research problem statement, purpose statements and research questions.

Chapters 2 presents reviewed literature to better understand existing research in the field of RPA regulation. The study frames an RPA friendly environment as one which addresses the following elements: sociocultural concerns with its sub-elements, compliance requirements and enforcement mechanisms. Chapter 2 reviewes literature that is premised on these elements, critically analysing the position of previous research and highlighting differentiation to be created by this study. The conceptual framework which underpins this study is presented in this chapter to provide a framework under which DMS can be categorised.

Chapter 3 outlines the research philosophy and approach, research design and methods used to collect and analyse data. The chapter further provides details that determined population selection and sampling, data analysis approach and outlined ethical considerations that had to be made with limitations that impacted the research methods.

Chapter 2: The Voyage of remote piloted aircraft regulations

2.1 Introduction

The phenomenon of RPAs has brought about varying challenges and scenarios that need to be investigated to better understand their integration in the current environment. In this chapter, a literature review is conducted to locate the study amongst existing literature for a comprehensive and contextualised theory base (Hofstee, 2006). A systematic literature review is adopted based on its consistency to review literature with guaranteed results that are explicit and reproducible. A systematic literature review provides guidelines for searching, appraisal, synthesis and analysis of existing literature (Booth, Sutton, & Papaioannou, 2016).

2.2 Method used to conduct the systematic literature review

The researcher explored methods used in ICT research reports to collate information on how to best conduct a systematic literature review for this study. Furthermore, the researcher used the Preferred Reporting Items for Systematic Review and Meta-analysis statement (PRISMA) shown in Figure 5 (Xiao & Watson, 2019) as a guideline for conducting a systematic literature review (Xiao & Watson, 2019). The study assumed the following systematic literature review steps:

i. Identification of research questions aligned with the research problem statement and purpose. A search for existing literature in line with the topic under study was conducted to conceptualise the research and identify gaps.
ii. Determination of the inclusion and exclusion criteria – the researcher used the generic database parameters such as language, dates, peer-reviewed studies and study types.

iii. Search for existing literature was done as shown in Section 2.3.1 below using themed search terms premised specifically on RPA regulations, drone management systems, socio-cultural concerns and compliance considerations.

iv. Studies were selected for inclusion based on the above-mentioned inclusion and exclusion criteria. The researcher used a screening process focusing on the title and abstract to exclude studies that were not related or relevant to the topic of the study.

v. Reviewed literature is presented in Section 2.4, providing a critical analysis of the existing literature and highlighting gaps to be addressed by the study (van Laar, van Deursen, van Dijk, & de Haan, 03 March 2017).

2.3 Results of the systematic literature review

This chapter reviews literature that is themed on the regulation of RPAs as an emerging technology, looking closely at the challenges presented by this technology. Central to the study is the DMS and its impact on creating an enabling regulatory environment for RPA usage in South Africa. PRISMA is used as a tool to conduct the systematic literature review as shown in Figure 5.

The following research questions drive the study and therefore the systematic literature review as well:
How can DMS be used to facilitate an enabling regulatory environment for RPA usage in South Africa?

The following sub-questions will be used to further explore the main research question:

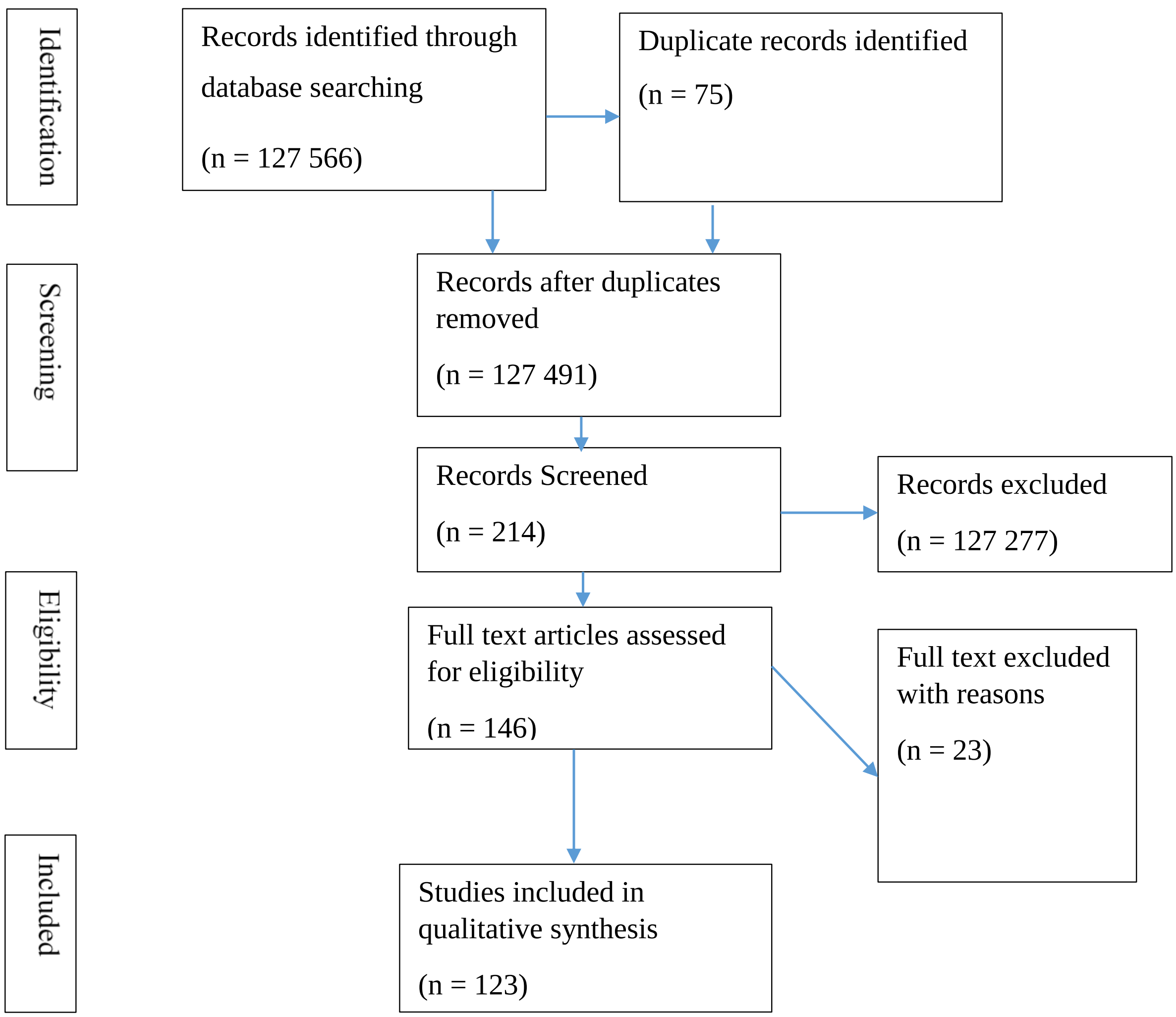
(1) How can drone management systems contribute towards the implementation of different regulatory approaches.

(2) To what extent can drone management systems alleviate sociocultural concerns associated with remote piloted aircraft usage in South Africa?

(3) How can drone management systems promote compliance with remote piloted aircraft requirements stipulated in the SACAA PART 101 regulations and enforcement challenges related to remote piloted aircraft usage in South Africa?

Figure 5

PRISMA Flowchart



Note. Adapted from “Guidance on Conducting a Systematic Literature Review” by Y. Xiao and M. Watson, 2019, Journal of Planning Education and Research, 39, p. 108. Copyright 2017 by Y. Xiao and M. Watson.

2.3.1 Search Terms and Journal Databases

Science Direct was the most used database as it is one of the leading databases containing technical literature. Google Scholar, Africa Portal and Taylor & Francis were also used as they are well-established databases with a broad focus. The search action is shown in Table 6 (Researcher, 2021).

Table 6

Search Action

Search Terms	**Focus**	**Period**	**Science Direct**	**Tylor & Francis**	**Google Scholar**	**Total records**	**Considered**	**Total used for research**
Regulation of drones	Principles-based regulation	2014 - 2021	796	1 054	301	2 151	17	17
	Adaptive regulation	2014 - 2021	1 326	910	8 910	11 146	13	13
	Collaborative regulation	2014 - 2021	719	756	16 000	17 475	15	15
	Future-oriented regulation	2014 - 2021	588	464	1 050	2 102	9	9
Drone manageme nt systems	Compliance	2017 - 2021	600	531	16 000	17 131	31	25
	Enforcement	2017 - 2021	814	665	15 800	17 279	32	18
Why do people obey the law	Social concerns	2014 - 2021	2 158	10 868	17 200	30 226	11	11
	Cultural concerns	2014 - 2021	1 224	9 812	19 000	30 056	18	15
	Total		**8 225**	**25 060**	**94 261**	**127 566**	**146**	**123**

Note. Researcher (2021)

2.3.2 Criteria for including and excluding articles

The researcher used a number of criteria for inclusion and exclusion of studies for literature review. The researcher used the following pre-configured database parameters: a) language, ‘English’, b) document type, ‘peer-reviewed articles’, and c) period, ‘2014 to 2021’. Furthermore, the inclusion criteria considered the following:

1. The usability of articles based on context and content.
2. Emphasis on the regulation of RPAs or interrelated terms. The operation of RPAs was considered in addition to its relation to the regulatory environment. This was used to avoid focusing on the technical and operational aspects of RPAs that do not relate to the regulatory environment.
3. Focus on the regulation of emerging technologies to frame the regulatory approaches that can be used to manage RPAs.
4. Emphasis on regulatory compliance and enforcement to determine the basis of compliance.

2.4 Content analysis and review

2.4.1 The traditional regulation of remote piloted aircraft

Regulation streams down from legislation and sets out rules and instructions to comply with the provisions of the legislation. Comprehensive regulations strive to be justifiable and balanced, looking at the needs of consumers, economic viability and innovation (Zainol, Hussein, Chun-Phuoc, & Hassan, 2019). The rapid development and technological innovation of RPAs, has generated interest with manufacturers, suppliers and consumers waiting for regulatory certainty in relation to RPAs. Governments are faced with a task of developing regulations that are balanced in terms of promoting the adoption of RPAs while safely integrating these devices into the airspace and public spaces as RPAs are inherently dangerous. Scholars have commented on the slow adaptation of ex-ante regulatory institutions and the negative economic impact caused as a result (Clarke, 2016). The traditional regulatory making process is cumbersome and includes among others the following stages: i) setting the agenda through discussion documents and inquiry, ii) regulatory drafting phase taking into consideration existing regulations and inputs from the discussion documents and inquiry, iii) public consultation to receive feedback on the draft regulations, iv) implementation of the final regulations, and v) monitoring and evaluation of the regulations (Zainol, Hussein, Chun-Phuoc, & Hassan, 2019). This process can take about two to four years to complete by which time the landscape has changed drastically. South Africa uses the same approach to regulate RPAs.

As a member of ICAO, South Africa uses the collaborative regulatory principle in the regulatory making process. Even though the collaborative principle has advantages, in South Africa's case, it is hindered by the traditional approach to regulation. The ICAO developed and released Circular 328 and the Remotely Piloted Aircraft Systems (RPAS) Manual which stipulate acceptable standards for RPA operations; these documents attempt to integrate RPAs into the civilian airspace with future documents looking at full integration of RPAs with manned aircraft. Countries have referred to the RPAS Manual as a guide to develop technical and operational regulations which specify requirements for user certification, RPA registration, airworthiness approvals, responsibilities of RPA operators, RPA operations, and remote pilot stations (Padmanabhan, 2017). Components that are incorporated in RPA regulations referenced from the RPAS Manual are: pilot's licence, registration of the RPA, restricted zones, and insurance. Jones (2017) lists six broad international approaches to commercial RPA regulation as: a) wait-and-see;

b) outright ban; c) effective ban; d) visual line of sight (VLOS); e) Experimental beyond visual line of sight (BVLOS); and f) permissive (Jones, 2017).

2.4.1.1 Regulatory principles for emerging technologies. Regulatory institutions need to review their reliance on traditional regulation when regulating emerging technologies and incorporate new principles in the regulatory making process. Principles-based regulation proposes for the use of high-level rules and standards which the regulated entities must conform with, instead of the heavy detailed and prescriptive rules. The Deloitte Centre for Government Insights recommends the following five regulatory principles for regulating emerging technologies: (i) Adaptive Regulation – advocates for a responsive approach focusing on continuous improvement, (ii) Regulatory Sandbox – controlled regulatory trials looking at approaches that best suit the regulated environment, (iii) Outcome-based Regulation –performance and result oriented regulations, (iv) Risk-weight Regulation – proposes for a data-driven approach rather than a blanket approach, and (v) Collaborative Regulation – promotes the alignment of regulations with national and international bodies (Zainol, Hussein, Chun-Phuoc, & Hassan, 2019). Emerging technologies are characterised by quick innovation and a dynamic market environment rendering the traditional regulation obsolete. Industry commentators have recommended four regulatory forms that are flexible and friendly for RPAs that government institutions can adopt, and they are: organisational self-regulation, industry self-regulation, co-regulation, and formal regulation. These regulatory forms will in part incorporate the five regulatory principles mentioned above in line with the specifications found in the RPAS Manual depending on the category and classification of RPAs (Clarke, 2014).

Organisational self-regulation presupposes that organisations will exercise self-restraint. Organisations using RPAs are expected to consider airspace rules and sociocultural concerns by having appropriate measures and controls through tools such as a Customer Charter or an internal Code of Conduct. Organisations can infuse the five regulatory principles using adaptive regulation, outcome-based regulations and regulatory sandboxing (Zainol, Hussein, Chun-Phuoc, & Hassan, 2019). Industry self-regulation is another soft-touch regulatory form where industry commits to take responsibility for regulatory matters. Similarly, to the organisational self-regulation, the industry has to adopt an Industry Code of Conduct pledging their commitment to protect and respect the rights of individuals and public concern related to RPA operations. Another form is co-regulation which requires a negotiated understanding between responsible stakeholders comprising of government institutions and industry. An effective co-regulation environment requires a proactive industry that leverages on their resources and expertise while collaborating with other stakeholders to ensure an all-encompassing environment that is within statutory provisions. The last recommended form is formal regulation where government institutions are given the mandate to regulate the civil aviation industry. In the context of emerging technologies like RPAs, this form is regarded as slow and reactionary thereby serving as a deterrent (Clarke, 2014).

Most countries have adopted the formal regulation approach based on the risks related to civil aviation (Jones, 2017). The researcher could not find evidence of countries that have adopted fully-fledged soft-touch regulatory forms which include: organisational self-regulation, industry self-regulation and co-regulation. This research, therefore, explores a form of co-regulation where government institutions work with other stakeholders through the use of DMS to create an enabling environment for RPA usage in South Africa.

2.4.2 Sociocultural concerns presented by remote piloted aircrafts

RPAs present a new dynamic in business with the industry already looking at ways to incorporate them in their operations but they also present sociocultural concerns that pose a regulatory conundrum. Clarke (2014) dissects the impact of RPAs from different dimensions of privacy and surveillance. RPAs are used for surveillance purposes focusing on physical surveillance involving monitoring aspects of the person's physical self, communications surveillance which focusses on intercepting written communications, listening to conversations, and access to various kinds of electronic messaging, data surveillance which observes transactions and exploits stored data and visual surveillance technologies which include such forms as closed-circuit television (CCTV) and automated number-plate recognition (Clarke, 2014). RPAs can fail mid-air and crash causing damage to property and posing an accidental risk, they can wander into no-fly zones posing safety and security breaches (Bharat Rao, 2016). The highlighted challenges emphasise the fact that RPAs need to be regulated and reviewed literature recommends different approaches to RPA regulation. A recommendation of self-regulation is proposed to ensure continuous development of the technology while government regulators develop a more robust regulatory framework after a wait and see approach. RPA regulation should consider current privacy legislation in all its dimensions, the safety of people, property and legislation regarding liability and insurance (Clarke & Moses, 2014). Most countries are signatories of the Chicago Convention meaning that they adopt and adhere to standards and recommendations as published by the ICAO. Legislation of RPAs in some states uses common law approach while the EU uses a civil law approach (Vacca & Onishi, 2017). Reviewed literature confirms the need to regulate RPAs with suggestions of co-regulation with state organs wherein RPA communities can be allowed to manage themselves. The suggested approaches do not detail how co-regulation will be executed nor does it state the systems that will be used to operationalise co-regulation. This study on the other hand looked at DMS as a system that can be used by state organs and RPA communities to ensure that there is an enabling environment for RPA usage in South Africa.

Countries have competing economic priorities and RPAs form part of these. M.E consulting put together a summary of RPA market estimates comprising of information from various global consulting firms. The estimates show strong growth in the short to medium term with the global market having a total value of US$127bn (2015-value). An appraisal of the European RPA market shows an estimate of EUR10bn by 2035 and over EUR15bn by 2050. The USA's RPA market is estimated to grow to $82.1bn between 2015 and 2025. According to the Consumer Technology Association, two million eight hundred thousand (2.8m) commercial RPAs were estimated to be sold in the USA in 2016/17 with total revenue of $953m (M.E. consulting, 2019). Raj & Sah (2019) on the other hand estimate an RPA market growth of 21.01% for the compound annual growth rate, from US $11.20 billion in 2022 to US $29.06 billion in 2027. In October 2014, logistics companies such as Amazon had begun piloting RPAs in their delivery services in 2013, before the FAA halted commercial RPA operations prompting Amazon to migrate the trials to the UK which had enabling regulations. At this time, Amazon had projected to create one thousand (1000) new permanent jobs at its centres across the UK which would serve as a positive injection into the economy of the UK (Luppicini & So, 2016).

An African perspective to the economic impact of RPAs is derived from the African Union's drone report which focuses on precision agriculture resulting from deploying RPAs. RPAs allow for optimisation of input factors for improved crop production and profit. Advanced location-specific sensors enable improved harvesting of data that leads to increased and qualitative produce. While an affordability assessment of African farmers to adopt precision farming and cost/benefit assessment of RPAs still has to be conducted, there are positive indications that agribusinesses in countries such as South Africa, Morocco, Sudan, and Mauritius, amongst others are already embracing RPAs (African Union, 2018).

The RPA market is not matured yet resulting in estimates being used in most literature to project the economic impact of RPAs. The inflexible global RPA regulations make it difficult for economic projections to be conducted as most organisations are unsure of the RPA investment propensity. The hypothesis mostly used is the ability of RPAs to optimise inputs to production or service delivery thereby resulting in reduced costs, increase in profit margins, improved data for decision making, improved turnaround times etc. Governments across the globe need empowering solutions concerning RPAs to enable them to pass RPA friendly regulations which in turn will lead to clarity with regards to the economic impact of RPAs. This study looked at a solution to create an enabling environment for RPA usage, specifically in South Africa, with an aim to empower the South African government to explore RPA friendly regulations thereby resulting in RPAs contributing positively to the South African economy.

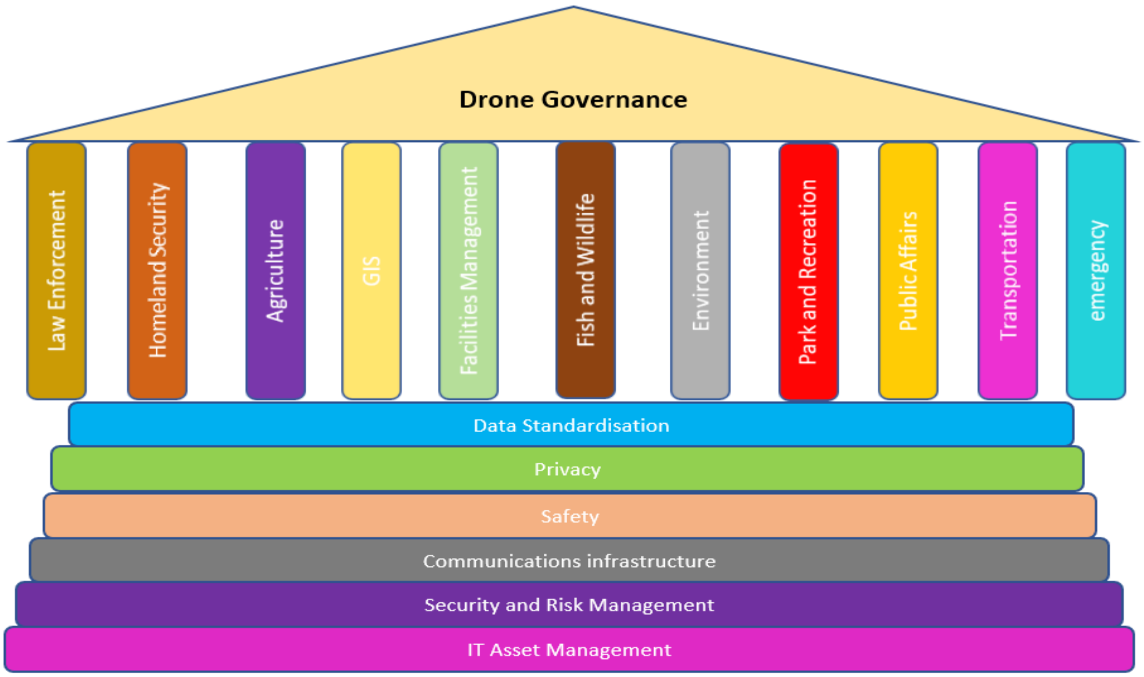
2.4.3 Introduction of drone management systems in remote piloted aircraft regulatory environments

Compliance with RPA regulations in South Africa is seen as a rigorous process with different licensing stages which include: user registration, RPA registration, licensing of the RPA, operator's licence and letter of approval issued by the SACAA director (African Union, 2018). This study focused on DMS also known as drone networks as a means to effectively manage all regulatory and operational requirements related to RPAs. DMS are centralised databases and applications that monitor, control and communicate with RPAs (Koub, et al., 2018). Air traffic management is vital for safety and security assurance and DMS provide a platform to manage all registered RPAs, providing active tracing of all on-air RPAs. This feature will enable effective air traffic management while also contributing to compliance. You cannot monitor or enforce laws on what you do not know or cannot prove, this is the conundrum facing regulators because of unregistered RPAs. DMS assist with providing the authorities with all registered users and RPAs and providing flight logs (Koub, et al., 2018). Even though the researcher of this study could not find the literature of DMS in South Africa, available literature provided insight on how these systems could benefit regulators and industry. Available literature also proposes a fresh approach to managing RPAs in indoor environments. The proposed approach uses a DMS to manage RPAs like an internet of connected devices with sensors and actuators. The application enables planning of indoor flights for a fleet of RPAs (Pereira et al., 2018). Available literature gives insight to drone networks with little evidence of drone networks being implemented on a larger scale as suggested in this study.

2.4.3.1 Remote piloted aircraft regulatory enforcement approach. An effective RPA governance ecosystem requires the collaboration of various departments. In South Africa, the Department of Transport (DoT) assumes the oversight role for RPA governance with the SACAA mandated to regulate civilian airspace. The African Union adopted the diagram in Figure 6 from NASIO, Estes et al. (2015) to illustrate the RPA governance ecosystem. RPA governance is founded on solid policies that address data protection, privacy, safety and security concerns. RPA management is the responsibility of all departments that are either on the service or infrastructure periphery as depicted by the vertical pillars in Figure 6 (African Union, 2018).

Figure 6

Governance Architecture for RPAs



Note. Adapted from "Drone on the Horizon Transforming Africa's Agriculture" by African Union, 2018.

As the RPA technology matures, clarity concerning law enforcement is vital to promote compliance with all the laws governing the RPA ecosystem. The CAA in collaboration with other state institutions is responsible for ensuring that law enforcement is established from the national government level down to the municipal level where bylaws need to be observed by the users of the RPAs (Heatherly, 2014). According to Padmanabhan (2017), twenty-two (22) states in the USA have satisfied the privacy protection law requirements, which includes but not limited, the need for law enforcement agencies to obtain a warrant when executing law enforcement operations using RPAs.

The researcher could not find literature that focuses on strategies and processes used by law enforcement institutions such as the SACAA to manage the enforcement of laws and regulations relating to RPA usage. Available literature mostly focuses on the responsibility of law enforcement agencies when conducting their operations using RPAs. This research however will look at ways that law enforcement institutions can be empowered to identify RPAs and determine if their compliance status and authorisation to conduct operations in line with the rules and regulations of South Africa.

2.5 Tackling non-compliance through deterrence principles

Reviewed literature conceptualises compliance around behaviour driven by an individual's morals and need to benefit from certain actions (Mailath, Morris, & Postlewaite, 2016). Drahos (2017) positions compliance as a bidirectional responsibility consisting of the perspective of the regulator and the regulated and further states that the relationship between the regulator and regulates is important as it helps to navigate the compliance space and ensure trust and legitimacy of the regulator. Reviewed literature on the relationship between law and morality is premised on criminal liability model with the focus on ethical principles of responsibility incorporated into the criminal code and not just a list of prohibited acts. Szczucki (2018) presents two types of legitimacy to criminal law which are primary and secondary. Primary legitimacy is founded on ethical principles of responsibility at its core to discern right from wrong. Even though ethics alone do not define law, without them, criminal law stands to lose validity and legitimacy making enforcement hard to manage. Secondary legitimacy is defined by the legitimacy of a legislated institution which determines the validity of its laws and decisions (Szczucki, 2018).

Individuals are not simply deterred from unlawful acts based on the law alone but are influenced among many other factors by the payoff of a behaviour. Collective behaviour influences the legitimacy of the law as it addresses or prejudices the needs of the collective. Therefore, laws need to factor the payoff of compliance against noncompliance and should consider the effects of the law on sociocultural (Mailath et al., 2016). Tyler (1990) discusses two perspectives that exist in literature which are a belief that people obey the law only when confronted with harsh sanctions and penalties and the other states that people obey the law because it is right and just to do so. The former perspective on compliance is instrumental in its focus while the latter is normative in its focus. This study has adopted the normative perspective to compliance and positions it in the South African context with a view that industry and general society are not against the PART 101 regulations but that these parties need the sociocultural, compliance and enforcement concerns to be addressed for proper use of RPAs. The question to answer is whether civil society would comply with the PART 101 regulations and other legislative requirements if their concerns are addressed. DMS promises a more effective and transparent way of managing RPAs, whether grounded or mid-air. Features such as RPA traceability and identification will go a long way in ensuring accountability and compliance (Koub, et al., 2018).

Compliance is central to this study and therefore soliciting an understanding of why people comply with the law is vital in order to lay the foundation which the study is built on. The SACAA is mandated through the Civil Aviation Act No. 13 of 2009 to regulate aviation in South Africa and the SACAA made an eighth amendment of the Civil Aviation Regulations, 2015 which contained Part 101 regulations focusing strictly on RPAs and therefore the SACAA is the agency empowered to enforce the regulations. Heatherly (2014) states that there needs to be a balance between technological advancement and law enforcement resulting from challenges presented by new technologies. The study questions the need and will to obey the law even when society views it as unjust and draconian. This stems from industry raising concerns about the PART 101 regulations being stringent while sociocultural concerns can potentially lead to people disobeying the law e.g. someone shooting an RPA that is hovering over their property (African Union, 2018).

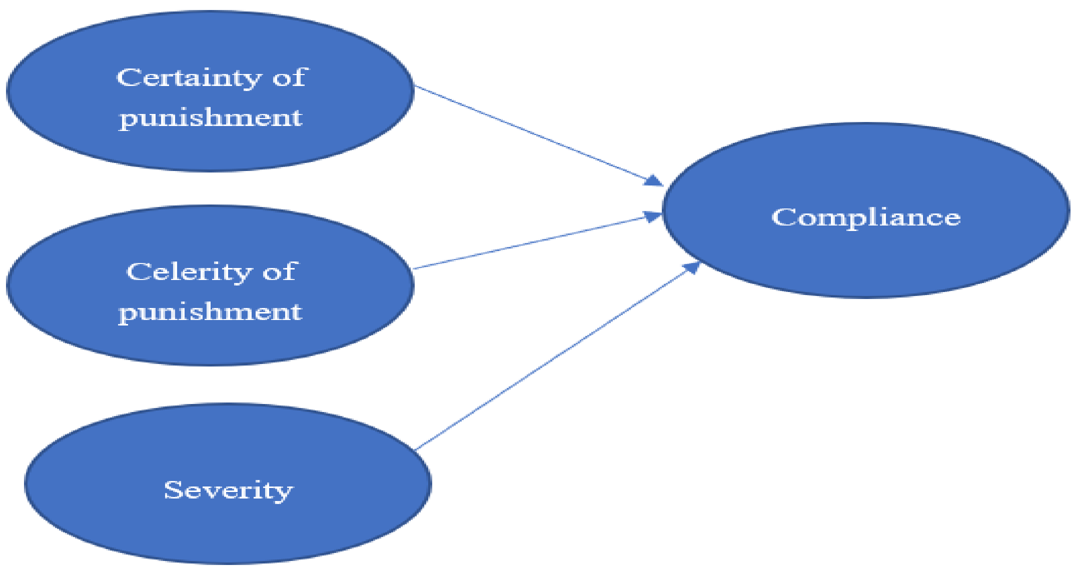
2.6 Conceptual Framework: The deterrence theory in a remote piloted aircraft regulatory environment

The views and reasons why people obey the law give credence to laws and the legitimacy of the responsible institution (Tyler, 1990). The deterrence theory is grounded on this principle with deterrence tools used to influence people to obey the law. The theory suggests factors to be considered by authorities to persuade people to comply with the law. Scholars present two perspectives to why people obey the law i.e. instrumental and normative perspective. The traditional deterrence theory aligns with the instrumental perspective which views people as conscious participants inspired by personal gain. As a result, authorities develop punitive measures to manage non-compliance influenced by the need to fulfil personal gain. The punitive measures serve to deter all non-compliers and highlight the consequences of non-compliance to the rest of the people (Drahos, 2017). A culture of compliance is created in two ways: 1) having effective measures to detect non-compliance; and 2) punishment needs to be greater than personal gains to be achieved through noncompliance. Authorities, therefore, need to strike a balance between these two measures to create a culture of compliance (Drahos, 2017).

Theorists of deterrence theory Hobbes, Beccaria, and Bentham frame deterrence around three critical components: certainty, celerity and severity as shown in Figure 7 (DiIulio, 1959). The certainty component emphasises the importance of punishment taking place in all cases of non-compliance. Once people know that non-compliance is punished, they will most likely not continue with that act. Moreover, the punishment needs to be severe to discourage criminal acts. Lastly, celerity of the punishment is the need for swift action in order to deter crime as an early application of punishment serves as an instant reminder to offenders of the consequences of their actions (DiIulio, 1959).

Figure 7

Deterrence theory: Instrumental perspective



Note. Adapted from "Deterrence Theory" by J. DiIulio, 1959.

The command and control approach used in the regulation of RPAs in South Africa is a form of instrumental deterrence. The SACAA and ICASA develop compliance requirements and stipulate penalties to manage non-compliance. However, the perceived inefficient compliance processes and ineffective enforcement mechanisms of the RPA regulatory environment present a challenge. These issues create a fertile ground for illegal RPA use as the measures to detect non-compliers are ineffective. The instrumental perspective argues that people always put personal gain ahead of compliance with the regulations in an environment with a low probability of detecting non-compliance (Tyler, 1990). The compliance requirements for RPA use in South Africa mimic the traditional manned aircraft regulations which discourage new entrants who do not have knowledge of the industry. This potentially skews the RPA industry towards established aviation companies and deters innovators from maximising the true potential of this technology.

2.6.1 An explorative view of the normative perspective in a remote piloted aircraft regulatory environment

The normative deterrence perspective is an alternative of the instrumental perspective, arguing that people have morals that compels them to obey the law. With this view, people are likely to comply without the need for punitive and aggressive measures because they see the law as right and just (Tyler, 1990). This, however, remains true in so far as the laws align with the people's morals. A misalignment between the law and people's morals potentially leads to resistance towards the law and the legitimacy of the responsible institution is called into question. Under normative deterrence, authorities need to learn about the stakeholders in their environment in order to set laws that promote voluntary compliance. This legitimises the authority empowered to enforce the law in the eyes of the policed and encourages people to comply (Drahos, 2017).

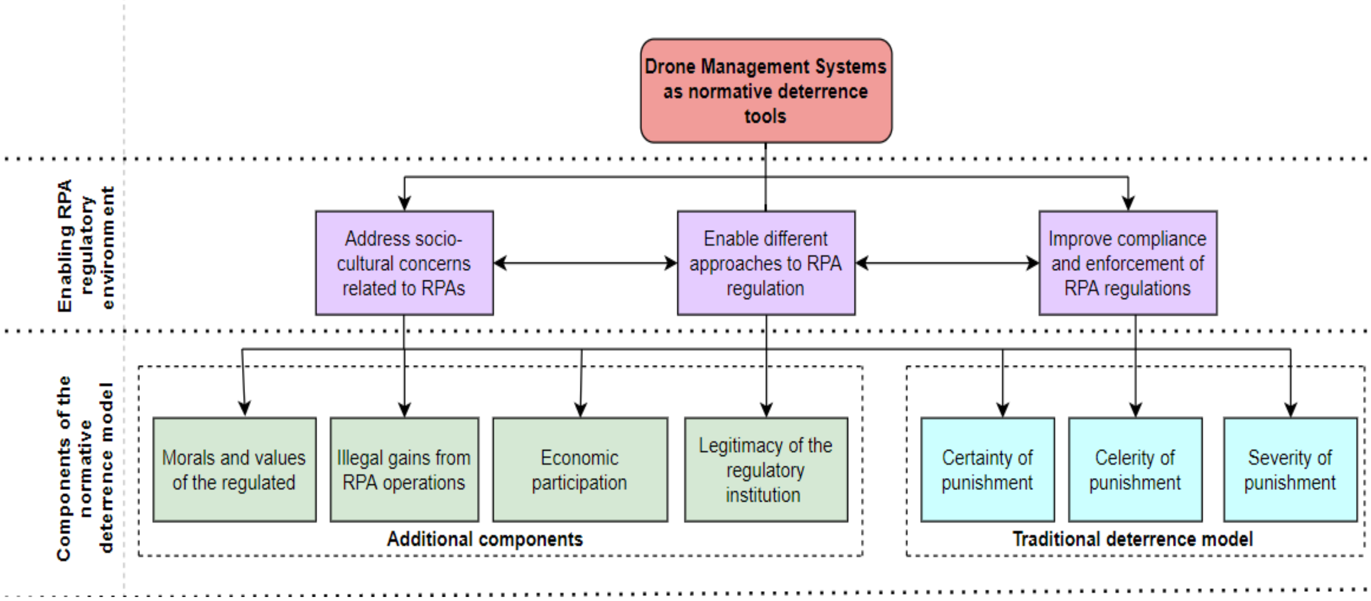
This study proposed a normative deterrence perspective to determine if this approach can facilitate an enabling regulatory environment for RPA use in South Africa. DMS promise e-procedural efficiency and transparency with all compliance related matters thereby encouraging interested parties to comply. A simple compliance environment coupled with the alignment of laws with people's morals promotes a culture of voluntary compliance (Drahos, 2017). An efficient process also legitimises the responsible institution and promotes fairness to all those who comply. The procedural efficiency of compliance empowers RPA operators to position their services better in the market. With improved operational plans and enforcement mechanisms, non-compliant service providers can be easily identified to promote a culture of compliance thereby influencing consumer choice (Drahos, 2017). This eases the pressure from regulatory institutions and creates an environment where the market indirectly promotes compliance on behalf of the authorities.

The study expands the deterrence theory by positioning DMS as normative deterrence compliance tool. The researcher suggests that the traditional deterrence theory needs to consider the following additional components to promote a culture of compliance: a) moral and social concerns, b) economic participation, c) illegal gains, and d) legitimacy of the institution. Sociocultural concerns present challenges with how the public views RPAs, potentially creating non-acceptance of the technology. Sociocultural concerns are viewed from the public's perspective and therefore the laws set by regulators need to reconcile with societal norms to mitigate against non-acceptance. The moral component of the normative perspective approaches regulations from the point of view of RPA operators and potential users. This component explores the moral conviction of RPA users to comply with regulations. The stringent PART 101 regulations challenge the morals of RPA operators and aspiring entrants (Luppicini & So, 2016). The regulations must be developed in such a manner that they encompass the moral values of RPA operators to promote a culture of compliance and encourage new entrants into the RPA environment. Economic participation pits the need to comply with the regulation against the need to actively pursue one's trade. The compliance environment must have measures in place to discourage illegal gains. The last component is the legitimacy of the institution charged with enforcing the particular regulation. The regulatory institution needs to conduct itself in a manner that accords legitimacy to the institution over and above enabling legislation. RPA users need to view the institution as legitimate based on (Tyler, 1990).

DMS provides authorities and society with a simple and efficient way of complying with the regulations through the ease of access to the database for RPA and user registration, scheduling RPA operations and monitoring. An RPA network system ensures transparency and effective management of RPA operations which could be used to allay sociocultural concerns and bolster the legitimacy of the authority (Koub, et al., 2018). The ability of DMS to manage RPA operations make them good enforcement management tools as all registered RPAs are logged in the system. This will facilitate a culture of compliance which will aid to discourage the pursuit of illegal gains. Tyler (1990) states that the normative perspective to compliance is premised on people willing to obey the law which positions the DMS as a perfect tool to work in this scenario as a readily available tool for people to register and access it at will in order to create an enabling regulatory environment for RPA usage in South Africa. The ease of compliance presented by DMS will facilitate a competitive RPA environment where new entrants will not encounter impossible hurdles. Figure 8 (Abusin, 2015) depicts a DMS as a normative perspective to compliance tool that can be used to address sociocultural concerns, compliance and enforcement challenges.

Figure 8

Normative Perspective to Compliance



Note. Adapted from "Approaches-and-factors-considered-in-analyses-of-determinants-of-noncompliance-with with fishery regulations" by S. Abusin, 2015

2.7 Conclusion

This chapter took a journey through time to trace existing literature on the regulation of RPAs in order to conceptualise different compliance perspectives. Following the review of literature, a conceptual framework premised on the deterrence theory was investigated. The instrumental and normative aspects of the deterrence theory were explored to determine their tenability in enabling an RPA friendly regulatory environment. A normative perspective to compliance framework is thereafter proposed for facilitating an enabling regulatory environment for RPA use in South Africa to addresses issues surrounding sociocultural concerns, compliance requirements and enforcement mechanisms.

Chapter 3: Using a qualitative research methodology to investigate the integration of drone management systems to create an enabling remote piloted aircraft regulatory environment

This chapter details the research philosophy used in the study guided by the research problem statement and further outlines the research instruments, data collection and data analysis methods. The research questions present challenges that need to be tested and this chapter maps the research design to address these challenges. A qualitative research approach which is a category of an interpretive paradigm is used in this study. Interpretivism is generally used with research in social sciences where there are people as well as things involved with an aim to understand social action in order to determine an outcome of course and effect (Greener, 2015). The research problem statement is interpretive in nature as it seeks to understand the existence of RPAs in an RPA friendly environment. The chapter concludes by outlining anticipated ethical considerations and limitations of the study.

3.1 Research Question

Main research question:

How can drone management systems be used to facilitate an enabling regulatory environment for commercial remote piloted aircraft usage in South Africa?

The following sub-questions will be used to further explore the main research question:

(1) How can drone management systems contribute towards the implementation of different regulatory approaches.

(2) To what extent can drone management systems alleviate sociocultural concerns associated with remote piloted aircraft usage in South Africa?

(3) How can drone management systems promote compliance with remote piloted aircraft requirements stipulated in the SACAA PART 101 regulations and enforcement challenges related to remote piloted aircraft usage in South Africa?

The main research question seeks to understand the RPA regulatory environment which needs firsthand data from experts in the RPA regulatory environment. A qualitative research paradigm with an interpretivism disposition is the adequate approach to obtain data for a study such as this.

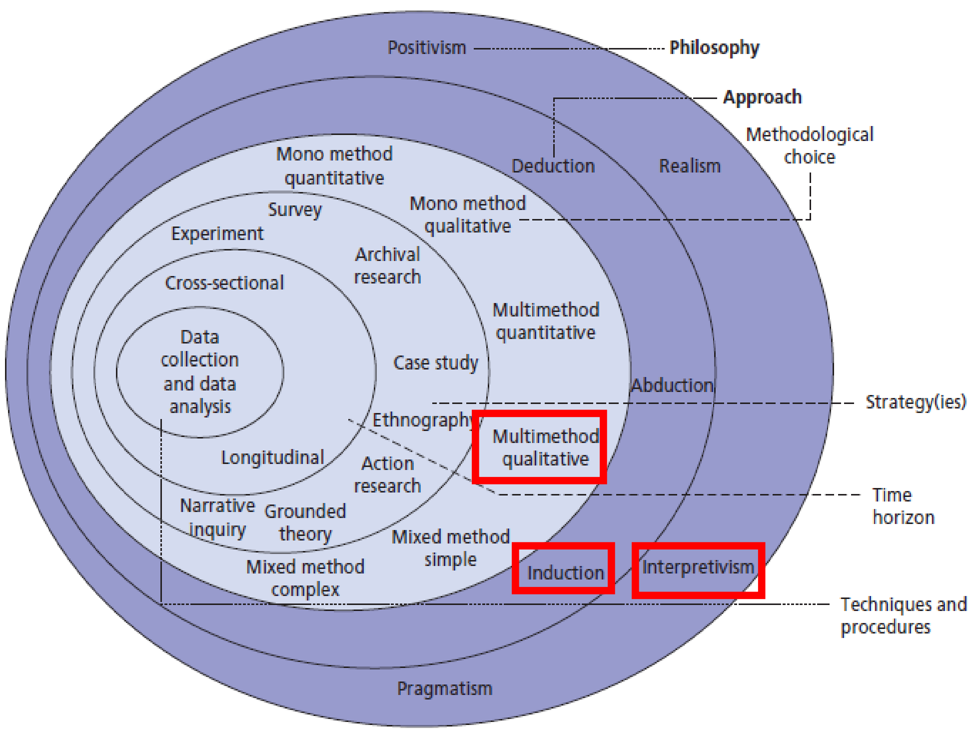
3.2 Research Philosophies and Approaches

Research philosophies are intertwined with the concept of knowledge with the following dominating views in research: ontology, epistemology, axiology and phenomenology. Research philosophies depicted in Figure 9 (Saunders, Lewis, & Thornhill, 2009) such as positivism, realism, pragmatism and interpretivism are used in research to formulate acceptable knowledge (Dudovskiy, 2018). This research is an exploration of the RPA regulatory environment, proposing an innovative system to potentially create an enabling environment for RPA usage in South Africa. An interpretivism philosophy is adopted based on the research problem statement which has a qualitative perspective that requires input from an authoritarian and empirical knowledge base (Dudovskiy, 2018). The authoritarian and empirical knowledge base are epistemological constructs used to source relevant data for this study. ICT is a progressive industry that exists within a sociocultural environment with norms and traditions, and therefore the interpretivism ontology used in this research is premised on the ontological sociocultural concerns of the South African population even though these social constructs cannot be fully representative. Dudovskiy (2018) defines ontology as “a system of belief that reflects an interpretation by an individual about what constitutes a fact" (Dudovskiy, 2018). The epistemological build of the South African RPA regulatory environment for this research is found in the policy, legislative and regulatory prescripts of RPAs and interviews of subject matter experts in the South African RPA regulatory space to gather representative data from the role players of this environment. Epistemology in research is concerned with the building blocks and limitations of knowledge (Greener, 2015).

The research philosophies adopted in this study work in tandem with the concept of convergence of knowledge and technology for the benefit of society (CKTS), defined as an interdisciplinary concept which facilitates a progressive collaboration between scientific disciplines, technologies, communities, and spheres of human interaction to create added value and new knowledge for the betterment of society in ways that isolated disciplines cannot. CKTS concept is aligned with the objectives of this study as it helps to frame the basis of knowledge in a converged ICT sector looking at the RPA regulatory environment and the impact of society in this space (Roco, Bainbridge, Tonn, & Whitesides, 2013).

Figure 9

The Research Onion



Note. Adapted from "Research Methods for Business Students" (fifth edition), by M. Saunders, P. Lewis and A. Thornhill, 2009, Pearson Education. Copyright 2009 by M. Saunders, P. Lewis and A. Thornhill.

3.3 Case Study Research Design

Qualitative research uses several analysis strategies which include the following: case study, content analysis, grounded theory, phenomenology, hermeneutics, ethnography, phenomenography (Bengtsson, 2016). A case study is used in this research as an empirical method that examines the contemporary phenomenon of RPA regulation in South Africa. This method is suitable for this research as it seeks to establish the licensing processes and enforcement mechanisms undertaken in the RPA regulatory environment for better comprehension of this environment (Yin, 2018). A case study is considered in this research to objectively engage and address the research problem and purpose. Furthermore, the researcher adopted a case study technique to inductively develop inferences from collected data by interlacing new information into theory (Bengtsson, 2016).

The purpose of the study proposes an alternative tool to be used in the regulation of RPAs that can create an enabling environment for RPAs to succeed and be adopted as an emerging technology in South Africa. The case study uses content analysis to structurally address the purpose statement. Content analysis guides the researcher during planning, data collection and data analysing steps of research (Bengtsson, 2016). These methodical steps contribute towards a replicable and valid research study while also helping the researcher to formulate or extract new theoretical outcomes. The South African RPA regulatory environment has not been actively amended for the last five years and this study reviews the South African RPA regulations to understand how DMS can be used in the RPA regulatory environment to improve the efficiency of compliance and effectiveness of enforcement processes.

3.4 Research procedure and methods

Research procedures and methods detail the research instruments to be used to perform data collection and data analysis. For this study, the research procedures and methods are used in line with the specifications of a case study with an inductive reasoning outlook. The research uses an authoritarian and empirical epistemological knowledge base derived from the South African RPA regulatory environment which consists of organisations such as SACAA, ICASA and ATNS.

The ontological assumptions are derived from societal concerns looking at cultural connotations of privacy, safety and economic benefit. Creswell (2014) describes research procedures as plans for research that span the steps from broad assumptions to detailed methods of data collection, analysis and interpretation. A qualitative research using interviews and document review (policy, legislation and regulations) is used in this study to investigate DMS as alternative regulatory mechanisms that can create an enabling environment for RPA usage in South Africa. Sociocultural constructs are reviewed to constructively determine whether DMS can address sociocultural concerns.

3.4.1 Data Collection

Data can be collected from documentary materials such as books, journals, magazines, newspapers and oral material which can either be spoken or printed (Kothari, 2004). The methodical steps of content analysis are used in this study comprising of planning, designing, preparation, data collection, data analysing and creating a report presentation of the result. The planning phase consists of the following sub-elements: the aim of the study, method of data collection, findings and analysis which outlines considerations that need to be made to formulate a meaningful outcome (Bengtsson, 2016). As evidenced by the planning element, data collection needs to be considered in the early stages of a study to outline the framework which prescribes methods for collecting information using techniques such as structured or semi-structured interviews, document review, observable material and determining the procedure for capturing and recording information (Creswell, 2014).

3.4.1.1 Interviews to frame the licensing processes and sociocultural concerns. Interviews were used in this study as primary data collection instruments with respondents from RPA regulatory institutions, general members of society and RPA operators. Dudovsky (2018) describes interviews as a qualitative research technique used to gather perspectives of respondents on a particular subject. The study assumed a semi-structured interview approach with pre-determined questions for all respondents based on its flexibility to allow additional questions during interviews for further clarity and posing specific respondent-based questions that could not be pre-determined. In semi-structured interviews the researcher is permitted to omit some questions depending on the flow of a particular interview, taking into account the specific context that ensues in relation to the research topic (Welman, Kauger, & Mitchell, 2005).

The researcher conducted virtual and telephonic interviews and respondents welcomed these forms of interviews. The researcher had planned to conduct face to face interviews which would have been ideal for this case study, however, the advent of the COVID-19 pandemic prevented same. The primary focus of the interviews was on the setup of the South African RPA regulatory framework with an aim to gather the processes used by the institutions in order to assess the efficacy of the regulatory framework against the concerns raised by industry and civil society. The secondary focus of the interviews sort to determine if the current South African RPA management infrastructure constituted all the elements of a DMS and further establish if the South African RPA regulatory institutions have knowledge of DMS and if they have any plans to deploy these as part of their operations.

3.4.1.2 Secondary data collection: a determination of the South African remote piloted aircraft regulatory environment. The RPA regulatory environment is founded on policy, legislation and regulation. These sources are used in the study as secondary data sources focusing on the major institutions involved in the regulation of RPAs. A preliminary review of these documents was conducted to determine the core pillars and current state of the RPA regulatory environment. Online platforms from Government departments, SACAA, ICASA and ATNS were used to collect documents relating to RPA regulations in South Africa as shown in Table 7 (Researcher, 2021).

Table 7

Secondary Data Sources

Institution	**Document**
Department of Digital Communications and Digital Technologies (DCDT)	National Integrated ICT white paper, 2016 Invitation to nominate candidates for the Presidential Commission on Fourth Industrial Revolution, published in government gazette No. 42078 on 4 December 2018. The Presidential Commission on Fourth Industrial Revolution, Summary Report and Recommendations, published in government gazette No. 43834 on 23 October 2020.
The Republic of South Africa	The Constitution of the Republic of South Africa, 1996 as adopted on 8 May 1996 and amended on 11 October 1996 by the Constitutional Assembly.
DoT	Draft Revised White Paper on National Transport Policy, 2017
Department of Science and Technology (DST)	White Paper on Science, Technology and Innovation, March 2019
SACAA	**ACT:** Civil Aviation Act, 2009 **REGULATIONS:** Civil Aviation regulations, 2011 PART101 regulations, 2015 **TECHNICAL STANDARDS:** SA-CATS 101 **OTHER:** List of Approved RPAS operators

ICASA	**ACT:** Electronic Communications Act, (Act No. 36 of 2005) as amended (ECA) **REGULATIONS:** Type Approval regulations, 2013 **TECHNICAL STANDARDS:** The Official List of regulated technical standards, 2015 Labelling regulations, 2013 **OTHER:** List of type approved RPAs (models)
ATNS	**ACT:** Air Traffic and Navigation Services Company Act, 1993 **OTHER:** ATNS Corporate plan 2019/20

Note. Researcher (2021)

A review of these documents elucidated the policy environment and future plans of government concerning innovation as a phenomenon and the core pillars of the RPA regulatory environment drawn from the respective legislations. Regulations gave insight to the processes undertaken by the RPA regulatory institutions to license and certify RPAs in South Africa. However, reviewing these documents alone does not provide full insight into the challenges presented in the problem statement wherein commentators view the South African RPA regulations as stringent and cumbersome to comply with. Further documents used include relevant documents relating to privacy, safety and annual strategic plans of the RPA regulatory institutions to determine future plans of these institutions.

3.4.2 Population selection and sampling

The population is the study object consisting of individuals, groups, organisations, human products and event (Welman, et al., 2005). This necessitates sampling as research needs to be specific on the population to be selected. This means that a representative group that relates to the study needs to be selected from the overall population (Creswell, 2014). Kumar (2011) defines a target population as the group of individuals from which the sample might be drawn and further elaborates that a sample is a group of people who take part in the investigation, referred to as "respondents" used to reach a conclusion about the research problem.

This study adopted a purposive sampling which is more aligned to qualitative research to derive the list of respondents shown in Table 8 (Researcher, 2021). Purposive sampling is a non-probability sampling technique where researchers rely on their experience or judgement when choosing members of the population to participate in the study (Welman, et al., 2005). The research problem and purpose statements were key to the judgement used by the researcher to choose respondents (Dudovskiy, 2018). According to Dudovskiy (2018), purposive sampling can be divided into the following six categories: a) typical case - used in average and normal cases; b) extreme or deviant case – sampling for unusual or rare cases; c) critical case sampling **-** focuses on specific cases that are dramatic or very important; d) heterogeneous or maximum variation sampling - relies on researcher's judgment to select participants with diverse characteristics. This is done to ensure the presence of maximum variability within the primary data; e) homogeneous sampling - focuses on one particular subgroup in which all the sample members are similar, such as a particular occupation or level in an organization's hierarchy; and f) theoretical sampling is a special case of purposive sampling that is based on an inductive method of Grounded Theory.

This study used homogeneous sampling to target key respondents with ontological and epistemological knowledge based on their experience or position (Welman et al., 2005). Key respondents for this study are experts and managers that work in the RPA regulatory environment which makes them credible subjects as they have knowledge of the environment being studied. A researcher is advised to note the saturation point, defined as the moment at which data collection no longer provides new data (Dworkin, 2012). The researcher reached a saturation point with ICASA respondents after gathering data from the three members listed in Table 8. Similarly, with the SACAA, the researcher interacted with an experienced expert who framed the RPA regulatory environment end to end while the other respondent is part of the Drone Regulatory Task Team. It is worth noting that the expert works closely with ICAO and the Joint Authorities for Rulemaking on Unmanned Systems (JARUS) thus giving insight to the global governance of RPAs. The two interviews conducted provided insight into the compliance and enforcement requirements. The researcher made contact with SACAA to secure interviews with Specialists responsible for RPA Licensing. With every contact made, the referrals led to the one particular expert that had already been interviewed.

The licensing requirements and processes are structured and therefore conducting a lot of interviews on this matter would not have yielded new information. The other group of respondents fall under the heterogeneous category where the researcher further used judgment to sample respondents from civil society that have beliefs around the socio-cultural concerns being studied. The sampled members of society had to be aware of the various delivery services in South Africa and to some degree be using them e.g. Uber Eats, DHL etc. to be able to deduce the differentiator of RPA services. The heterogeneous approach was also used to sample RPA operating respondents. Chosen RPA operators have knowledge and experience of the SACAA and ICASA processes and have views about the RPA regulatory environment. The spatial demographics that categorised the members of society are:

i. respondent from a suburban area living in a gated community.
ii. respondent from a suburban area living in a free-standing house.
iii. respondent from a township living in a free-standing house.
iv. respondent from a rural village.

The study made a confidentiality provision, choosing respondents over the age of 18 years to facilitate a safe space for respondents to contribute without fear of judgement and victimisation of any form based on their opinions. Table 8 lists the respondents that were identified through purposive sampling.

Table 8

List of respondents

No	Respondent	Pseudonyms
1	Manager: Type Approval (ICASA)	RTABN
2	Type Approval Specialist (ICASA)	RTAFC
3	RF Regional Specialist (ICASA)	RIRCM
4	Drone regulatory task team member (SACAA)	RATM
5	Drone regulatory expert (SACAA)	RAZM
6	Drone operator 1	DOJM
7	Drone operator 2	DOIM
8	Drone operator 3	DOPF
9	Drone operator 4	DORS
10	Drone operator 5	DOA
11	Drone operator 6	DCST
12	Member of Society 1	CSUT
13	Member of Society 2	CSAM
14	Member of Society 3	CSMR
15	Member of Society 4	CSTM
16	Member of Society 5	CSTMS
17	Member of Society 6	CSPZ

Note. Researcher (2021)

3.5 Ethical consideration

Ethical consideration determines the integrity of the research report paying attention to issues of personal disclosure and authenticity (Israel & Hay, 2006). Cognisance is needed in research as the process involves people which potentially presents an obtrusive element (Dudovskiy, 2018). Based on the qualitative nature of this study, ethical considerations had to be observed. Dudovskiy (2018) elaborates that the researcher needs to maintain the integrity and ensure participants are: a) not subjected to harm in any way; b) respected in every aspect during the course of the research; c) protected from afforded confidentiality; and d) treated fairly with honesty and transparency.

The researcher obtained an ethics clearance certificate (attached herein as Appendix A) to ensure adherence with the University's ethical code of conduct and that the researcher conducts himself in a responsible and accountable manner. Participation information sheets (Appendix B) were used throughout the data collection exercise as a preamble that: a) introduces the participants to the researcher, b) outline the purpose of the study c) outline the conditions under which the participants will be subjected to and d) inform participants of their rights with regards to their participation. Participants had to sign an informed consent form (Appendix C) as an indication that they understood the conditions of their participation as outlined in the participant information sheet.

3.6 A Qualitative data analysis

A case study needs a systematic approach to collect written or oral data from which themes and patterns are developed for analysis. Lou (2019) encourages researchers who use interviews for primary data collection to use semi-structured interviews for a more effective and nuanced analysis. Luo (2019) outlines the following steps for analysis: a) determine key concepts from collected data from which codes are derived; b) make preliminary notes from the initial analysis; c) initial coding scheme emerges from key concepts; d) categorise codes into hierarchical clusters; and e) prepare categories and codes for reporting.

The collected data was transcribed and clustered into three categories i.e. normal civilians; RPA operators and regulatory experts from the SACAA and ICASA. This approach is supported by Saldana (2009) who recommends a systematic approach to qualitative data analysis, advocating for coded data to be categorised into similar characteristics. The transcripts were imported into a computer-aided qualitative data analysis software (CAQDAS) Atlas Ti 8 for coding and theming for analysis. The researcher used Atlas.Ti to organise large amounts of data into quotes and codes which were manageable and easy to interpret. Data coding involved classifying collected data into codes and themes that relate to research problem. The RPA operator cluster is composed of six operators that have interacted with regulatory institutions and the regulatory cluster has five experts in total, with three experts from ICASA and two experts from the SACAA. Lastly, the normal civilians’ cluster also contained six general members of society as shown in Table 8.

3.7 Limitations

Limitations allude to anticipated challenges the researcher might encounter during the data collection process; challenges of data availability, securing permission and interview schedules

(Kothari, 2004). Most DMS that were reviewed through literature and electronic-based material are not developed in South Africa and therefore the RPA manufacturers and operators based in South Africa are not the custodians of the software and applications that power the DMS. This did not adversely affect the research as all interviewees in the RPA regulatory space are aware of these systems. The initial plan to collect primary data was to conduct in-person interviews with respondents listed in Table 8. This plan had to change due to the COVID-19 pandemic which resulted in a declaration of a state of emergency and subsequent implementation of a national lockdown in South Africa. During this period all respondents were forced to stay or work at home and visitations or face to face meetings were limited to essential services which meant that the researcher could not have in-person interaction with the respondents. Proper time management is needed in research projects taking into account the value the researcher puts into the project versus the candidates to be interviewed. Furthermore, the researcher could not find respondents from ATNS, which is an integral part of RPA management. Attempts to contact three respondents from the ATNS via email and telephone were futile as no responses were received.

3.8 Conclusion

This chapter outlines the research methodology used to inform the study in order to discern fact from fiction. The research methodology is presented in the form of a research philosophy and approach. Furthermore, the case study research design was used to objectively interrogate the research problem and purpose as laid out in Chapter 1. Data collection and analysis methods were presented in this chapter to provide a basis for the conception of information and knowledge of this study. The end of this chapter provides the ethical considerations and limitations of this study.

3.9 Chapter Outline

Chapter 4 presents collected data used to investigate DMS for effective compliance with RPA regulations in South Africa. Data is presented in a narrative form, using document review interchangeably with data collected from interviews. The chapter draws the structure of the RPA regulatory environment using policy, legislation and regulations as reference.

Chapter 5 provides an analysis of the findings presented in Chapter 4, premised on the conceptual framework and the elements of the research problem. The study proposes a normative perspective to deterrence theory looking at elements such as moral and social perspectives, economic participation, illegal gains and legitimacy of the relevant law institutions. The analysis illustrates the relationship between DMS and an effective RPA regulatory environment.

Chapter 6 reviews the data presented in Chapter 4 and the analysis presented in Chapter 5 to draw conclusions in line with the research problem and research questions. Recommendations are made for all relevant stakeholders in the RPA regulatory environment

Chapter 4: A 360-degree review of the remote piloted aircraft regulatory environment

4.1 Introduction

This chapter presents data collected to investigate the integration of drone management systems to create an enabling remote piloted aircraft regulatory environment in South Africa. A breakdown of the taxonomy of the RPA regulatory environment from policy, legislation and regulatory level is used to outline the purpose and objectives of the RPA regulatory environment to lay the land of operation for RPAs. To achieve this, the chapter references the purpose and objectives of the legislative and regulatory framework using document review focused on published policies, legislation, regulations. This research focuses on specific legislative and regulatory sections that relate to the governance and management of RPAs in South Africa. An overview of policy that talks to future plans for RPA regulation in South Africa is also presented. This exploration is used in conjunction with data collected from experienced campaigners in the RPA regulatory environment and data collected from ordinary citizens of South Africa. This approach serves as a 360-degree review of the RPA regulatory environment. One of the principles of data collection articulated by Yin (2018) is the use of multiple sources of evidence as that strengthens a case study.

4.2 Through the looking glass: The current South African remote piloted aircraft regulatory environment

The South African RPA environment is primarily regulated through three separate major pieces of legislation i.e. Aviation Act, ICASA Act and ECA. The Aviation Act allows for the establishment of the SACAA which is mandated to regulate the civil aviation industry under the auspice of the DoT. ICASA is empowered through the ICASA Act and ECA to regulate the electronic communications sector and administratively reports to the DCDT. The Aviation Act and the ECA are operationalised through their respective regulations as shown in Table 7.

4.2.1 The fundamental clauses of the Electronic Communications Act addressing remote piloted aircraft

The ECA was enacted in 2005 and amended in April 2014 (Act 1 of 2014). The ECA repealed the Telecommunications Act ("Telecoms Act") (Act No. 103 of 1996) which was more telecommunications oriented. The researcher surmises that this was in response to the emergence of the ICT sector that the Telecommunications Act could not adequately address. This narrative is relevant for this study as RPAs and other emerging technologies have once more cast doubt on the efficacy of the current RPA legislative and regulatory environment. The section below reviews sections of the ECA to understand its contribution to the RPA environment.

The ECA aims to:

"…to make new provision for the regulation of electronic communications services, electronic communications network services…… to provide for the granting of new licences and new social obligations; to provide for the control of the radio frequency spectrum".

To postulate on the need for RPAs to adhere to ICASA requirements, this study zoomed in on sections of the ECA that mainly relate to the management of the RPA environment. Section 2 of the ECA lists objects of Act that provide a broad and overall encapsulating framework to position the ICT sector. A summary of the objects of the Act is as follows:

Innovation and convergence in the ICT sector necessitated enabling legislation for effective promotion of the telecommunications, broadcasting, information technologies and other services[6]. A converged environment needs to address interoperability of multidisciplinary networks and devices. RPAs have to adhere to the requirement of interoperability considering the technical design that goes into their functionality. Interoperability addresses the internal design of RPAs where all the different electronic and radio frequency modules have to work in harmony. This requirement further extends to the external impact that RPAs have on the environment in which they operate. Regimes of technical standards development ensure that manufacturers adhere to interoperability requirements in their designs (Ruplal, 2017). Section 2 (e) of the ECA mandates ICASA to ensure efficient use of the radio frequency spectrum and this was reemphasised by respondent RAZM from the SACAA who feels that SACAA should collaborate with ICASA to enforce RPA regulations on matters related to the radio frequency spectrum. According to respondents RTABN, RTAFC & RIRCM, RPAs by their nature use radio frequency spectrum, with ICASA given the mandate to manage and regulate the radio frequency spectrum. Technical standards are some of the tools used to manage a harmonised and efficient use of the radio frequency spectrum (Ruplal, 2017).

The conceptual framework advances the importance of economic participation that regulators need to factor in regulatory development. Section 2 (d)(f)(h) & (m) of the ECA make provision for economic impact achieved through deliberate and purposeful investment and innovation in the communications sector. Bauer (2009) emphasizes this notion by highlighting the impact that policy and regulation have on investment and innovation. Quality management is core to the success of the ICT sector and the ECA acknowledges this requirement by setting objectives

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[6] Electronic Communications Act, (Act No. 36 of 2005) published in government gazette No. 28743 on 18 April 2006

to provide a variety of quality electronic communications services at reasonable prices. Regulators need to balance the need for economic participation with a quality-oriented objective. RPAs are therefore subjected to a quality management process with a requirement to adhere to a minimum set of technical standards. Respondents RTABN & RTAFC advised that ICASA has prescribed technical standards for efficient use of radio frequency spectrum, EMC and safety. Electronic communications equipment, which RPAs are a part of, have to comply with these standards.

Respondents CSTM and CSMR raised concerns related to security stating that the country is not ready for RPAs yet because this technology is susceptible to cybercrime. Section 2 (q) of the ECA sets assurance for information security and network reliability. ICASA addresses this objective by prescribing technical standards that ensure network reliability. ICASA has established a Cybersecurity Council Committee to develop regulations and prescribe standards to address information security.

With regards to management of the radio frequency spectrum, Respondents RTAFC, RTABN & RIRCM stated that RPAs are technically designed to operate in the radio frequency spectrum, predominantly in the licence-exempt bands: 2400 – 2483.5MHz and 5150 – 5350MHz. There are developments of RPAs that operate in other frequency bands as evidenced from the bill drafted by the Thailand National Regulating Authority (CSA Group, 2020). The ECA is rich on provisions that mandate ICASA to manage the radio frequency spectrum. Section 30 (1) provides for ICASA to manage the use and licensing of the radio frequency spectrum and therefore everyone involved in the value chain of RPAs have to observe and understand this provision for compliance purposes. RPA operators are required to be proficient in the use of two-way radios in order to be able to communicate with airspace users and other services e.g. ambulance in case of an emergency

(SACAA, 2011). Respondent RIRCM, DOST and DOA pointed out the need for RPA operators to obtain a radio frequency channel and call sign to identify the RPA and for operating the two-way radio. This view is supported by sections 31 (1)(6), 32 (1) and 34 (2)(3) of the ECA which stipulates the need to have a radio frequency licence to transmit or receive any radio signal and the protocol to be observed in the allocation and management of radio frequency spectrum.

Over and above the need to observe clauses that relate to the radio frequency spectrum, RPAs need to adhere to section 35 and 36 of the ECA. These sections make provision for the approval of electronic communications equipment, electronic communications facility and radio apparatus. All electronic communications equipment to be used, supplied, sold, offered for sale or lease or hire have to be type approved by ICASA in line with section 35 of the ECA. In carrying out type approval, ICASA is empowered through section 36 of the ECA to prescribe technical standards, subject to the Standards Act, 1993 (Act No. 29 of 1993) focusing on efficient operability of equipment, electronic communications facility, including radio apparatus.

4.2.2 Ensuring regulatory adherence by remote piloted aircrafts through the ICASA Act

The ICASA Act through section 17A allows for the establishment of a Complaints and Compliance Committee (CCC) which is chaired by a judge of the High Court of South Africa. The CCC has a litigious posture evidenced by other members of this Committee that include a highly experienced advocate or attorney with at least 10 years' appropriate experience. The CCC handles all complaints and non-compliance matters referred to it through the operational structures of ICASA and makes recommendations in line with the provisions of the ECA. Section 17F & 17G provides for the appointment of inspectors to monitor and investigate compliance by licensees and certificate holders as a control measure to manage the efficient use of the electronic communications resources in South Africa. Respondent RIRCM corroborated this stating that ICASA inspectors conduct enforcement to ensure compliance and that they are expected to visit anybody who sells and/or operates an RPA to ensure that the device which they are selling or operating is Type Approved. Respondent RIRCM highlighted the collaboration that exists between ICASA and the SACAA to enforce regulatory compliance stating that ICASA ensures that any complaint which comes from the SACAA relating to illegal use or abuse of electronic communications resources is adequately investigated and managed. ICASA inspectors are also expected to observe the requirements of the Safety at Sports and Recreational Events Act (Act No. 2 of 2010) (SASREA). SASREA governs big events where there are mass gatherings, social gatherings, sports recreation. Government institutions collaborate to manage safety and security at these events and ICASA has received complaints related to RPAs which operate without approval or authorisation (RIRCM).

4.2.3 The fundamental clauses of the Aviation Act addressing remote piloted aircraft

The Aviation Act came into force on 27 May 2009, repealing the South African Civil Aviation Authority Act No.40 of 1998. The Aviation Act allows for the establishment of the SACAA entrusted with managing and regulating safety and security in the civil aviation industry under the tutelage of DoT. The Aviation Act 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 surface of the earth". This definition puts RPAs squarely within the mandate and scope of the SACAA. Respondent RAZM confirmed that RPAs are regulated by the SACAA in line with the Civil Aviation Regulations of 2011 and that the regulations are established in line with the Aviation Act. The respondent further stated that the Civil Aviation Regulations regulate all aspects of aviation that the CAA is responsible for, be it at airports, air traffic control, flight operations, training and RPAs are no exception.

Section 2 (1) of the Aviation Act sets the scene of application and the actors involved in the aviation sector. All aircraft, facilities designated for aviation, operators, passengers or any person boarding an aircraft or entering an aerodrome is subjected to the Aviation Act. However, the South African National Defence Force (SANDF) and the South African Police Services (SAPS) are exempted from the Aviation Act. Considering that these institutions potentially use RPAs, the researcher did not establish the kinds of collaborations between the SACAA and the aforementioned institutions to effectively manage RPAs operations. The Aviation Act puts the Minister of DoT at the forefront of the aviation sector as the office is entrusted with oversight of the SACAA.

The study suggested in section 1.4.2 above that an RPA enabling regulatory environment is one that addresses privacy and safety concerns among other elements. The Aviation Act encapsulates privacy and safety elements under section 8 which makes provisions to manage trespassing, nuisance, damage and insurance requirements. Flight operators need to adhere to the general rules and ensure that all operations are conducted in safe conditions as prescribed in the Aviation Act. Section 9 of the Aviation Act empowers the SACAA to establish an Aircraft Accident and Aircraft Incidents, aviation safety investigation board governed in alignment with the requirements of ICAIO. Respondent RATM believes that the general restrictions and stipulations in section 8 and 9 serve as a mechanism to ensure that an individual’s safety and privacy is protected.

4.3 Suggestion box on the regulation of remote piloted aircraft in South Africa

4.3.1 Considerations for the SACAA remote piloted aircraft licensing requirements

In 2015, the SACAA felt it prudent to amend the Civil Aviation regulations of 2011 in order to integrate RPAs into the South African aviation environment. The SACAA included a new section in the Civil Aviation regulations of 2011, PART 101 regulations[7] supported by the South African Civil Aviation Technical Standards[8] (SA-CATS 101) and technical guidelines. The PART 101 regulations stipulate requirements for user and RPA registration, RPA operations and set out rules, general guidelines and limitations for RPA usage. The SACAA classified RPAs into five (5) classes as shown in Table 9 (SACAA, 2015):

Table 9

SACAA RPA Classifications

Class	**RPA Classification**			
	Line of sight	**Energy (kJ)**	**Height (ft)**	**MTOM (kg)**
Class 1A	R-VLOS/VLOS	E < 15	h < 400	m < 1.5
Class 1B	R-VLOS/VLOS/E-VLOS	E < 15	h < 400	m < 7
Class 1C	R-VLOS/E-VLOS	E < 34	h < 400	m < 20
Class 2A	R-VLOS/E-VLOS	E < 34	h < 400	m < 20
Class 2B	**Experimental/Research**			
Class 3A	BVLOS	E < 34	h < 400	m < 150
Class 3B	VLOS/E-VLOS	Any	h > 400	m < 150
Class 4A	BVLOS	Any	h > 400	m < 150
Class 4B	Any	Any	Any	m > 150
Class 5	Reserved	Reserved	Reserved	Reserved
Reserved - means to be defined in the future				
h - means height above the surface				
E - means energy at impact				
Note: All operations are limited to radio line-of-sight				

[7] PART 101 regulations, published in government gazette No. 38830 on 27 May 2015.
[8] SA-CATS 101 amended by the Director of Civil Aviation through SA-CATS 1/2017 w.e.f. 1 June 2017

Note. Adapted from "List of Technical Standards: Remotely Piloted Aircraft Systems" by South African Civil Aviation Authority, 2015.

Respondent DOA mentioned that RPA operations need to be within a 1 km radius making it hard for RPAs to be an option for innovative services. At 500 meters there needs to be a spotter in cases where operations cannot maintain visual line of sight (DOA). Respondent DORS also mentioned the difficulty of acquiring a licence to operate beyond visual line of sight and that most RPA operators would prefer this class of service for RPAs to have a meaningful impact as an emerging technology. The requirements for Beyond Visual Line of Sight (B-VLOS) and Extended Visual Line of Sight (E-VLOS) services need one to be licensed and approved under stricter rules (DOA &DORS). Respondent DOA suggested that the compliance processes of the SACAA are not streamlined thereby creating bottlenecks. Even getting a ROC is not sufficient for most businesses which require one to get a B-VLOS which takes further time as this licence gives you beyond visual line of sight which is more than a kilometre. New entrants, however, are not adept in the aviation sector and therefore need aviation consultants to assist with the SACAA compliance requirements. SACAA charges and hourly rate to review an application which is accompanied by a lot of reports and manuals. Aviation consultants assist prospective operators to compile reports and manuals at a cost of about R50 000 (DORS). Respondent DOA added that the SACAA compliance costs are around R1500 per hour and review findings amount to added costs as the hours to assess an application increases. Respondent DCST considers South Africa to be an RPA friendly environment but needs a review of the regulations as they were promulgated in 2015 and are now lagging behind the industry needs.

4.3.1.1 The SACAA Commercial remote piloted aircraft approval and registration. According to Goitom (2019), commercial RPAs need the SACAA Director's letter of approval (RLA) and a certificate of registration to operate in South Africa as shown in Figure 10 (Researcher, 2021). Requirements for approval and registration are: RPA design specifications and standards; safety reports demonstrating the safety standards that the RPA adheres to; or system safety documentation as prescribed in the SA-CATS 101. Respondents DOIM, DOA & DORS alluded to the fact that the RLA and certification of registration are just an entry into the sector but one needs to acquire more licences thereby spending even more money and time. Furthermore, the SACAA certificates and licences have periodic renewals. Respondents DOIM, DOA & DORS deem the SACAA compliance processes as stringent and this stems from the traditional aviation compliance requirements adopted by the SACAA in regulating RPAs.

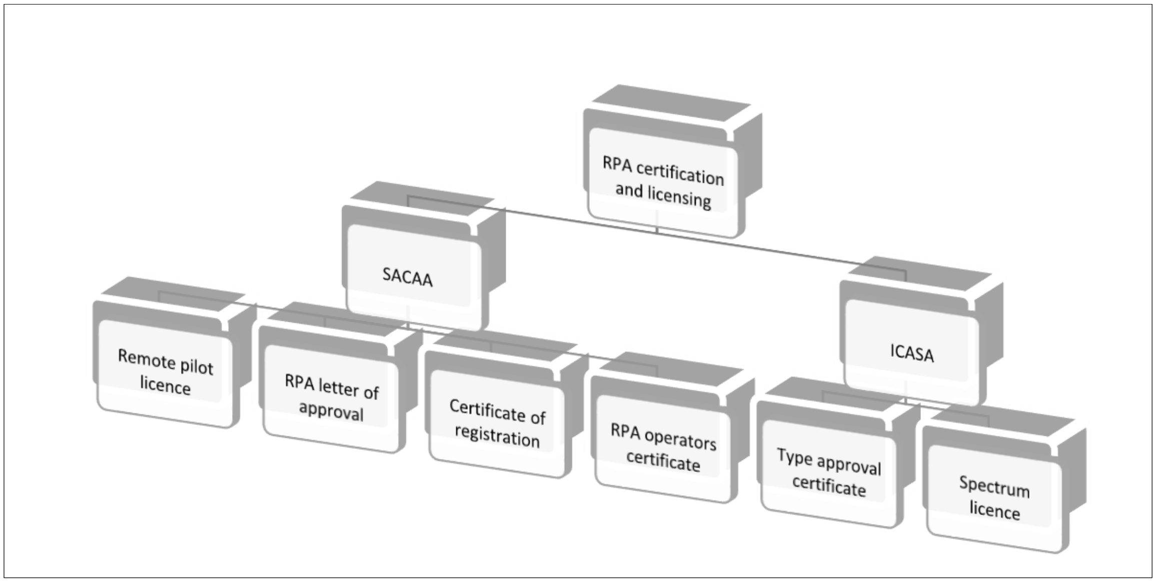
4.3.1.2 Personnel Licensing for commercial remote piloted aircraft operations. RPA operators need to possess a Remote Pilot License (RPL) in South Africa, which is one of the steps to be followed in order to be a certified RPA operator as depicted in Figure 10. According to the PART 101 regulations, the RPL is categorised as follows: Remote Pilot License for (Aeroplane) (RPL(A)), Remote Pilot License (Helicopter) (RPL(H)), and Remote Pilot License (Multi-rotor) (RPL(MR)). Furthermore, the SACAA endorses RPLs according to the following ratings: visual line-of-sight (VLOS) operations; extended visual line-of-sight (E-VLOS) operations; and beyond visual line-of-sight (B-VLOS) operations (Goitom, 2016). Respondent DOIM termed the personnel licence as an air service licence stating that RPA operators have to demonstrate skills in handling dangerous goods, firefighting unit, quality management in aviation and safety in aviation for them to be certified. Requirements for obtaining an RPL are contained in Subpart 3 of the

PART 101 regulations. An RPL is valid for two years after which the holder is required to conduct a revalidation check before the RPL can be renewed (SACAA, 2011).

4.3.1.3 Commercial remote piloted aircraft operator certificate. Over and above obtaining an RLA, certificate of registration and an RPL, RPA operators need to have a ROC for commercial operations, renewed yearly. Respondent DOIM considers the SACAA processes efficient stating that SACAA takes applicants through the process and assists throughout the whole process. From the beginning of the process to the end, SACAA walks with the applicant and assign an inspector who provides undivided attention. Respondent DOIM does however indicate that it took her company two years to complete the compliance processes of the SACAA and feels that there needs to be improvement with regards to turnaround times for licensing and certification. The SACAA has adopted the ICAO five-step process for obtaining a ROC: pre-application, formal application, document evaluation, demonstration and inspection, and certification (SACAA, 2011). A ROC comes with various requirements such as developing a manual of operations for the SACAA Director's approval. The manual is similar to that of helicopter operations wherein stipulations of the scope of operations and safety requirements need to be outlined. Further requirements include security measures and clearances by conducting background checks and periodic criminal record checks on personnel that work with RPAs and possession of third-party liability insurance (Goitom, 2016). Respondents DCST, DORS & DOPF provide consultancy to prospective operators, assisting with adherence with all SACAA compliance requirements mentioned above based on their years of experience in the aviation sector. The SA-CATS 101 outline the labelling requirements and stipulates that all RPAs that have been approved and registered by the SACAA Director's office must have a legible mark of identification permanently affixed to the RPA. RPA operators and consultants lamented the turnaround times to comply with SACAA requirements.

Figure 10

RPA licensing process



Note. Researcher (2021)

4.3.1.4 The stipulations of ICASA equipment authorisation regulations. Central to the purpose set out in the ECA is the management and control of the radio frequency spectrum. There are various approaches used to control the allocation and use of the radio frequency spectrum. ITU, World Bank, InfoDev, & IFC (2011) lists the following approaches as additional spectrum control mechanisms: spectrum licensing, certification of radio operators, type approval, type acceptance and international notification and registration. The ECA has among others, made provision for type approval through section 35 & 36 as additional mechanism to manage ICT device use and allocation of the radio frequency spectrum. ICASA is mandated through section 4 of the ECA to develop regulations to manage the electronic communications sector. The control of the radio frequency spectrum is captured in Section 2 (3) of the Type Approval regulations, stipulating the aim to protect the integrity of public networks, the consumer and to avoid harmful interference. The protection of consumers is in line with ICASA's vision of regulating in the public interest.

Global and national trade require products and services to meet pre-determined standards before being placed in the market and this process is defined as conformity assessment. Conformity assessment is necessary to ensure that products and services meet safety, interoperability and performance standards. To activate section 35 & 36 of the ECA, ICASA developed Type Approval regulations to manage ICT equipment authorisation. The Type Approval regulations define equipment requiring type approval as "any equipment used or to be used in connection with the provision of electronic communications, unless explicitly exempted by the Authority". Type approval is a certification based regime confirming adherence of a product to have met pre-determined standards. Type approval is not industry-specific and can be used in any sector requiring conformity assurance. RPAs have to adhere to ICASA type approval as they have electronic communication services. RPAs have to meet ICASA's regulated technical standards to avoid causing harmful radio frequency interference and network degradation. ICASA's requirements, amongst others, ensures that radio communications and terminal equipment conform with technical performance, electromagnetic compatibility and safety technical standards. These requirements include the following:

1) Technical standard requirements include operational requirements such as temperature, modulation scheme, frequency separations, maximum transmitter radiated field strength / maximum output power to a defined antenna, duty cycle, capabilities for withstanding surge, etc. that are necessary to operate the equipment. Equipment should meet international performance standards before it is placed on the market.

2) Safety requirements – refer to the safety of persons, domestic animals or property in contact with radio communications and terminal equipment. The equipment should meet mechanical, heat, radiation, electrical safety standards.

3) EMC requirements refer to the specification that requires the equipment not to generate electromagnetic disturbances that exceed levels allowing radio and telecommunications equipment and other apparatus to operate as intended and that the apparatus should have some adequate level of intrinsic immunity to electromagnetic disturbance to enable it to operate as intended. The radio communication and terminal equipment should meet the prescribed EMC standards before it is placed on the market.

The technical standards are regulated through the Official List of Regulated Standards for technical equipment and communications equipment[9]. The third set of regulation for equipment authorisation is the Labelling regulations[10] requiring all devices that have been granted equipment authorisation to display a mark of conformity in a form of an ICASA label. RPA users, manufacturers, suppliers and distributors are required to comply with these regulations for RPA usage in South Africa. RTABN confirmed that RPAs by their nature use radio frequency spectrum, with ICASA given the mandate to manage and regulate the radio frequency spectrum. Respondents RTABN, RTAFC & RIRCM highlighted that ICASA's approach to Type Approval focuses on technical conformity looking at electromagnetic compatibility (EMC) and efficient use of the radio frequency spectrum. Therefore, an RPA has to comply with the three technical standards of RF, EMC and safety to be approved by ICASA. Respondents DCST & DOIM feel that the ICASA process is not that difficult and long if one understands the requirements and have all the documentation for type approval. This view is in comparison with the SACAA turnaround times where the feeling is that their processes are very long even if one has all the required documents.

[9] Official List of Regulated Standards for Technical Equipment and Electronic Communications Facilities Amendment Regulations of 2020, published in government gazette 43132 on 24 March 2020.
[10] Labelling regulations, published in government gazette No. 36786 on 26 August 2013.

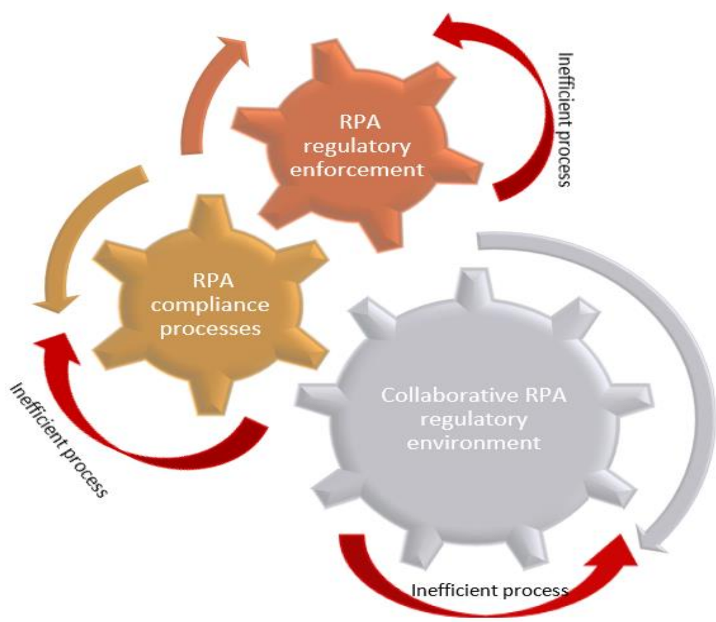
The SACAA operations are not streamlined and therefore tend to create bottlenecks. Different departments manage different applications of the five-phase process which makes it hard for one to seamlessly register an application.

4.4 Challenges with the remote piloted aircraft regulatory environment

The problem statement positioned the RPA regulatory environment as draconian, a view that is held by some sections of industry (African Union, 2018). The researcher explored this view during the interview sessions to get an understanding of the phenomenon. This exploration is viewed from the perspective of the regulatory institutions, RPA operators and consultants that were interviewed. There is concern from regulatory institutions of the uncoordinated efforts between institutions which create regulatory uncertainty and inefficiency. Respondent RIRCM supported this view stating that there is no collaboration between the SACAA and ICASA to regulate RPAs.

Figure 11

Inefficient RPA regulatory environment



Note. Researcher (2021)

Respondent RTABN also feels that there is a lack of coordination between RPA regulatory institutions with no clear communication on responsibilities and objectives which results in inefficient regulatory processes as shown in Figure 11 (Research, 2021). Respondent RTABM further stated that there were complaints from industry about the turnaround time to process applications thus affecting time to place electronic communications products in the market and RPAs happen to be in this category. Respondent RAZM admitted to shortcomings and gaps that need to be filled through a review of the PART 101 regulations as the current regulations should be viewed as a starting point. Respondent DORS supported this view and stated that the South African RPA regulations are a lazy regulation. South Africa was one of the first countries to publish RPA regulations in 2011 ahead of a lot of European countries but there have not been improvements ever since and the initial regulations took a lot of concepts from the manned aircraft regulations.

Respondent DCSM is of the view that the PART101 regulations are not easy to comply with, stating that the PART 101 regulations follow the same standards and approach as the manned aircraft regulations making it hard for someone who does not have an aviation background to understand and comply. This approach intentionally or unintentionally creates a gatekeeper phenomenon making it hard for new entrants in this market. Respondent DCST articulated his position as a consultant who manages RPA compliance on behalf of RPA operators and companies interested in integrating RPAs in their operations. The RPA's selling point is innovation and efficiency while opening the environment up to new ideas and entrants. Respondents DORS & DOA suggested that more young and innovative thinkers should be allowed to enter the aviation sector and therefore the SACAA should look at ways to balance the fields between traditional aviation players and new players. The current regime cannot do that with the PART 101 regulations as they are stringent and hard to comply with. Respondents DOA & DCSM pointed out that the SACAA times are very long even if one has all the required documents. Working individually to compile the required reports and manuals for compliance with SACAA regulations is cumbersome and might take years to a point that when one is done, the RPA to be used is already outdated (Respondent DOIM). The SACAA operations are not streamlined and therefore tend to create bottlenecks. Different departments manage different applications of the five-phase process which makes it hard for one to seamlessly register an application once. The regulations as they are, do not have any problems, the only challenge is that they are outdated and need to be reviewed to align with industry needs (Respondent DCST).

4.5 Illuminating sociocultural concerns in relation to remote piloted aircraft

Privacy finds its roots in section 14 of the South African Constitution which provides rights for South African citizens to not be searched in: a) person or their homes; and b) their property. Furthermore, section 14 of the South African Constitution provides rights to South African citizens against the seizing of their possessions and their communications infringed. The study argues that emerging technology such as an RPA needs to address socio-cultural concerns to succeed and be adopted. Figure 12 (Barker, 2017) is a depiction of the elements of privacy mostly highlighted by some respondents. Respondent RTABN refers the privacy and safety concerns to the regulatory making process where regulatory institutions follow public consultative processes to allow members of the public or any interested party to air their views. Over and above the regulatory making process, there is a complaints and consumer affairs tool for members to raise their concerns. Respondents DOIM & CSUT support the adherence to existing statutes citing that PART 101 regulations make provisions to protect citizen's rights to privacy and safety.

Figure 12

Privacy elements to be considered

Note. Reprinted from “New platform helps enterprises comply with privacy regulations” by I. Barker, 2017 (https://betanews.com/2017/02/14/enterprise-privacy-compliance/). Copyright 2021 by Betanews.

The regulations have rules, general guidelines and limitations that all RPA operators must adhere to. However, ICASA regulations focus on electric safety of electronic communications devices and not necessarily on-air flight operation safety. The SACAA is the regulatory institution responsible for on-air traffic safety and the protection of privacy from on-air operations (Respondent RIRCM). Respondents RTABN & RIRCM stated that there is nothing which empowers ICASA to enforce issues of privacy and therefore ICASA has no legal standing to enforce or ensure compliance with privacy. However, RPA legislation and regulations need to align with POPIA as it outlines the general needs for privacy. There needs to be a consolidated effort to guide RPA operators on all legislative and regulatory requirements they need to adhere to. Currently, there are gaps with defining the rules of flying in public space where one has to look at all available Acts before they can deem their operations as safe which creates uncertainty (Respondent DOPF). Interviewees raised concerns related to cybersecurity, noting that RPAs are susceptible to this form of crime. Of major concern, however, is the lack of a regulatory framework to deal with cybercrime (Respondent RTAFC). This sentiment is shared by Respondents DOJM & CSTM who feel that the country is not ready to deal with cybercrime and RPAs remain vulnerable to cyber hacks. If the issue of cybercrime is not addressed, RPAs will potentially meet resistance from civil society and industry as they will put the privacy and safety of people in jeopardy (Respondent CSTM).

Respondent CSTM is sceptical of RPA operated services, or anything that is operated that can be able to view his property as he views this as a huge security risk. RPA operator DOJM understands the safety concern and states that RPA operators cannot just have flight operations without proper management and accountability. Operators must comply with the regulations by conducting periodic maintenance of their RPAs. Civil society members CSTMS & CSPZ, however, presented a familiarity dynamic stating that the mere fact that they do not know much about RPA operations makes them apprehensive of this technology and they doubt that it will be solely used for good. Other members of society, CSAM & CSMR though do not think RPAs pose any risk so long as they maintain a safe operating distance that is not harmful to the people.

With regards to economic participation, Respondents DOA & DORS alluded to the cost to comply and views it as a barrier to entry as compliance is expensive and to some degree, the costs match the manned aircraft costs. Entrepreneurs from a disadvantaged background are already on a backfoot as the aviation industry is generally expensive and these regulations do not address this issue and they are a barrier to entry (Respondent DOIM). The average company that wants to start up an RPA operated service is not RPA specific, they are small entrepreneurs but the PART 101 regulations force operators to be aviators which ends up limiting the number of participants (Respondents DORS, DOJM & DCST). New entrants believe that the market is protected for conventional aviation players. The inefficient compliance processes coupled with the costs involved creates disillusionment as evidenced by Respondent DOA's complaint where it took over a year to get a rejection response from SACAA after having spent a lot of money in the project trying to fulfil the compliance requirements. The industry is designed in a way that requires one to have a lot of financial resources and investment to set up operations and the insurance needed is another expensive tool that one needs for compliance purposes. Respondent DOIM, however, balances this narrative and points out that the costs related to participating in RPA operations are not heavily leaned towards the SACAA compliance requirements but are more indicative of the overall expensive aviation sector e.g. cost of RPAs, insurances and medical aid.

Respondent DOJM suggested that the lack of operational categorisation resulting from blanket type regulations is an inefficient approach as small projects become uneconomical. This view was supported by Respondent DOIM who feels that it does not make sense to categorise small RPA operations in the same category as large-scale operations. RPA operators and consultants are of the view that the RPA regulations should not focus too much on the model of the RPA as regulations lag technological innovation and development. The approach should be operation centric where the approval process is focused on use case per operator, looking at risk mitigation and the proposal made by the specific operator. The use cases will showcase how the operator will manage operations from end to end giving comfort to the regulator for them to approve (Respondents DCST, DORS, DOJM, DOPF & DOA).

4.6 The strengths and limitations of drone management systems

Sentiments received from RPA operators and consultants suggest an issue of inefficiency and not necessarily effectiveness with regards to the RPA regulatory environment. RPA regulatory institutions seem not to have streamlined internal and external processes to enable efficient licensing and improved collaboration. The study proposes the integration of DMS as a system that can aid create an enabling RPA regulatory environment for RPAs in South Africa. The unique proposition of DMS' is the centralised processing of RPA regulatory requirements which help improve compliance and enforcement (Haeberlé, 2018). Respondent RTABN admitted to frustration coming from industry concerning Type Approval turnaround times that are too long thereby impacting organisational strategies and time to place products in the market. According to Respondents RTAFC, RTABN & RIRCM, ICASA is currently using an online system called Automated Spectrum Management System (ASMS) to manage spectrum licensing and type approval certification. This system however cannot be defined as a DMS as it is not specific to RPA management. Moreover, ICASA does not license a fleet of RPAs but only conducts representative or sampling certification. From this perspective, it is quite clear that the ASMS does not have a register of all RPAs that are in operation in South Africa and therefore cannot be considered fit for purpose to manage RPA licensing and enforcement. The SACAA currently uses the same system to license manned aircraft and RPAs. Different licensing processes are conducted in different divisions and systems within the SACAA and the DoT which does not centralise the licensing of RPAs (Respondent DCST).

The above narrative highlights the need for a more centralised IMS to manage the licensing and certification requirements of RPA regulatory institutions. This view is supported by Respondents DOIM & DOPF who feel that a system is needed to track and trace all registered RPAs in the airspace. Respondent DOIM further iterated that a DMS is needed to manage issues of illegal RPA use, protect people's right to privacy and safety. At a primary level DMS' help everyone using airspace to better manage their operations. An innovative view of DMS is for them to be used to better protect the privacy of civilians, where the centralised database is used to register all RPAs and have a requirement that all surveillance RPAs should provide their footage to the database and ensure that footage is scrutinised for any malicious acts and infringements of privacy (Respondent DOA). Civil society interviewees unanimously agreed on the need to have a centralised system that can register RPAs, trace and track them for safety and security purposes. Delivery RPAs need to have identity tags to create trust and comfort in the services. Respondents DCST & DOA feel that DMS can work if they are managed by the SACAA but they do not feel they would benefit the operators as their RPAs already come pre-configured with data logs of all operations. Respondent RAZM cautioned as well that the ATNS might be the institution better suited to use a DMS as air traffic management is under their scope.

However, Respondents DORS, DCST & RAZM indicated that there are a few applications or systems in existence already that are designed with RPA operators in mind and not necessarily a regulator's perspective. There is currently research ongoing on-air traffic management from a regulator and air traffic management services point of view and these systems are yet to integrate this aspect in their design. Respondents DORS, DCST & RAZM feel that DMS developers need to consider regulations for them to be fully adopted as most available DMS' do not align with regulatory requirements and processes. Original Equipment Manufacturers (OEM), RPA operators and regulators need to collaborate and develop an all-encompassing system that considers aviation governance. Respondents RAZM & DCST highlighted that flight plans differ from country to country and this poses a challenge for DMS' as they do not consider flight traffic management information and therefore the current DMS' promise is limited to RPA tracing and data logging which most RPAs already possess.

4.7 A look at compliance and enforcement mechanisms on the ground

An RPA enabling regulatory environment is one that has good enforcement mechanisms to allow fairness and transparency. Regulatory institutions have legislative empowerment to appoint field inspectors who carry out enforcement of regulations. The SACAA and ICASA rely heavily on inspection projects, complaints and tip-off as instruments for regulatory enforcement (Respondent RTABN). Marks of conformity are used by ICASA as an inspection tool for all type approved devices. Field inspectors conduct planned investigations at points of sale and RPA operator's premises to check for conformity and compliance. Respondent RIRCM confirmed that ICASA has received complaints related to RPA operations where these devices did not receive approval to operate. RPAs use the radio frequency spectrum to operate and communicate and therefore must receive an ICASA radio licence. ICASA inspectors deal with interference issues emanating from two-way radios. ICASA collaborates with the SACAA to investigate any illegal use or abuse of the radio frequency spectrum (Respondent RIRCM).

Respondent DOIM confirmed that the SACAA conducts ad hoc inspections and that the yearly renewals of licences are also a form of enforcement and control mechanisms. Respondent DOA held strong views on enforcement stating that the SACAA lacks the will power to enforce the regulations and are not willing to collaborate with the industry to create a culture of compliance. Illegal RPA operators as well, pose a challenge to this initiative as they always want to exploit all the gaps that the SACAA cannot address at the moment. Respondent DOIM reiterated the scourge of illegal RPAs that are in operation stating that the inefficient compliance and enforcement processes open room for this phenomenon. South Africa has a huge challenge with enforcement and non-compliance. According to Respondents DCST, DOA, DOJM & DOIM, the SACAA has a huge challenge as there are a lot of RPAs in operation making it hard to identify them as they do not have identity tags. A proposed solution to mitigate against this challenge is for the SACAA to collaborate with other state organs in order to be more effective with enforcement.

4.8 Flying into the future: The South African policy on remote piloted aircraft integration

The draft revised White Paper on National Transport Policy of 2017 advocates for the liberalisation of air transport to enable the advancement of technologically driven air traffic management systems. The DoT further emphasises the need to protect the environment and users of air transport services as well as the increased need to regulate RPAs. DoT aims to promote safety policies in line with the ICAO framework with SACAA being the authority mandated to regulate safety and security throughout the civil aviation industry including the operations of RPAs (Department of Transport, 2017).

The Department of Science and Technology (DST) published the White Paper on Science, Technology and Innovation on March 2019 ("STI White Paper") to promote innovation in order to improve economic growth, employment, government performance and service delivery. According to the DST, government and industry can leverage innovation to form new technology-based solutions thus promoting economic growth. The STI White Paper however does not explicitly state its innovation ambitions as they relate to RPAs and the RPA environment (Department of Science and Technology, 2019).

The DCDT published an invitation to nominate candidates for the Presidential Commission ("the Commission") on fourth industrial revolution on 4 December 2018 in government gazette No. 42078. The Commission is tasked with the development of a comprehensive action plan to deal with the Fourth Industrial Revolution (4IR). The advent of 4IR compels South Africa to develop new policies and strategies to adapt and leverage the new digital economy. RPAs are an integral part of the 4IR and it is imperative for the Commission to look at ways to integrate them into its policies and strategies (Department of Communications and Digital Technology, 2018). On 23 October 2020, the Commission recommended an adaptation of 4IR policy and regulatory processes that are beneficial to the economy, society and government. Part of the recommendations included regulatory sandboxes to design RPA policies and regulations that effectively integrate ATM with UTMS for South Africa to benefit from the potential of this technology (Department of Communications and Digital Technology, 2020).

4.9 Conclusion

This chapter presented findings from collected data using the narrative approach. The chapter systematically presented data by drawing the RPA legislative and regulatory environment. A review of policies, legislation and regulations was conducted to present the RPA regulatory environment focusing on provisions that are specific to RPAs. The chapter presents findings in line with the proposition of study looking at regulatory compliance requirements and enforcement mechanisms. Core to the research is socio-cultural concerns of privacy and safety and collected data is presented to illuminate the views of interviewees. The study hinges on the creation of an

RPA enabling regulatory environment with DMS' positioned as tools that can be used to facilitate an RPA enabling regulatory environment. Collected data from interviews about DMS is presented in this chapter, painting a picture of the current systems being used by regulatory institutions while also looking at the integration of DMS within the current regulatory setup.

Chapter 5: A step outside the frame to see the full remote piloted aircraft regulatory picture

5.1 Introduction

A regulatory environment plays a pivotal role in determining the technological advancement of a country. For the introduction of RPAs in South Africa to be a success, a complementary effective regulatory environment is required, not one that tends to stifle progress and innovation. Remedying a stifling regulatory environment requires regulators to recognise the views of the society that is being regulated. The management of compliance and enforcement processes is essential in ensuring regulatory efficiency; this was corroborated by reviewed literature and collected data.

The purpose of this study was to investigate an alternative tool to be used in the regulation of RPAs that will create an enabling regulatory environment for RPAs to succeed and be adopted as an emerging technology in South Africa. DMSs were explored as systems to assist with creating an enabling RPA regulatory environment. This chapter provides an analysis of the findings presented in Chapter 4, referenced with the conceptual framework explicated in Chapter 2. The study proposed a normative perspective to the deterrence theory looking at elements such as moral and social perspectives, economic participation, illegal gains and legitimacy of the relevant law institutions. An analysis of findings related to these elements is presented in this chapter to determine their relationship with the purpose of the study. The discussion further expounds on the relationship between DMS and an effective RPA regulatory environment. A subject-oriented analysis was conducted in this study, coding collected data using the simultaneous coding technique due to the relatability of the elements under study. Simultaneous coding allows for ease of creating themes out of coded data which translates to information and knowledge (Saldaña, 2009).

The researcher views the South African RPA regulatory environment as being premised on the traditional deterrence theory using a command and control approach for adherence to compliance. The deterrence theory advocates for a compliance environment that provides regulatory certainty, consequence management in cases of non-compliance and celerity of punishment to deter non-compliance (DiIulio, 1959). However, this study focused on a normative deterrence approach, which views society as more likely to comply without the need for punitive and aggressive measures because they see the law as right and just (Tyler, 1990). It recognizes the complexity of the individual that is being regulated. This study further aimed to determine whether the current RPA regulatory framework can be viewed as an RPA friendly regulatory environment. It argues that an RPA friendly regulatory environment is one that addresses compliance, enforcement and socio-cultural concerns. The findings presented in Chapter 4 postulated on these elements indicating that South African citizens have socio-cultural concerns related to RPA use. Furthermore, RPA operators and consultants ventilated their concerns related to compliance and enforcement, with representatives from RPA regulatory institutions acknowledging the concerns raised by citizens and RPA operators.

5.2 An analysis of the South African remote piloted aircraft regulatory landscape

Legislation and regulations are tools used, inter alia, to govern the use of RPAs. RPA legislation and regulation need to address all spheres related to RPA use. The document review conducted in this study shows that South Africa has a legislative and regulatory framework to govern RPA use. The South African parliament enacted three crucial Acts that are used in the governance of RPAs i.e. ICASA Act, ECA and the Aviation Act. These Acts are supported by regulations referenced from chapters of the respective legislations as shown in Table 7 above. A view expressed by Clarke (2016) alludes to the fact that regulatory environments almost always lag technological advancements resulting in knee-jerk reactions which are ineffective for RPA usage. Therefore, governments need to align the regulatory environment with technological advancements and the strategic objectives of the country.

ICASA adopted the Type Approval regime as a form of pre-market conformity assessment[11]. This approach typically involves the assessment of a representative sample of a product which applies to future batches. With this regime, ICASA assesses the equipment and provides a decision through a certificate or rejection document to authorise or restrict the sale and/or use of the equipment. This decision is based on an assessment of technical test reports compiled from accredited test laboratories. Type Approval is generally supported by a robust market-surveillance mechanism to improve confidence that the products being placed on the market are of the same quality as those for which Type Approval was granted. This approach seems to benefit RPAs as most interviewees expressed contentment with ICASA requirements. RPA operators stated that an RPA of interest is more often than not already type approved by ICASA and this helps reduce the turnaround time to receive an outcome. ICASA has approved 227 models of RPAs to date attached hereto as Appendix D. This implies that one can either buy an already type approved RPA in the market or one can request a simplified type approval from ICASA. Regulation 6 of the Type Approval regulations, 2013 makes provision for a simplified type approval whereby a supplier applies for type approval in relation to identical equipment that

[11] Conformity Assessment Framework for Equipment Authorisation, published in government gazette No. 43047 on 25 February 2020

has already been type approved by ICASA. The benefit of this process is that it is less cumbersome as it does not require the submission of technical test reports which take time to analyse, however, a representative sample may be required.

The SACAA uses the ICAO Circular 328 and RPAS Manual as a guide to developing technical and operational regulations which specify requirements for user certification, RPA registration, airworthiness approvals, responsibilities of RPA operators, RPA operations, and remote pilot stations (Padmanabhan, 2017). From a policy and regulatory perspective, these requirements are good and necessary but they need proper implementation strategies for them to be effective. Section 4.4 of this study listed challenges with the current RPA regulatory environment gathered from collected data. The SACAA regulations are put in the spotlight much more than the ICASA regulations in this study based on the inherent nature of RPAs using the airspace. A look at the concerns raised by interviewed RPA operators indicates dissatisfaction with the blanket approach adopted by the SACAA in regulating RPAs. The SACAA has put a requirement for all commercial RPAs to be certified and licensed in the same manner as manned aircraft even though they are technically and operationally different. Important to note is that the researcher did not use a quantitative review to determine the efficiency of the SACAA licensing processes but a look at collected data attests to perceived long turnaround times for licensing by SACAA. Collected data reveals unanimous agreement that the current South African RPA regulatory environment is restrictive and not RPA friendly. Complaints from respondents confirmed that it took over two years for them to be licensed by the SACAA. Other respondents went as far as giving up on the process and opted to use the services of co mpliance consultants. The SACAA has issued 79 ROC licences since the PART101 regulations were promulgated on 27 May 2015 as shown in Table 10 (SACAA, 2021).

Table 10

SACAA list of RPA operators

RPAS Operators
Abeod (Pty) Ltd
Aeromapix (Pty) Ltd
Agizo (Pty) Ltd
Anglo Operations (Pty) Ltd - Coprorate ROC
Atlantic Tech Group (Pty) Ltd
BAC Helicopters CC
Banzoflash (Pty) Ltd
Caelum Technologies (Pty) Ltd
Cairn UAS Division (Pty) Ltd
CCD Technologies (Pty) Ltd
Compact Aerial Services (Pty) Ltd
Corporate Aviation Management Services (Pty) Ltd
Cortac (Pty) Ltd
Darkwing Aerials (Pty) Ltd
DC Geomatics (Pty) Ltd
Diaruk (Pty) T/A Kimfly Charters
Drone Ops (Pty) Ltd
Drone Pilot School (Pty) Ltd
Drone Visuals (Pty) Ltd
Droneinsight (Pty) Ltd
Dronepix (Pty) Ltd
Eagle Drone Service (Pty) Ltd
EMS - Western Cape Government Health - Non- Profit ROC
Endangered Wildlife Trust
Epic Air Aerial Services (Pty) Ltd
Eugene Pretorius & Associates (Pty) Ltd

FC Hamman Films CC
Garden Route Media (Pty) Ltd
GC Geofly (Pty) Ltd
Greenfly Aviation (Pty) Ltd
Heli - X Charters (Pty) Ltd
Helivate (Pty) Ltd
Henley Air (Pty) Ltd
Higher Results People (Pty) Ltd T/A Drone IT
Idube Forestry 2 CC
Incredible Technologies (Pty) Ltd
Infinity Aerial (Pty) Ltd
Integrated Aerial Systems (Pty) Ltd
Izimbwiwa Coal (Pty) Ltd (Corporate ROC)
Liebenconsult (Pty) Ltd
Look Up Productions CC
MS Aviation (Pty) Ltd - Corporate ROC
Neo Precision (Pty) Ltd
Old Mutual (Pty) Ltd - Corporate ROC
PacSys (Pty) Ltd
Parthenius Project Consultants (Pty) Ltd
Peakfull CC
Premier Aviation CC
Pro Wings Training (Pty) Ltd
Prommac (Pty) Ltd
Purple Turtle Aviation CC
Robot Air (Pty) Ltd
Rocketmine (Pty) Ltd
Ronin Inventory Management Systems (Pty) Ltd
RPAS Consulting (Pty) Ltd
Salaria (Pty) Ltd

Saphire Blue (Pty) Ltd
Sasol Mining (Pty) Ltd - Corporate ROC
Scarab Industries CC
Sky High Solutions (Pty) Ltd
Skyhook (Pty) Ltd
Skyriders Access Specilists (Pty) Ltd
SNA Civil and Structural Engineers (Pty) Ltd - Corporate ROC
Starlite Aviation (Pty) Ltd
Step Above (Pty) Ltd
Streamline Cinema (Pty) Ltd
Terra Survey (Pty) Ltd
Tharisa Minerals (Pty) Ltd - Coporate ROC
Tristan Export (Pty) Ltd
UAV & Drone Solutions (Pty) Ltd
UAV Aerial Works (Pty) Ltd
UAV Industries (Pty) Ltd
UAV Inspection (Pty) Ltd
UAV Technologies (Pty) Ltd
Visual Air Productions (Pty) Ltd
Visuals from Above (Pty) Ltd
VPM Surveys CC
Vula Aviation Technologies (Pty) Ltd
Zutari (Pty) Ltd - Corporate ROC

Note. Adapted from “RPA operators” by SACAA, 2021 (http://caa.co.za/Pages/RPAS/RPAS%20operators.aspx). Copyright 2017 by SACAA

Respondents are of the view that South Africa should look at a performance-based, adaptive and future-oriented regulatory approach and move away from the compliance-based approach. The performance-based approach is focused on the SACAA working with operators to physically check the operations of an applicant and approve them based on the assessment at a specific point in time. There should be a partnership between the SACAA and RPA operators where use cases and assessment of operations form the basis of approval. Proposals from industry are for the SACAA to categorise licences according to the size of RPA, type of operation to be conducted and area of operation. This proposal is in line with Clarke (2014) where he classifies four flexible regulatory forms that can create an RPA friendly environment and they are: organisational self-regulation, industry self-regulation, co-regulation, and formal regulation. These regulatory forms are entrenched in the foundations of the RPAS Manual RPAs (Clarke, 2014).

The PART 101 regulations were developed in anticipation of a huge rise in RPA use in South Africa. The PART 101 regulations adopted a risk-based approach which resembles the manned aircraft regulations. Five years on and South Africa is yet to see a review of the SACAA RPA regulations. The lack of progress in this regard is causing disillusionment among RPA developers and operators with some feeling that the country is missing out on an innovative opportunity. However, SACAA respondents revealed that a review of the regulations is underway and that most concerns raised by industry will be addressed.

5.3 Addressing sociocultural concerns stemming from remote piloted aircraft usage

In Chapter 2, the researcher sought a theoretical framework for addressing sociocultural concerns that stem from RPA use. A normative perspective to the deterrence theory was proposed with elements such as moral and social perspectives, economic participation, illegal gains and legitimacy of the relevant legal institutions with a view to determine if this approach can facilitate an enabling regulatory environment for RPA use in South Africa.

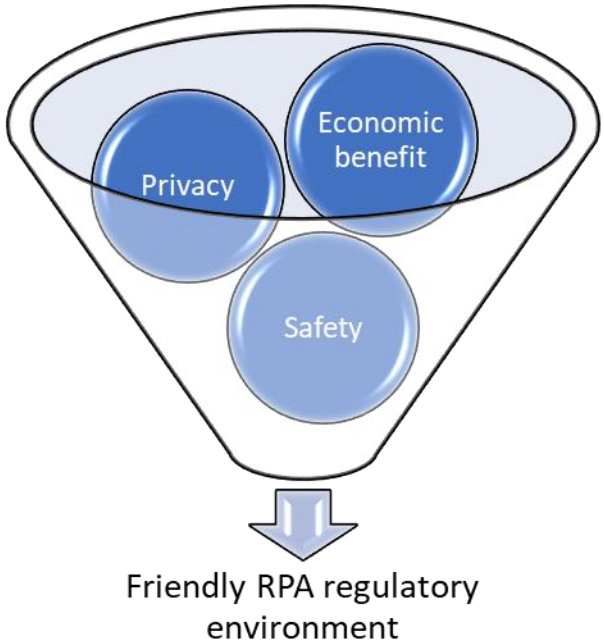
5.3.1 The moral and societal dilemma of remote piloted aircraft

Literature suggests that RPAs are technologically advanced, configured with high definition features such as cameras, surveillance tools and the ability to carry payloads, which presents a threat to privacy and safety (Clarke, 2016). This view is corroborated by a number of respondents who acknowledged that the RPA regulations do not adequately address concerns of privacy and safety presented by RPA use. Respondents identified as civil society members raised concerns related to the proximity of RPAs to their persons, area of residence and issues of cybersecurity thus suggesting an awareness of RPA capabilities. The small size of some RPAs creates distrust and fear among respondents who feel that this device can be abused and used in illegal activities. A respondent who resides in the township expressed concern on the readiness of townships to accept RPA use. These narratives stem from various factors such as attacks on RPAs perceived to be threatening job security, hijacks to steal payloads, distrust based on residents being unfamiliar with RPAs and spying concerns. Clarke (2014) reasons that society's apprehension of RPAs is that they pose a threat to personal privacy where an individual is free to act as they want, without spying and intrusion from others.

Apart from the above-discussed apprehension from some members of society, there is another section of society that is keen to use RPAs for economic and social benefit. Respondents have expressed a desire for a more inclusive RPA economy that supports small, medium and micro-enterprises.

Figure 13

Solving the moral and societal dilemma of RPA operations



Note. Researcher (2021)

This view is supported by the African Union (2018) which expresses the need to address cost and technical barriers for RPA adoption to succeed. This can be achieved by building an adaptive regulatory framework for RPA governance and regulation as seen in Figure 13 (Researcher, 2021). There is a view that the average company that wants to start up an RPA operated service is not RPA specific, but are small entrepreneurs. However, the current RPA regulatory environment forces them to be aviators, which ends up limiting the number of participants. The South African RPA market is thus perceived as protected for conventional aviation players. An inclusive RPA economy is one that supports new entrants and people that are not inherently from the aviation sector. Another impediment to the use of RPAs for economic and social benefit is the cost to comply with the RPA regulations. Respondents have complained about the cost involved in operating RPAs stating that it is more expensive to register an RPA than a plane. The overall cost to comply with the South African RPA regulations exceeds R500, 000 which makes it impossible for small businesses to participate.

5.3.2 The resultant illegal gains

A view from reviewed literature is that laws by themselves do not address the costs and benefits derived from the action of people. A law aimed at prohibiting non-compliance does not alter an individual's ability to contravene the law, but it does influence behaviour (Mailath, Morris, & Postlewaite, 2016). This is corroborated by RPA operators interviewed in this study who confirmed the existence of illegal RPA use in South Africa. They reasoned that the inefficient compliance processes and lack of enforcement contribute to illegal RPA use which leads to illegal gains. Regulatory instruments can be used to directly or indirectly influence the behaviour of the regulated entities and a common view is that there should be rationality in this endeavour (Drahos, 2017). Illegal gains are intertwined with the cost-benefit calculation from the perspective of the RPA operator who decides to contravene the regulations. This, therefore, requires a two-pronged approach, dissecting the rationality and inclusivity of the regulations and the reasons of the transgressor. Rational and inclusive regulations aid in creating a culture of compliance and transparency. In a rational and inclusive regulatory environment, the severity element of deterrence theory can be used to manage non-compliance (Drahos, 2017).

Respondents from regulatory institutions categorised the regulated entities into the following: compliant user, uninformed user and users who deliberately contravene the regulations. A compliant user is well informed and always tries to adhere to the regulations. The uniformed user at times has no knowledge of the regulations and sometimes does not understand the regulations well enough and this group is easy to address through education. The third category is aware of the regulations, and they intentionally break the regulations for personal gain. The illegal gains element needs to analyse all these categories of users taking into consideration all the factors that contribute to non-compliance and apply appropriate control measures. A dominant concern from respondents is procedural inefficiency experienced in the RPA regulatory environment which contributes to non-compliance. Some RPA operators have waited for over two years to complete the licensing processes at which time the envisioned opportunity is gone (African Union, 2018). Some respondents believe that the RPA regulatory institutions lack the will power to deal with illegal RPA use which contributes to illegal gains. The cost-benefit analysis of illegal gains emanating from illegal RPA use focuses on the decision and action of RPA operators to understand the phenomenon. A look at the South African RPA regulatory environment leads one to surmise that there is a level of disillusionment about the capacity of the RPA regulatory institutions to effectively manage RPA operations. The lack of enforcement in this regard influences the cost-benefit calculation ending up with illegal gains.

5.3.3 The importance of a legitimate remote piloted aircraft regulatory institution

The RPA regulatory environment needs to exude a symbiotic relationship between the regulator and the regulated. Literature suggests that it is vital for laws and regulations to align with people's needs and morals. Laws and regulations are only as good as their ability to address societal needs and ambitions. Society tends to resist and rebel against laws that do not advance their needs and ambitions and this creates a legitimacy crisis for law enforcement institutions (Drahos, 2017). Evidence from respondents suggests an element of distrust from RPA operators who view the RPA regulatory environment as unfriendly. The challenge of procedural inefficiency calls the reputation of RPA regulatory institutions into question as people need to trust these institutions. Persistent reputational damage potentially leads to doubt related to the legitimacy of the RPA regulatory institution (Tyler, 1990). RPA operators raised concerns of illegal RPA use, stating that the SACAA was not equipped to manage this challenge. RPA operators, however, use the whistleblower approach to alert the SACAA against illegal RPA use which aid to curb this phenomenon. A view of whistleblowers was mostly based on their desire to see a more fair and transparent environment where everyone plays by the same rules. It must be noted that RPA operators invest a lot of money and effort to adhere with RPA regulatory requirements and having an environment that allows some players to operate illegally creates regulatory uncertainty. Regulatory uncertainty stemming from lack of enforcement is a serious indictment on responsible regulatory institutions. Testimony to this are respondents who doubted the will of RPA regulatory institutions to enforce the regulations stating that the lack of enforcement contributes to illegal RPA use. The normative perspective views legitimacy as an important component to deterrence and therefore, it is imperative for RPA regulatory institutions to align the regulatory environment with the needs and morals of the regulated entities as this influence regulatory behaviour (Tyler, 1990). RPA regulatory institutions need to have procedural efficiency and effective enforcement to improve the culture of compliance (Drahos, 2017).

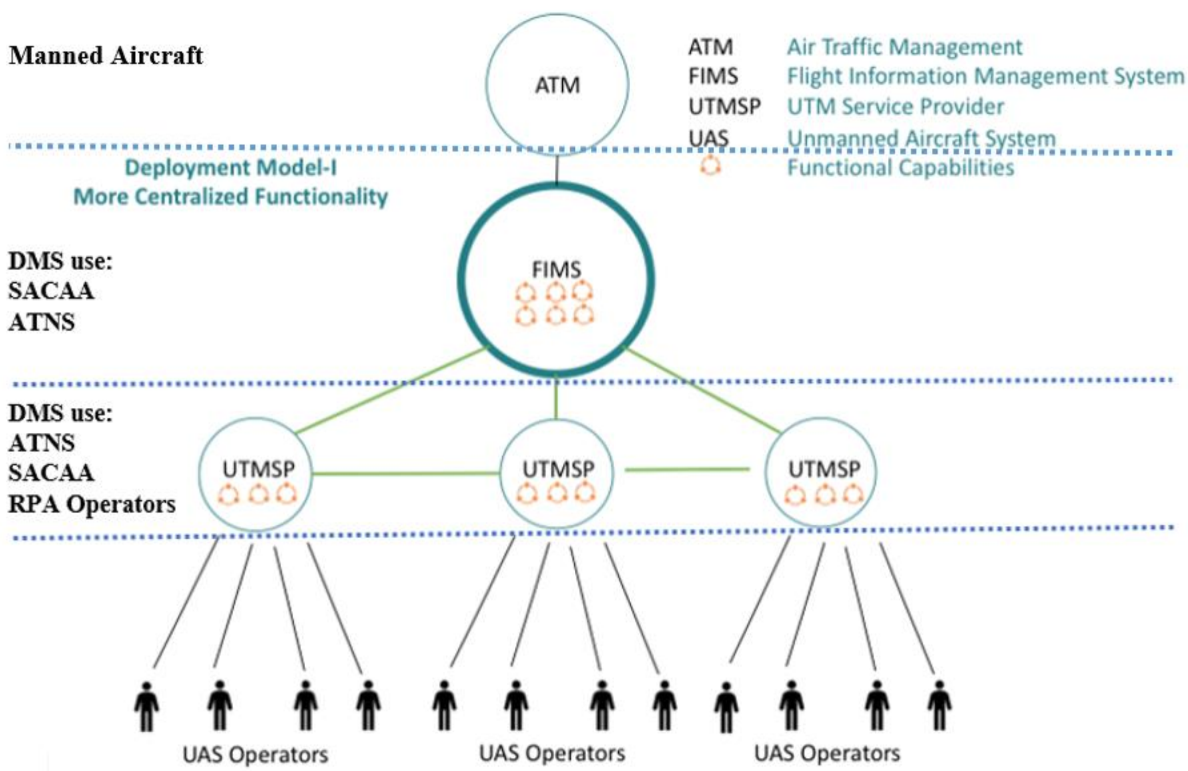
5.4 The integration and developmental considerations of drone management systems

This study proposed the use of DMSs to aid facilitate an enabling regulatory environment for RPA use in South Africa. Collected data presented concerns related to compliance procedural inefficiency, lack of enforcement and lack of mechanisms to address privacy and safety as mentioned in section 5.5.3 where applicants narrated their challenging experiences related to the licensing process. The core feature of a DMS is a centralised database that offers compliance efficiency and effective enforcement. DSM developers present the system as being efficient at performing the following activities: RPA and user licensing, no-fly zones designation, RPA flight plans and management of flight operations. DMSs provide e-procedural efficiency which empowers RPA operators and consultants to manage their applications with the SACAA. Efficient processes contribute to reduced compliance turnaround times enabling stakeholders to seamlessly access the industry (Haeberlé, 2018). Collected data, however, revealed mixed views from RPA operators and RPA consultants. A common theme around DMSs is that these systems are developed from an operator's perspective without the regulator and other stakeholders in mind. One major concern is the inability of a DMS to seamlessly integrate with ATMS to enable features such as B-VLOS to be implemented. International Civil Aviation Organisation (2020) confirmed that the current airspace classification is not friendly to B-VLOS operations. Respondents leaned more on the airspace flight rules stating that these rules set the protocol of engagement in the airspace and DMSs are incompatible with systems used to manage the airspace (Internation Civil Aviation Organisation, 2020).

Respondents are of the view that DMSs need to consider the regulations for them to be fully adopted; the concern with DMSs is that they are not fully customised to manage regulatory requirements and processes but merely have a generic database structure and workflow process. There is a development gap that needs to be completed where OEMs and regulators have to collaborate to create an all-encompassing system that can provide a solution that considers aviation governance requirements. Reviewed literature presented DMSs as systems that can formulate and manage an RPA network. An integrated RPA network makes it easy to develop manageable flight operational plans and enforcement mechanisms (Koub, et al., 2018). However, the major challenge causing DMSs to be unable to manage flight plans is that flight information management differs from country to country thus making it hard to factor flight traffic management information in the development of DMSs. Therefore, the view from respondents is that DMSs are only capable of RPA tracing and flight data logging which most RPAs already possess (International Civil Aviation Organisation, 2020). An inclusive DMS development involving SACAA, ATNS, traditional aviators and RPA operators can result in an effective system that can help integrate the Unmanned Traffic Management System (UTMS) which DMSs are a component of with Manned Traffic Management Systems (MTMS) as shown in Figure 14 (Ganjoo, 2019).

Figure 14

Integration of DMS with UMTM and ATM



Note. Adapted from "A Deep Dive into UTM and the Flight Information Management System for Drones [Long Form]" by A. Ganjoo, 2019 (https://dronelife.com/2019/08/22/a-deep-dive-into-utm-and-the-flight-information-management-system-for-drones-long-form/). Copyright 2019 by Dronelife.

5.4.1 Using drone management systems to manage compliance and enforcement

The deterrence approach used in the current South African RPA regulatory environment hinges on three core elements of punishment i.e. certainty, severity, and celerity. The certainty component recommends that punishment must take place at all times in cases of disobedience. Advocates of deterrence theory suggest that a given punishment needs to be severe enough to ensure a just and effective result and the punishment needs to be swift in order to have memorable outcomes that can aid to deter future offences (Tyler, 1990).

Collected data suggests that the South African RPA regulatory environment has policy and regulatory certainty with clear legislative and regulatory provisions. However, the legislative and regulatory certainty is overshadowed by process and procedural inefficiency. Findings further confirmed a lack of enforcement mechanisms in the South African RPA regulatory environment. These two major factors render the deterrence components ineffective as law enforcement agencies cannot guarantee certainty of punishment at all times which creates an unfair and non-transparent treatment. Celerity of punishment advocates for a swift process and an inefficient environment negatively impacts this component as RPA law enforcement agencies have challenges with identifying offenders. There is growing confidence among offenders that the RPA law enforcement agencies do not have capacity to manage non-compliance thereby nullifying the core theme of deterrence theory. To address the shortcomings of the current RPA regulatory environment, the researcher inductively advanced the normative perspective to deterrence using DMS as tools to create an RPA friendly regulatory environment.

Interviews conducted for this study, specifically with RPA operators and consultants indicated that there is a fair amount of RPA use in South Africa. Indications, however, suggest that a number of RPA operators are licensed to operate within VLOS which restricts operations to a 1km radius. Findings suggest that operators need the B-VLOS feature to be easily attainable from the SACAA to allow South Africa to maximise the potential of RPAs. The business case for delivery services for an example heavily relies on the B-VLOS feature and having adaptive and principles-based licensing requirements would enable mileage-based services to adopt RPAs. Jones (2017) highlighted the positive contribution that RPAs can make in the green economy through reduced carbon emission generated by fleet and delivery services. South Africa needs to provide quality services to rural areas and RPAs can assist with rural programmes, especially in hard to reach locations. Respondents pointed to the COVID-19 pandemic as a period where RPAs could have been used to deliver medical supplies and test kits to rural clinics. It is difficult to have such operations currently due to the stringent nature of the RPA regulations.

Notwithstanding concerns raised by RPA operators and consultants, there is general support that DMSs can help create an enabling regulatory environment for RPA use. Respondents overwhelmingly agree that DMSs are needed to manage: a) compliance and enforcement requirements, b) illegal RPA use, and c) the protection of people's right to privacy and safety. The challenge of illegal RPA use is intertwined with morals and values of individuals and it can be reduced by an environment with efficient compliance and strong enforcement processes (Drahos, 2017). DMSs are seen as systems that can bring regulatory certainty and process flexibility thus paving way for a relaxed and adaptive regulatory environment. The stringency of the PART 101 regulations deters new entrants and innovators who otherwise would use RPAs in their projects. This point is supported by respondents who indicated that average companies interested in RPA services are not aviation-oriented but the PART 101 regulations forces them to be aviators which ends up limiting the number of respondents. This segment of operators can benefit from the integration of DMSs in the RPA regulatory environment. Drahos (2017) emphasises the importance of a regulatory environment in addressing the needs and morals of the regulated. Therefore, the economic participation component needs to be equally addressed through an inclusive RPA regulatory environment. One respondent stated the following:

> "More young and innovative thinkers should be allowed to enter the aviation sector and therefore the SACAA should look at ways to balance the fields. But we cannot do that with the current regulations as they are stringent and hard to comply with."

DMSs promise e-procedural efficiency that will pave way for all stakeholders to seamlessly comply with RPA regulations (Jiang, Geller, Ni, & Collura, 2017). As a primary function, DMSs can support everyone using airspace to better manage their operations. These systems can be managed by the ATNS and SACAA in order to have real-time flight traffic management information.

Interviewed members of society supported the idea of RPAs having identifications similar to vehicle registrations. The view is that identifiable RPAs provide some level of comfort; civil society respondents raised an element of familiarity, stating that they can accept and make use of RPA services if they have assurance that their privacy and safety is protected. Considering all the above, DMSs have the potential to create an RPA friendly regulatory environment provided that all relevant stakeholder in the RPA environment collaborate to customise these systems according to right specifications and needs.

5.5 Conclusion

The belief held about the South African RPA regulatory environment as being unfriendly is largely supported in this study. The current RPA regulatory environment has clear compliance requirements which creates an impression of an effective environment. However, this study suggested that a seemingly effective regulatory environment might be marred by efficiency challenges that render it ineffective. South Africa is one of the first few countries to pass RPA regulations in the year 2015. This was seen as a positive move as it showed at a basic level that the country was looking at this technology. The initial outlook and theme of the PART 101 regulations replicated the manned aircraft regulations. Unfortunately, this approach resulted in RPAs being over-regulated and stifled as a technology. The general notion from industry is that the South African RPA regulations are equal to a technical ban considering the compliance requirements that are not operation and RPA oriented. The South African RPA regulatory environment has weak enforcement mechanisms which opens room for fraudulent activities. The sample interviewed in this study indicated an interest in the RPA technology where RPA operators presented innovative services that can be unlocked by this technology. These RPA operators however raised concerns and frustrations about the RPA regulatory environment stating that they deem it as unfriendly due to inefficient and cumbersome compliance requirements and weak enforcement.

The conventional deterrence used in the South African RPA regulatory environment is ineffective as a result of a cumbersome compliance and weak enforcement environment. The licensing process does not provide RPA identification thereby making it difficult to circumvent transgressions. Conventional deterrence advocates for the certainty of punishment and this fact alone poses a challenge wherein RPA regulatory institutions do not have a centralised and live database for monitoring RPA operations. Therefore, regulatory institutions cannot guarantee that all offenders can be identified and punished. However, the study is limited in this instance as it did not focus on the ability and capability of South African RPA regulatory institutions to identify and punish offenders. The study further advances a point that difficulty in identifying offenders creates a ripple effect on the other two elements of deterrence i.e. celerity and severity as one cannot ensure celerity in an unfriendly regulatory environment. Severity of punishment can potentially create an impression of an unfair and non-transparent treatment by regulatory institutions.

The results of this study support the proposed integration of DMSs to remedy the unfriendly RPA regulatory environment and the expansion of the deterrence theory to add elements that produce a normative perspective to deterrence. The study uncovered a need and room for DMSs in the South African RPA regulatory environment. At a fundamental level, DMSs can be used to facilitate a friendly licensing and enforcement environment. RPAs come preconfigured with tracing and data logging functions and this can ease the integration of DMSs with RPAs. However, one vital factor that needs to be developed for DMSs to be highly effective for all stakeholders is the inclusion of flight information management. The availability of this feature could potentially lead to the relaxation of the requirements to attain a licence for B-VLOS operations and services which will enhance the usefulness of RPAs. Therefore, all stakeholders must collaborate and develop DMSs that will take regulatory requirements and socio-cultural concerns into consideration. This collaborative effort aligns with the normative perspective to deterrence advanced in this study with the DMS at the centre of creating a friendly RPA regulatory environment.

Chapter 6: A synthesis of the integration of drone management systems in the South African remote piloted aircraft regulatory environment

6.1 Introduction

This chapter reviews the analysis presented in chapter 5 to draw conclusions in line with the research problem and research questions. Recommendations are made for all relevant stakeholders in the RPA regulatory environment and furthermore, this chapter outlines the limitations of this study. The study used the deterrence theory as a conceptual framework with a suggestion to extend it to include socio-cultural constructs. The extended deterrence theory aims to explore a liberal approach in the regulation of RPAs which differs from the command and control approach currently used in the South African RPA regulatory environment. The main research question is detailed as follows:

How can DMS be used to facilitate an enabling regulatory environment for commercial remote piloted aircraft usage in South Africa?

The sub-questions used to further explore the main research question are as follows:

(1) How can drone management systems contribute towards the implementation of different regulatory approaches.

(2) To what extent can drone management systems alleviate sociocultural concerns associated with RPA usage in South Africa?

(3) How can drone management systems promote compliance with RPA requirements stipulated in the SACAA PART 101 regulations and enforcement challenges related to RPA usage in South Africa?

6.2 Revisiting the purpose of the study

The study sought to investigate an alternative tool to be used in the regulation of RPAs that will create an enabling regulatory environment for RPAs to succeed as an emerging technology in South Africa. The study explored DMSs as systems that can assist with creating an enabling RPA regulatory environment through effective RPA management in all spheres of society. To achieve this, the study had to frame the RPA regulatory environment looking at the use and management of RPAs. DMS are then presented in this study, highlighting their integration in the RPA environment. The integration of DMSs is in line with the normative deterrence theory adopted as a conceptual framework for this study.

6.3 Inferences related to the research questions

The research sub-questions are used in this section to link the major findings with the purpose of the study.

6.3.1 Research sub-question 1

This section aims to provide synthesis on the first sub-question of this study:
How can drone management systems contribute towards the implementation of different regulatory approaches?

Emerging technologies need a flexible, robust, adaptive and effective regulatory environment. A rigid ICT regulatory environment hampers technological innovation with adverse effects to the economic outlook of the country (Zainol, Hussein, Chun-Phuoc, & Hassan, 2019). RPAs present a complex regulatory challenge due to their inherent risk related to airspace use.

Therefore, RPA regulatory institutions need to develop balanced regulations focused on safety and fair use of these devices. The study shed light on how the current use of a traditional regulatory making process is not fit for purpose in relation to the management of RPAs. The process is slow and cumbersome taking almost two to four years to complete which is not good enough to integrate emerging technologies. Moreover, in South Africa, the traditional regulatory approach is marred by inefficient compliance and enforcement processes. Clear policy and regulatory requirements need to be supported by effective and efficient processes which is not the case in South Africa.

DMSs can support the adoption of adaptive, principled and future oriented regulation. A centralised database can aid to improve collaborative initiatives between regulatory institutions (Black, Hopper, & Band, 2007). Interviewed regulatory consultants advocated for an outcome and performance-based regulation stating that this approach would ensure that individual RPA projects are evaluated on their own merits, which differs from the blanket regulatory approach which tends to disadvantage small scale projects. DMS has effective flight operation planning which would assist the SACAA to categorise operations and better manage risk related to airspace use. Risk-weight regulation promotes for a shift from blanket regulation to a data-driven approach and DMS will aid in the collection of data logs from all connected RPAs. DMS allows constant monitoring of RPA operations befitting of an adaptive regulation which focuses on responsiveness. DMSs can help with the use of regulatory sandboxes to manage risks during testing stage. Regulatory sandboxes enable regulators and stakeholders to pilot their models and operational concepts in a live controlled environment for a defined period before formally adopting an approach. DMSs will help with the planning of regulatory sandbox projects while also ensuring that normal day to day operations are effectively managed.

6.3.2 Research sub-question 2

This section aims to provide synthesis on the second sub-question of this study: To what extent can drone management systems alleviate sociocultural concerns associated with RPA usage in South Africa?

The analysis of collected data and document review enabled the researcher to determine how DMS can be used to alleviate concerns related to economic benefit, privacy and safety as stipulated in the recommendations below. The study discovered a gap in the RPA regulatory environment regarding concerns related to personal privacy and safety. Even though there is evidence of existing policy on privacy and safety, the RPA regulatory environment does not specifically address personal privacy and safety. This leads to a lack of trust and resistance in RPA usage in South Africa. The study also reveals that the RPA regulatory environment in its current state does not adequately address the element of economic benefit. The sector is currently skewed towards traditional aviation players creating a barrier for new entrants and this limits the potential promise of RPAs.

There is consensus that DMSs have a role to play in the RPA regulatory environment and that they could contribute to alleviating socio-cultural concerns related to RPA usage in South Africa. The normative deterrence theory used in this study suggests for RPA regulatory institutions to consider socio-cultural concerns, economic participation and legitimacy of the institution in regulatory development. The study elaborated on the reasons for RPA regulatory institutions to consider the normative perspective to deterrence. The flight operations management feature of the DMS can improve enforcement processes through effective tracking and tracing of registered RPAs. The improvement of enforcement processes will in turn help to address issues related to privacy and safety. Addressing socio-cultural concerns translates to reduced resistance from civil society and new entrants related to RPA usage in South Africa. However, there is a need for a collaborative effort in developing DMSs for these systems to be relevant and accepted in the RPA regulatory environment.

6.3.3 Research sub-question 3

This section aims to provide a synthesis on the third sub-question of this study:
How can drone management systems promote compliance with RPA requirements stipulated in the SACAA PART 101 regulations and enforcement challenges related to RPA usage in South Africa?

Inefficient processes potentially lead to regulatory uncertainty which breeds a culture of non-compliance thereby causing reputational damage to the relevant regulatory institution (African Union, 2018). This case is uncovered in the South African RPA regulatory environment with inefficiencies experienced in the compliance pipeline. The analysis revealed that there are clear policies and regulations in South Africa, however, these regulations are hampered by inefficient processes and a non-transformative approach to RPA regulation. Collected data also confirms the held perception that the South African RPA regulatory environment is stringent with cumbersome processes.

It is for this reason that DMSs are presented in this study as systems that can assist to streamline the compliance processes of the RPA regulatory institutions. According to Haeberlé (2018), DMS centralises the processing of compliance requirements and offers administrative efficiency through e-procedures. Efficient compliance processes give confidence to RPA operators while also improving the reputation and legitimacy of the regulatory institution. Therefore, the study supports the integration of DMSs in the RPA regulatory environment as they will improve the compliance processes and enable regulatory institutions to adopt flexible and adaptive regulations. The current regulatory regime is seen as rigid as it uses a blanket approach for all RPA categories and operations. DMSs will enable regulators to relax their regulations and adopt a performance-oriented approach that considers the area of operation.

A compliance environment needs to be complemented by an effective enforcement environment (Clarke, 2016). Recalling Section 1.4.1, the researcher could not find mechanisms used by the RPA regulatory institutions to enforce regulations, especially for in-flight operations. Analysis of collected data further confirms the position that the RPA regulatory environment has weak enforcement controls to manage RPA use in South Africa. There is concern from industry players about the lack of enforcement which contributes to non-compliance. The findings of this study support the integration of DMSs in the RPA regulatory environment to help strengthen the enforcement mechanisms of RPA regulatory institutions. DMSs connect RPAs into a network of RPAs enabling them to communicate with each other. A network of RPAs simplifies the planning of flight operations (Hazon Solutions, 2018). Data analysis indicates support for a system that can provide a function to identify and track RPAs. DMSs can help with tracking and tracing RPA operations and in the process, provide regulatory inspectors with the ability to manage RPA traffic. Improved enforcement process will curb the scourge of illegal RPA use and bring fairness and certainty in the regulatory environment. Furthermore, regulatory certainty will help to legitimise the regulatory environment as suggested in the normative deterrence perspective.

6.4 Research limitations and further research

The study sought to determine if DMSs can be used to facilitate an RPA friendly regulatory environment. In doing so, the study explored the efficacy of the compliance processes in the RPA regulatory environment. The qualitative research approach adopted in this study posed a challenge in this instance as the researcher could not provide statistical data on the number of applications received and processed by RPA regulatory institutions. Furthermore, the researcher could not find respondents at the SACAA who work directly in the Licensing Unit, processing licensing requests. Therefore, this limited the study's ability to determine the efficacy of the compliance processes. The sub-element of economic benefit under this study also has a quantitative outlook that the study does not address. The study does not present statistical data on the number of new entrants and innovators who attempted to enter the RPA sector, but failed due to the stringency of the RPA regulatory environment. Having this data could have elucidated the conversation related to the RPA regulatory environment being a barrier to entry for new entrants and aspiring innovators who are not traditional aviators.

The researcher could not find respondents who develop DMSs in order to provide a comprehensive view of these systems. The challenge presented by the RPA regulatory expert and RPA operators suggests that there is a gap in the development of DMSs as they do not take the regulator's view into consideration. Therefore, the researcher was unable to explore this view from the DMS developer's perspective.

6.5 Conclusion

This study unearthed a number of challenges experienced within the RPA regulatory environment as expounded in Chapters 4 and 5. This chapter provided an array of possible solutions that can be attained through the adoption of a DMS in an RPA regulatory environment. The findings of this study show that DMS can be considered to facilitate the implementation of different RPA regulatory approaches. Furthermore, the findings show that DMS can contribute positively towards the alleviation of sociocultural concerns associated with RPA usage in South Africa. Lastly, the study showed that DMS can provide the added benefit of improved compliance processes and enforcement mechanisms.

6.6 Recommendations

The findings show that DMSs can be used to facilitate an RPA friendly regulatory environment in the following ways:

a) streamline administrative compliance functions by offering a centralised e-procedural database;
b) manage unmapped flight operations;
c) improve enforcement management;
d) enable adaptive regulations using a performance-oriented approach;
e) assist in the integration of UTMS with ATMS; and
f) provide input to complaints management systems.

The achilles heel of DMSs is the lack of mapped flight information which limits their ability to manage flight operations as this area is still being developed. Therefore, this study can serve as input to understand how DMSs can be used at the regulatory level to improve compliance and enforcement processes. Additionally, the study provides perspective for existing RPA communities on how to collaborate and leverage on existing RPA management systems.

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Appendix A: Ethics clearance certificate

SCHOOL OF Literature, Language and Media RESEARCH ETHICS COMMITTEE

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: SLLM/M19/03**
PROJECT TITLE	Investigating Drone Management Systems for effective compliance with the South African drone regulations
INVESTIGATOR	**Siyanda Nkamisa**
SCHOOL/DEPARTMENT	SLLM/ LINK Centre
DATE CONSIDERED	8 November 2019
DECISION OF THE COMMITTEE	Approved

This ethical clearance is valid for 1 year and may be renewed upon application.

EXPIRY DATE December 2020

ISSUE DATE OF CERTIFICATE November 2019 **CHAIRPERSON**

cc: Supervisor(s) : Mr Thabiso Thukani

DECLARATION OF INVESTIGATOR

To be completed in duplicate and **ONE COPY** returned to the Chairperson of the School/Department ethics committee.

I fully understand the conditions under which I am are authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

Signature **Date** 08 / 03 / 2020

Appendix B: Participant Information Sheet

MASTERS RESEARCH REPORT: Investigating the integration of drone management systems to create an enabling remote piloted aircraft regulatory environment in South Africa

Dear Prospective Participant,

My name is Siyanda Nkamisa, a student at the University of the Witwatersrand (Wits), doing a Masters of Arts in the field of ICT Policy and Regulation (MA ICTPR). As part of my studies, I am conducting research on drone management systems to create a drone friendly regulatory environment. The aim of this study is to investigate an alternative approach to drone regulation that will create an enabling environment for drones to succeed and be adopted as an emerging technology in South Africa.

I hereby invite you to participate in the interview for this study. Your inputs will be valuable in mapping the data relevant to understanding the drone regulatory framework in South Africa. The responses you provide will be used exclusively for the purposes of the research report, and for related scholarly publishing and capacity building. I therefore request your permission to audio record this 45-60-minute interview, and possibly consult with you in future should I need to clarify any issues.

Your words, input and personal details will be kept anonymous by utilising a naming convention rather than your actual name or other identifiers, unless you expressly require that your name or position be published. Confidentiality will be observed with respect to any matters discussed in the interview that you do not wish to be reported.

Participation is entirely voluntary. Should you wish to withdraw from the interview at any time during or after, you are free to do so without giving reasons and any responses provided will not be reported. If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. This study will be written up as a research report which will be available online through the university library website. If you wish to receive a summary of this report, I will be happy to send it to you (optional). Should you have any concerns about this research, please do not hesitate to contact my supervisor, Mr. Thabiso Thukani at the LINK Centre, University of the Witwatersrand or Shaun Schoeman at the University of Human Research Ethics Committee (Non-Medical).

Researcher: Siyanda Nkamisa

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Cell: +27 81 471 7153

Research Supervisor: Mr. Thabiso Thukani

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Cell: +27 83 212 0152

Shaun Schoeman

telephone +27(0) 11 717 1408,

Email Shaun.Schoeman@wits.ac.za

Appendix C: Informed consent form

MASTERS RESEARCH REPORT: Investigating the integration of drone management systems to create an enabling remote piloted aircraft regulatory environment in South Africa

I ____ hereby agree to participate in the research study title: Investigating the integration of drone management systems to create an enabling remote piloted aircraft regulatory environment in South Africa.

I will participate in a recorded interview of approximately one hour in length, in which I will give my views on drone regulations and drone management systems. The research has been explained to me and I understand the study. I have been informed of (i) the names and affiliations of the researcher; (ii) the purpose, content, objectives and potential benefits of the study; (iii) the fact that the content of my responses may be reported, anonymously, in the study's published outputs (e.g., conference paper, research report, journal article, book chapter); (iv) the study's procedures for storage and use of the data collected from the interview in a manner that ensures anonymity and confidentiality of the data; and (v) the steps I can take if I have questions or concerns or feel that I have been harmed by the research. I understand that this is a research project whose purpose is not to benefit me personally.

1. I confirm that I have read and understand the information sheet for the above study and have had the opportunity to ask questions.	Yes	No
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving a reason.	Yes	No
3. I understand that the researcher will not identify me by name in any publications using information obtained from this interview and that any views I express will remain confidential where such confidentiality is required; or	Yes	No
4. I understand that my name will not be explicitly stated in the reporting of data and that any views I express will remain confidential where such confidentiality is required.	Yes	No
5. I agree to a 45-60 minutes interview being audio recorded.	Yes	No

6. I may be contacted post the interview for clarification on any points I made. | Yes | No |

7. I agree to the use of anonymised quotes in any publications. | Yes | No |

8. I agree that data gathered from me in this study may be stored (after it has been anonymised) and may be used for future research. | Yes | No |

_______________________________	____________________	____________________
Name of Research Participant	Signature	Date
_______________________________	____________________	____________________
Name of Researcher	Signature	Date

Appendix D: ICASA approved remote piloted aircraft models

MASTERS RESEARCH REPORT: Investigating the integration of drone management systems to create an enabling remote piloted aircraft regulatory environment in South Africa

APPLICANT NAME	EQUIPMENT MAKE	EQUIPMENT MODEL	TA-NUMBER
TARSUS DISTRIBUTION	DJI	DJI INSPIRE 1 T600	TA-2016/1487
RSK Hobbies CC	DJI	GL300 A/B	TA-2016/547
DRONE WORLD CC	IFLIGHT TECHNOLOGY CO LTD T/A DJI	GL 658 C	TA-2016/1826
DRONE WORLD CC	IFLIGHT TECHNOLOGY CO LTD T/A DJI	W323B	TA-2016/1809
DRONE WORLD CC	IFLIGHT TECHNOLOGY CO LTD T/A DJI	W322A	TA-2016/1811
DRONE WORLD CC	IFLIGHT TECHNOLOGY CO LTD T/A DJI	T601	TA-2016/1810
ORMS CC	DJI TECHNOLOGY	GL200A, GL200B	TA-2016/2589
DRONE WORLD CC	DJI INSPIRE	DJI INSPIRE 2 (T650A)	TA-2016/3188
ODIEART CC	ST DJI TECHNOLOGY CO. LTD	GL200A, GL200B, MIP, MIQ	TA-2016/3427
ODIEART CC	ST DJI TECHNOLOGY CO. LTD	GL6D10A, GL6D10B, T650A, T650B	TA-2016/3426
DRONE WORLD CC	DJI	GL658B	TA-2017/1057
ODIEART CC	SZ DJI TECHNOLOGY CO. LTD	GIS	TA-2017/1061
DRONE WORLD CC	Iflight Technology	MM1A	TA-2017/1357
DRONE WORLD CC	Iflight Technology	SPARK REMOTE	TA-2017/1356
IFIX REPAIR SPECIALISTS (PTY) LTD T/A WEFIX	SZ DJI TECHNOLOGY CO., LTD	G1S	TA-2017/1495
RSK HOBBIES CC	DJI TECHNOLOGIES	WM331A, WM331B	TA-2017/2300
RSK HOBBIES CC	DJI TECHNOLOGIES	M1P, M1Q	TA-2017/2299
RSK HOBBIES CC	DJI TECHNOLOGIES	MM1A, MM1B	TA-2017/2298
ODIEART CC	SZ DJI TECHNOLOGY CO. LTD	UIIX, UIIXI	TA-2017/3456
RECTRON PTY LTD	SZ DJI TECHNOLOGY CO., LTD	MM1A, MM1B	TA-2018/1101
RECTRON PTY LTD	SZ DJI TECHNOLOGY CO., LTD	M1X, M1Z	TA-2018/1102
RECTRON PTY LTD	SZ DJI TECHNOLOGY CO., LTD	G1P	TA-2018/1103

RECTRON PTY LTD	SZ DJI TECHNOLOGY CO., LTD	OM160	TA-2018/2418
RECTRON PTY LTD	SZ DJI TECHNOLOGY CO., LTD	G1S	TA-2018/1104
RECTRON PTY LTD	SGS-CSTC STANDARDS TECHNICAL SERVICES CO., LTD	M1P, M1Q	TA-2018/1105
RECTRON PTY LTD	SZ DJI TECHNOLOGY CO., LTD	RM-10	TA-2018/1107
RECTRON PTY LTD	SZ DJI TECHNOLOGY CO., LTD	T650A, T650B	TA-2018/1108
RECTRON PTY LTD	SZ DJI TECHNOLOGY CO., LTD	U11X, U11X1	TA-2018/1109
RECTRON PTY LTD	SGS-CSTC STANDARDS TECHNICAL SERVICES CO., LTD	WM332A, WM332B	TA-2018/1110
RECTRON PTY LTD	SHENZHEN MORLAB COMMUNICATIONS TECHNOLOGY CO., LTD	RM-6	TA-2018/1111
CCD TECHNOLOGIES (PTY) LTD	SZ DJI TECHNOLOGY	T600	TA-2017/3119
IFIX REPAIR SPECIALISTS (PTY) LTD T/A WEFIX	SZ DJI TECHNOLOGY CO., LTD	G1P	TA-2017/3429
IFIX REPAIR SPECIALISTS (PTY) LTD T/A WEFIX	SZ DJI TECHNOLOGY CO., LTD	OAS1	TA-2017/3427
HART MEDIA (PTY) LTD	DJI	T601	TA-2018/819
HART MEDIA (PTY) LTD	DJI	GL 658C	TA-2018/818
THE CORE BUILDING COMPUTER BUSINESS (PTY) LTD	SZ DJI OSMO TECHNOLOGY CO., LTD	MM1A, MM1B	TA-2018/1252
THE CORE BUILDING COMPUTER BUSINESS (PTY) LTD	SZ DJI OSMO TECHNOLOGY CO., LTD	M1P, M1Q	TA-2018/1251
THE CORE BUILDING COMPUTER BUSINESS (PTY) LTD	SZ DJI OSMO TECHNOLOGY CO., LTD	U11X, U11X1	TA-2018/1249
HART MEDIA (PTY) LTD	DJI	T600	TA-2018/960
RECTRON PTY LTD	DJI	M210 RTK V2, M200 V2, M210 V2	TA-2019/2586
PACSYS (PTY) LTD	SZ DJI	MG-IP (3WWDSZ-10016)	TA-2018/2980

THE CORE COMPUTER BUSINESS (PTY) LTD	SZ DJI TECHNOLOGY	DJI RM500	TA-2018/3588
ORMS CC	DJI	L1PA	TA-2018/3428
ORMS CC	DJI	L1ZA	TA-2018/3427
TELEEYE SOUTH AFRICA	DJI ENTERPRISE	WM334R	TA-2018/3577
TELEEYE SOUTH AFRICA	DJI ENTERPRISE	L1ZE	TA-2018/3578
CAPI LUX SA	DJI	TLW004, TLW004A	TA-2018/3743
RECTRON (PTY) LTD	DJI	L1DE	TA-2019/1344
SKYSALES (PTY) LTD	SZ DJI TECHNOLOGY CO., LTD	GL900A	TA-2019/373
TRISTAN EXPORT (PTY) LTD	DJI	T650A	TA-2019/1407
THE CORE COMPUTER BUSINESS (PTY) LTD	SZ DJI OSMO TECHNOLOGY CO., LTD.	OF100	TA-2019/1208
WANTECH ELECTRONICS	XINYU ELECTRONICS	DJI Matrice 200 SERIES M200, M210, M210RTK	TA-2019/1184
TRISTAN EXPORT (PTY) LTD	DJI	GL6D10A	TA-2019/1388
PACSYS (PTY) LTD	DJI	3WWDZ-15A (AGRAS T16)	TA-2019/1514
TRISTAN EXPORT (PTY) LTD	DJI	CS785	TA-2019/1436
RECTRON PTY LTD	DJI	OK100	TA-2020/093
ORMS CC	DJI	T601	TA-2016/903
ORMS CC	DJI	WM330A	TA-2016/908
ORMS CC	DJI	W323B	TA-2016/909
IFIX REPAIR SPECIALISTS (PTY) LTD t/a IFIX	Phantom 4	WM330A	TA-2016/1458
IFIX REPAIR SPECIALISTS (PTY) LTD t/a IFIX	PHANTOM 3	W321	TA-2016/1456
IFIX REPAIR SPECIALISTS (PTY) LTD t/a IFIX	PHANTOM 3 ADVANCED	W322A	TA-2016/1455
INTERFOTO CC	GUANGDONG CHEERSON HOBBY TECHNOLOGY	CX-32	TA-2016/1372
INTERFOTO CC	GUANGDONG CHEERSON HOBBY TECHNOLOGY	CX-35	TA-2016/1373
KHABARIA CRESCENT 808 PROJECTS PTY LTD	DJI	AG012	TA-2016/1352

KHABARIA CRESCENT 808 PROJECTS PTY LTD	DJI	GL 658 C	TA-2016/1351
SINGER PHOTOGRAPHIC SERVICES PTY LTD	PARROT SA	PARROT DISCO	TA-2016/1637
SINGER PHOTOGRAPHIC SERVICES PTY LTD	PARROT SA	SWING	TA-2016/1636
SINGER PHOTOGRAPHIC SERVICES PTY LTD	PARROT SA	MAMBO	TA-2016/1635
HOMEMARK	KOOME CRAFTS & TOYS	K300, K300C, K300C-H,,,	TA-2016/2350
DRONEWORLD (PTY) LTD	SZ DJI TECHNOLOGY CO	WM330A (PHANTOM 4)	TA-2016/1974
PINNACLE MICRO (PTY) LTD	SHENZHEN ZERO-TECH UAV LIMITED	UA3500	TA-2016/1967
VERSUS TECHNOLOGY	GOPRO INC	KWST1 (GOPRO / KARMA)	TA-2016/2559
RSK HOBBIES CC	DJI	WM330A	TA-2016/2368
OPTRON (PTY) LTD	SnseFly	eBee	TA-2016/2579
IFIX REPAIR SPECIALISTS (PTY) LTD T/A WEFIX	DJI	GL200A, GL200B	TA-2016/2808
IFIX REPAIR SPECIALISTS (PTY) LTD T/A WEFIX	DJI	MAVIC PRO M1P, M1Q	TA-2016/2879
MAC AFRICA COMPUTERS CC	SZ DJI TECHNOLOGY	DJI INSPIRE 2	TA-2017/196
MAC AFRICA COMPUTERS CC	SZ DJI TECHNOLOGY	DJI MAVIC PRO	TA-2017/197
DRONE WORLD CC	DJI	GL658B	TA-2017/1057
ARTIF X DISTRIBUTORS	GUANGDONG MEIJIAXIN INNOVATIVE TECHNOLOGY CO	JD168, JDX6, JYX5, Z1	TA-2017/800
IFIX REPAIR SPECIALISTS (PTY) LTD T/A WEFIX	DJI	WM331A, WM331B	TA-2017/863
IQ LASER (PTY) LTD	SENSEFLY	eBee GROUND MODEM	TA-2017/658
STYLCO (PTY) LTD	IMG ELECTRONICS LTD	MQUAD 1100 CAM	TA-2017/1198
TEVO (PTY) LTD	Shenzhen Hubsan Technology	H502C	TA-2017/1053
TEVO (PTY) LTD	Shenzhen Hubsan Technology	H501A	TA-2017/1054

TEVO (PTY) LTD	Coolerstuff Co, Ltd	D61	TA-2017/1377
DRONE WORLD CC	Iflight Technology	MM1A	TA-2017/1357
IFIX REPAIR SPECIALISTS (PTY) LTD T/A WEFIX	SZ DJI TECHNOLOGY CO., LTD	MM1A, MM1B	TA-2017/1496
iFix Repair Specialists (Pty) Ltd t/a Wefix	DJI Goggles	G1S	
iFix Repair Specialists (Pty) Ltd t/a Wefix	Spark	MM1A,MM1B	
INTEL SOUTH AFRICA CORPORATION	INTEL DEUTSCHLAND GmbH	INTEL FALCON 8+	TA-2017/2871
INTEL SOUTH AFRICA CORPORATION	INTEL DEUTSCHLAND GmbH	intel cockpit ground control station	TA-2017/2870
The New Just Fun Group (Pty) Ltd - Just Fun Toys	Spin Master Toys	6037679	TA-2017/1949
The New Just Fun Group (Pty) Ltd - Just Fun Toys	Spin Master Toys	6037691	TA-2017/1948
The New Just Fun Group (Pty) Ltd - Just Fun Toys	Spin Master Toys	6040078	TA-2017/1946
ACTION CAMERAS (PTY) LTD	IFLIGHT TECHNOLOGY CO. LTD T/A DJI	DJIP4P	TA-2017/2090
ACTION CAMERAS (PTY) LTD	IFLIGHT TECHNOLOGY CO. LTD T/A DJI	DJIM600	TA-2017/2184
ZT IMPORT & EXPORT	-	DJI MAVIC PRO	TA-2017/1954
ACTION CAMERAS (PTY) LTD	IFLIGHT TECHNOLOGY CO. LTD T/A DJI	DJI SPARK	TA-2017/2506
ACTION CAMERAS (PTY) LTD	IFLIGHT TECHNOLOGY CO. LTD T/A DJI	DJI MAVIC PRO	TA-2017/2505
ACTION CAMERAS (PTY) LTD	IFLIGHT TECHNOLOGY CO. LTD T/A DJI	DJI MATRICE 210 RTK	TA-2017/2507
PACSYS (PTY) LTD	DJI	AGRAS MG-1S (DLG60A)	TA-2017/2412
ARTIF X DISTRIBUTORS	SHENZHEN BRITFULL INDUSTRIAL CO LTD	JD168, JDX6, JYX5, Z1	TA-2017/2526
TELEEYE SOUTH AFRICA	DJI ENTERPRISE	DJI INSPIRE 1V2	TA-2017/2877
TELEEYE SOUTH AFRICA	DJI	DJI MATRICE 200 SERIES M200, M210 , M210RTK	TA-2018/106
TELEEYE SOUTH AFRICA	DJI ENTERPRISE	DJI LIGHTBRIDGE 2	TA-2018/237
IFIX REPAIR SPECIALISTS (PTY) LTD	SZ DJI TECHN	K80, K90, K100, K130	TA-2017/3322
NEUX ELECTRONICS	RC DRONE	BX5SW, BX5, BX8, BD6	TA-2017/3038

THIRD WAVE DISTRIBUTION (PTY) LTD	DRONE AIRCRAFT	X5UW, X15W (720P), X5C, X4	TA-2018/2837
OPTRON (PTY) LTD	SENSEFLY	EBEE PLUS	TA-2017/2810
Global Concept Group Asia (Pty) Ltd	DJI	Mavic Air	TA-2017/2897
TELEEYE SOUTH AFRICA	DJI ENTERPRISE	DJI PHANTOM 4 PRO & OBSIDIAN VERSION WM331A, WM331B	TA-2017/3306
TELEEYE SOUTH AFRICA	DJI ENTERPRISE	DJI INSPIRE 2 T650	TA-2017/3189
ACTION CAMERAS (PTY) LTD	IFLIGHT TECHNOLOGIES CO. LTD T/A DJI	DJIM210	TA-2018/292
ACTION CAMERAS (PTY) LTD	IFLIGHT TECHNOLOGIES CO. LTD T/A DJI	DJIM200	TA-2018/3221
RECTRON PTY LTD	SZ DJI TECHNOLOGY CO., LTD	MM1A, MM1B	TA-2018/1101
RECTRON PTY LTD	SGS-CSTC STANDARDS TECHNICAL SERVICES CO., LTD	M1P, M1Q	TA-2018/1105
RECTRON PTY LTD	SZ DJI TECHNOLOGY CO., LTD	RM-10	TA-2018/1107
RECTRON PTY LTD	SZ DJI TECHNOLOGY CO., LTD	T650A, T650B	TA-2018/1108
RECTRON PTY LTD	SZ DJI TECHNOLOGY CO., LTD	U11X, U11X1	TA-2018/1109
RECTRON PTY LTD	SHENZHEN MORLAB COMMUNICATIONS TECHNOLOGY CO., LTD	RM-6	TA-2018/1111
ACTION CAMERAS (PTY) LTD	IFLIGHT TECHNOLOGIES CO. LTD T/A DJI	DJI PHANTOM 4 ADVANCED	TA-2018/493
ACTION CAMERAS (PTY) LTD	IFLIGHT TECHNOLOGIES CO. LTD T/A DJI	DJI MAVIC AIR U11X, U11X1	TA-2018/486
ACTION CAMERAS (PTY) LTD	IFLIGHT TECHNOLOGIES CO. LTD T/A DJI	TELLO TLW004, TLW004A	TA-2018/487
CSRS TRADERS CC	REMAX	H235, Z1+, LH-X25G-WF720P, M39G	TA-2018/783
HART MEDIA (PTY) LTD	DJI	T601	TA-2018/819
ORMS CC	DJI	U11X	TA-2018/834
ORMS CC	DJI	T650A	TA-2018/833
ORMS CC	DJI	WM331S	TA-2018/830

ORMS CC	DJI	TLW004	TA-2018/813
ORMS CC	DJI	M1P, M1Q	TA-2018/836
ORMS CC	DJI	MM1A	TA-2018/835
PRIMATOY AND LEISURE TRADING (PTY) LTD	SILVERLIT TOYS MANUFACTORY LTD	84807	TA-2019/167
PRIMATOY AND LEISURE TRADING (PTY) LTD	SILVERLIT TOYS MANUFACTORY LTD	84820	TA-2019/168
TEVO (PTY) LTD	WOWITEC	H4816S	TA-2018/1140
SINGER PHOTOGRAPHIC	Parrot	Parrot Anafi	TA-2018/1133
TOOL & PROFFESIONAL SERVICES CC	SHANTOU HELICUTE MODEL AIRCRAFT INDUSTRIAL CO., LTD	H817W, H816HW, H818HW, H809SW	TA-2018/2254
TELEEYE SOUTH AFRICA	DJI ENTERPRISE	DJI MATRICE 600 PRO	TA-2018/1417
WATER BERRY TR 12 CC T/A TOYS N ALL	KOOME CRAFTS & TOYS CO., LTD	UJ99-XXXXX	TA-2018/1590
TELEEYE SOUTH AFRICA	FLIR SYSTEMS	DJI MATRICE 100	TA-2018/1509
TELEEYE SOUTH AFRICA (PTY) LTD	FLIR	FLIR E5 WIFI, E8 WIFI, C3	
Global Concept Group Asia Pty Ltd	DJI	DJI Mavic 2 Pro	TA-2018/1899
Global Concept Group Asia Pty Ltd	DJI	DJI MAVIC 2 ZOOM	TA-2018/1900
AMIC TRADING	NINCO POCKET DRONE	NH90102(8801)	TA-2018/2722
Syntech Distribution (Pty) Ltd	QUADRANT	H818HW, H826HPW, H822HW, H809HW	TA-2018/2239
RECTRON PTY LTD	SZ DJI TECHNOLOGY CO., LTD	DJI MATRICE 600 PRO	TA-2020/091
SMD TECHNOLOGIES (PTY) LTD	SMD TECHNOLOGIES PTY LTD	VK-6001, VK-6003, VK-6004	TA-2018/1960
Global ConceptS Group Asia Pty	DJI TECHNOLOGIES	TLW004, TLW004A	TA-2018/2208
GLOBAL CONCEPT GROUP ASIA PTY	DJI	DJI OM170 / OSMO MOBILE 2	TA-2018/2209
Interfoto CC	Voyage X35 RC Drone	VOY-DRX17, VOY-DRX35	TA-2018/2389
RUGGED SA PTY LTD	HUBSAN INTELLIGENT	H501A	TA-2018/2264
DAHUA TECHNOLOGY SOUTH AFRICA (PTY) LTD	ZHEJIANG	DH-UAV-AIRCRAFT-X820	TA-2018/2194
PACSYS (PTY) LTD	SZ DJI	MG-IP (3WWDSZ-10016)	TA-2018/2980

DRONE WORLD CC	IFLIGHT TECHNOLOGY CO LTD T/A DJI	L1Z, L1ZA	TA-2018/2933
DRONE WORLD CC	IFLIGHT TECHNOLOGY CO LTD T/A DJI	L1P, L1PA	TA-2018/2934
DAHUA TECHNOLOGY SOUTH AFRICA (PTY) LTD	ZHEJIANG	DH-UAV-AIRCRAFT-X1550	TA-2018/2912
THIRD WAVE DISTRIBUTION (PTY) LTD	JUNYI	JY006, JY019	TA-2018/3596
ORMS CC	DJI	L1PA	TA-2018/3428
ORMS CC	DJI	L1ZA	TA-2018/3427
TELEEYE SOUTH AFRICA	DJI ENTERPRISE	WM334R	TA-2018/3577
TELEEYE SOUTH AFRICA	DJI ENTERPRISE	L1ZE	TA-2018/3578
DAHUA TECHNOLOGY SOUTH AFRICA (PTY) LTD	ZHEJIANG DAHUA	DHI-UAV-AIRCRAFT-X1100	TA-2018/3496
MIA SOUTH AFRICA (PTY) LTD	BEIJING FIMI TECHNOLOGY LIMITED	MI DRONE MINI / YKFJ01FM	TA-2018/3672
THIRD WAVE DISTRIBUTION (PTY) LTD	GUANGDONG SYMA MODEL AIRCRAFT INDUSTRIAL CO., LTD	X25PRO	TA-2018/3914
CAPI LUX SA	DJI	TLW004, TLW004A	TA-2018/3743
RECTRON (PTY) LTD	DJI	L1DE	TA-2019/1344
DRONE WORLD (PTY) LTD	DJI	L1DE	TA-2019/172
DRONE WORLD (PTY) LTD	DJI	L1ZE	TA-2019/171
TELEEYE SOUTH AFRICA	DJI ENTERPRISE	DJI MATRICE 200 v2 SERIES M200, M210 and M210RTK	TA-2019/239
ADL TRADING CC	JUNYI TOYS	JY019	TA-2019/636
TRISTAN EXPORT (PTY) LTD	DJI	T650A	TA-2019/1407
TOY KINGDOM PTY LTD	GUANGDONG SYMA MODEL AIRCRAFT INDUSTRIAL CO., LTD	X25PRO	TA-2019/1153
TOY KINGDOM PTY LTD	GUANGDONG SYMA MODEL AIRCRAFT INDUSTRIAL CO., LTD	X26, W1, S5H, X5HW	TA-2019/1154
WANTECH ELECTRONICS	DJI	DJI MATRICE M200, M210 , M210RTK	TA-2019/1973
WANTECH ELECTRONICS	XINYU ELECTRONICS	DJI Matrice 200 SERIES M200, M210, M210RTK	TA-2019/1184

THIRD WAVE DISTRIBUTION (PTY) LTD	GUANDDONG SYMA MODEL AIRCRAFT INDUSTRIAL CO., LTD	Z1	TA-2019/1467
RECTRON (PTY) LTD	DJI	MT1SD25, MT1SD25A	TA-2019/1526
RECTRON (PTY) LTD	SZ DJI	MR1SD25, MR1SD25A	TA-2019/1525
UAV & DRONE SOLUTIONS (PTY) LTD	BEIJING PINECONE ELECTRONICS	HERELINK HX4-06074, HX4-06075	TA-2019/1546
TEVO (PTY) LTD	IMG	X9	TA-2019/1702
THE CORE COMPUTER BUSINESS (PTY) LTD	SZ DJI OSMO	DJI MAVIC MINI, MT1SD25/MT1SD25A	TA-2019/1924
LEICA GEOSYSTEMS SOUTHERN AFRICA (PTY) LTD	WINGTRA AG	WINGTRAONE	TA-2019/2617
NTSU AVIATION SOLUTIONS (PTY) LTD	SKYLLE	SKYLLE (1550+SG)	TA-2019/2534
IQLASER (PTY) LTD	QUANTUM SYSTEMS	Trinity	TA-2020/073

CompanyName	**Equipment Name**	**Equipment Model**	**TA/TE Number**
Khabaria Crescent 808 P	DJI Aircraft Drone - Mavic 2 Enterprise	L1ZE	TA-2019/5577
Avicomply (Pty) Ltd	DJI MATRICE 100 DRONE	M100	TA-2019/5664
Avicomply (Pty) Ltd	DJI	Mavic 2 Enterprise Dual - L1DE	TA-2020/5005
Avicomply (Pty) Ltd	DJI	DJI Mavic 2 PRO - L1PA	TA-2020/5029
Avicomply (Pty) Ltd	DJI	DJI Mavic Mini MT1SD25, MT1SD25A	TA-2020/5004
DG COMPLIANCE GURU	DJI	DJI MAVIC AIR 2 - MA2UE1N, MA2UE3W	TA-2020/5536
DG COMPLIANCE GURU	DJI	DJI RC231, RC231A	TA-2020/5317
Khabaria Crescent 808 P	DJI Smart Controller Enterprise	RM500-ENT	TA-2020/5487
DG COMPLIANCE GURU	DJI	WM331S, WM331S1	TA-2020/5925
DG COMPLIANCE GURU	DJI	GL300L, GL300P	TA-2020/5979
TeleEye	DJI	Matrice 300 RTK	TA-2020/6068
TeleEye	DJI	GL900A	TA-2020/6083
TeleEye	DJI Smart Controller Enterprise	RM500-ENT	TA-2020/6142
DG COMPLIANCE GURU	DJI OM 4 GIMBAL	OK100	TA-2020/6415
PACSys (Pty) Ltd	DJI	Phantom 4 RTK	TA-2020/7174
DG COMPLIANCE GURU	DJI	DJI RSC 2, P10	TA-2020/7064
DG COMPLIANCE GURU	DJI	DJI RS 2, P02	TA-2020/7065
DG COMPLIANCE GURU	DJI	DJI WV-001	TA-2020/7053
DG COMPLIANCE GURU	DJI	DJI OT-213	TA-2020/7051

DG COMPLIANCE GURU	DJI	DJI POCKET 2, OT-212	TA-2020/7058
Rectron Limited	DJI Mavic Mini 2 Camera Drone	MT2PD	TA-2020/7394
Rectron Limited	DJI RONIN SC2 Camera Bracket	P10	TA-2020/7223
Rectron Limited	DJI POCKET 2 COMBO - DJI RS 2	P02	TA-2020/7251
DG COMPLIANCE GURU	DJI	MT2PD	TA-2020/7316
Khabaria Crescent 808 P	DJI Smart Controller Enterprise	RM500-ENT	TA-2020/7286
DG COMPLIANCE GURU	DJI DRONE	FDIW4K, FDIW4KA	TA-2020/7767
DG COMPLIANCE GURU	DJI GOGGLES V2	FGDB28, FGDB28A	TA-2020/7763
DG COMPLIANCE GURU	DJI REMOTE CONTROLLER	FC7BGC, FC7BGCA	TA-2020/7766
Rectron Limited	DJI	Matrice 300 RTK	TA-2020/7852
Rectron Limited	DJI FPV Drone	FD1W4K , FD1W4KA	TA-2020/8153
Rectron Limited	DJI FPV Goggles V2	FGDB28 , FGDB28A	TA-2020/8149
Rectron Limited	DJI FPV Remote Controller 2	FC7BGC , FC7BGCA	TA-2020/8148
Timber Trend International PTY Ltd	Under Water Drone	Titan	TA-2019/5011
Khabaria Crescent 808 P	DJI Aircraft Drone - Mavic 2 Enterprise	L1ZE	TA-2019/5577
Khabaria Crescent 808 P	DRONE	M200 V2, M210 V2, M210 RTK V2	TA-2019/5440
Avicomply (Pty) Ltd	DJI MATRICE 100 DRONE	M100	TA-2019/5664
HKDC AFRICA (PTY) LTD	UAV - ROTARY DRONE	MD4-1000	TA-2020/5519
HKDC AFRICA (PTY) LTD	UAV - ROTARY DRONE	MD4-1000	
Tevo Pty Ltd	Drone (Quadcopter)	LM06, 1807	TA-2020/6715
Rectron Limited	DJI Mavic Mini 2 Camera Drone	MT2PD	TA-2020/7394
DG COMPLIANCE GURU	DJI DRONE	FDIW4K, FDIW4KA	TA-2020/7767
Rectron Limited	DJI FPV Drone	FD1W4K , FD1W4KA	TA-2020/8153

Appendix E: Interview guide

MASTERS RESEARCH REPORT: Investigating the integration of drone management systems to create an enabling remote piloted aircraft regulatory environment in South Africa

Introduction **15 min**

The researcher provided a brief overview of Wits University – Link Centre, described the objectives of the research and the description of drones and drone management systems, regulatory compliance, enforcement and sociocultural concerns in the context of this research. Then the participants can ask questions of clarity on the above.

Interview questions **1hr 0min**

RPA regulatory institutions
(1) According to you, how are RPAs regulated in SA? (2) What role does your institution play in the regulation of drones? (3) Is this regulatory system effective for drone usage in SA? (4) Is this regulatory system efficient for drone usage in SA? (5) What is the regulated turnaround time for licensing a drone in SA? (6) How does your institution ensure that society's right to safety and privacy are protected? (7) How does your institution manage and enforce compliance with RPA regulations? (on-air operations) **(8)** Has your institution received any concerns about RPAs from society/general public? (9) What kind of concerns are these and how are these concerns addressed? (10)What information management system does your institution use to regulate RPAs? (11)What is your knowledge of DMS? (12)In your view, is the system used by your institution a DMS and why? (13)Is your institution open to a coregulation approach presented by DMS?

End of Programme

Interview questions **1hr 0min**

Remote piloted aircraft operators and consultants
1. What service do you use the RPA for? 2. Would you consider SA to be a friendly environment for drone usage? 3. Have you registered the RPA with the regulatory institutions? 4. If yes: did you find the regulatory processes easy to comply with and why? (compliance requirements between ICASA and SACAA radio (spectrum) licence and call signs...turnaround times) 5. If no: why have you not complied with the RPA regulations? 6. In your view, what regulatory approach would you recommend for RPA management in SA? 7. How do you ensure that the public's right to privacy is protected from your RPA operations? 8. How do you ensure that the public's right to safety is protected from your RPA operations? 9. What is your knowledge of DMSs? 10. Can DMSs be used in conjunction with PART 101 compliance requirements? if yes, how? and if no, why? 11. How can regulatory institutions and industry benefit from using DMS? 12. What regulatory enforcement agencies does your RPA operations have to comply with? 13. Are you aware of any other enforcement mechanisms used by the regulatory institutions in relation to compliance with RPA regulations?

End of Programme

Interview questions **1hr 0min**

Civil Society
1. What is your view on RPA operated services? 2. Would you consider using a RPA service and for what service? 3. Has there been RPA operations in your area and how do you feel about them? 4. Do you have any concerns related to RPA operated services? 5. Do these concerns deter you from RPA operated services? 6. What is your view on privacy and safety in relation to RPA operations? 7. Would you feel comfortable participating in an event where drones are used? 8. In your view, should RPAs be registered with regulatory institutions and why? 9. Is it important for RPAs providing a service to have an identity and why? 10. Do you know where complaints/concerns relating to RPA operated services are lodged or reported? 11. Do you know of any rules and general guidelines governing the use of drones?

End of Programme