INVESTIGATING THE TECHNOLOGICAL GROWTH OF THE DRONE INDUSTRY IN SOUTH AFRICA

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ABSTRACT

The regulation of drones is a huge challenge for most countries around the world. The regulation and application processes are as much a challenge in South Africa as they are elsewhere. The number of drones is growing at a rapid pace, and there is a need to improve the current status to benefit from the technology. The purpose of this paper is to evaluate the South African drone industry and to propose recommendations to enhance drone technology in South Africa. The research design applied in this paper was qualitative. Data was collected by interviewing drone operators who were interested in participating in this study. This was done to understand the drone approval process in South Africa and the perceptions of drone operators. The results indicated that commercial drone operators are being negatively impacted by the drone approval structure in South Africa and that it is holding the industry back. Key factors affecting the existing drone approval structure were identified and used to propose the strategies for improvement. The findings in this study could assist stakeholders in the South African drone industry to make effective decisions and to formulate policies that would promote the technological growth of the industry.

OPSOMMING

Die regulering van hommeltuie is 'n groot uitdaging vir die meeste lande regoor die wêreld. Die regulering en aansoekprosesse is net so 'n uitdaging in Suid-Afrika as elders. Die aantal hommeltuie groei vinnig, en daar is 'n behoefte om die huidige situasie te verbeter om voordeel te trek uit die tegnologie. Die doel van hierdie artikel is om die Suid-Afrikaanse hommeltuigbedryf te evalueer en om aanbevelings voor te stel om hommeltuigtegnologie in Suid-Afrika te verbeter. Die navorsingsontwerp wat in hierdie artikel toegepas is, was kwalitatief. Data is ingesamel deur onderhoude te voer met hommeltuigoperateurs wat belangstel om aan hierdie studie deel te neem. Dit is gedoen om die hommeltuiggoedkeuringsproses in Suid-Afrika en die persepsies van hommeltuigoperateurs te verstaan. Die resultate het aangedui dat kommersiële hommeltuigoperateurs negatief geraak word deur die hommeltuiggoedkeuringstruktuur in Suid-Afrika en dat dit die bedryf terughou. Sleutelfaktore wat die bestaande hommeltuiggoedkeuringstruktuur beïnvloed, is geïdentifiseer en gebruik om die strategieë vir verbetering voor te stel. Die bevindinge in hierdie studie kan belanghebbendes in die Suid-Afrikaanse hommeltuigbedryf help om effektiewe besluite te neem en om beleide te formuleer wat die tegnologiese groei van die bedryf sal bevorder

1. INTRODUCTION

Drones are also known as unmanned aircraft systems (UAS), unmanned aerial vehicles (UAV), or remotely piloted aircraft systems (RPAS). UAS, UAV, and RPAS will be referred as 'drones' in this paper. The increasing use of drones has led several countries to establish new regulations [1]. A South African Civil Aviation Authority (SACAA) representative stated during an interview with NewzAfrika that the use of drones in South Africa means adapting to developing technology; that drones can reach the same areas as helicopters; and that they can effectively and efficiently do things that helicopters cannot do [2]. Drones are slowly changing how things are done, and offer benefits to various industries such as agriculture, mining, filming, security, and manufacturing. In an interview with SABC News, a United Drone Holdings representative stated that commercial drones are being used in construction, security, agriculture, and as a data collection device, but that, in future, drones will also be involved in deliveries [3].

There are still difficulties in using drones for commercial purposes, but there are ongoing discussions to improve the situation [4]. Drones are poised to become even more significant as technology evolves and as they are applied in creative ways [5]. In July 2018, Absa Bank put on the 'Absa drone light show' in Johannesburg's central business district (CBD), even though it was not approved and did not follow the RPAS Part 101 regulation requirements when running the light show [6]. This indicates that drone companies need to follow many rules before conducting commercial operations, and that some drone companies are still not fully aware of the regulations and laws governing commercial drone operations.

There are many commercial applications in South Africa, but there are few licensed commercial drone operators, which leads to most people ending up operating drones illegally because of the cost and the complex nature of achieving compliance [7]. As a regulator, the SACAA takes up to 6 months to complete the registration process, and 436 operators await Part 101 regulation approval (EE Publisher, 2018). It was reported in 2018 that 27 commercial drone approvals had been issued since the regulation was published in 2015 [6]. In February 2020, an SACAA representative stated that 65 commercial drone operators had been approved [2]. This means that an estimated 38 approvals were issued between 2018 and 2020. Drone technology is developing quickly, and so the SACAA application process is struggling to keep up with this growing technology [8]. These delays affect drone operators who need certificates to fly them commercially, and have a negative impact on the Part 101: Remotely piloted aircraft systems regulation. The technology is developing around the world; and commercial drones are devices that will contribute to the Fourth Industrial Revolution (4IR).

To date, no investigation has focused on improving the existing drone framework in order to keep up with the technological growth of the drone industry in South Africa. Since there is insufficient literature on ways to improve drone-related processes, this paper addresses this gap by investigating the effectiveness of the current drone framework in order to check whether it is sufficient to accommodate the growth of the drone industry in South Africa. Drones are under-researched in South Africa; so, because it is a leading country in Africa, more research in this field should be developed. The research question of this paper is: *Is the existing drone regulation and approval process adequate to keep up with the technological growth of the drone industry in South Africa?*

This paper consists of an introduction, a literature review, the methodology, the results and discussion, and the conclusion and recommendations. In this introduction the background to the study has been presented, focusing on the difficulties facing the drone industry in South Africa. The literature review discusses the literature related to this study, focusing on drone technology, the application of drone technology, the economic impact of drones on the South African market, the challenges to drone technology growth, drone regulation, and the drone approval framework. The section on the research methodology focuses on how the study was conducted, noting that a qualitative research approach was chosen. The primary data was collected via interviews using an established questionnaire to evaluate the drone approval process. In the section on the results and in the discussion that follows, the collected data is analysed and reported. Thereafter the conclusion and recommendations of this paper are presented.

2. LITERATURE REVIEW

2.1. Drone technology

According to Vergouw [49], there are three major developments in drone technology: miniaturisation, autonomy, and swarms. It is evident that drone technology is currently being used and that it will continue

to be used in the future. Drone technology's future developments include drones becoming smaller, lighter, more efficient, and cheaper [49]. The technology is benefiting most countries around the world, including South Africa. Mohsan *et al*. [47] note that a Deloitte report and the 2021 World Economic Forum disclosed that drone technology could be cost efficient for governments to use. These authors add that the implementation of drone technology during Covid-19 could have reduced costs and enhanced vaccine availability in a wide range of circumstances, and have overcome the capital costs of system deployment [47].

According to Shahmoradi [48], drone technology can be an alternative solution for a financially efficient approach. Drone technology is used in various situations for improvements. New models are being developed at a fast pace owing to the increasing popularity of drone technology; so it is difficult to describe every drone model that currently exists [49]. Therefore, it can be agreed that drone technology impacts and will continue to impact the world in various ways. The conclusion of Mohsan *et al*. [47] is that drone technology has 'changed the game' in the aviation sector.

2.2. Applications of drone technology

Tsiamis *et al*. [1] explain that drones have been employed in multiple sectors such as for military, surveillance, recreational, scientific, and research purposes. The authors add that, in some US states, the police use drones for crowd control, at accident scenes, for crime tracing, to monitor crime suspects, and in search-and-rescue operations. Most countries are beginning to employ drones in activities that are fit-for-purpose such as transportation, surveillance, and monitoring. The Korea National Land Information Corporation states that drone use is increasing in various fields in Korea [10], and has announced that it will build a forum to energise the space information industry by using drones and to grow drone-related businesses [10]. In the recent Covid-19 crisis, drones have proven to be the best technology to use in areas such as sanitising processes [11].

Bodecker and Wackwitz [12] advance the opinion that drone applications also include environmental protection, environmental law enforcement, and environmental crime prevention; and drones have been used in Africa to deal with illegal poaching, which threatens the life of animal species. Sandvik [13] states that drones are being used to fight the poaching of elephant and rhino in South Africa, Namibia, Kenya, the Democratic Republic of the Congo, Zambia, Zimbabwe, and Tanzania. Rhino poaching is a huge problem in South Africa, and drone technology is one of the solutions that can be used to mitigate the killing of these animals. In construction, the data generated by drones can be used for planning, to view construction sites for updates, analysis, and site progress monitoring, and to inspect projects [9].

Thus several sectors are starting to integrate drones, and more will follow. Sandvik [13] expresses the view that drones are a game changer for development in Africa, humanitarian aid, 'the war on poaching', and peace keeping. On the other hand, Bodecker and Wackwitz [12] state that drones are very complex devices, and that inappropriate handling could lead to a decline in quality. Figure 1 shows a drone operator flying a drone at a manufacturing plant.

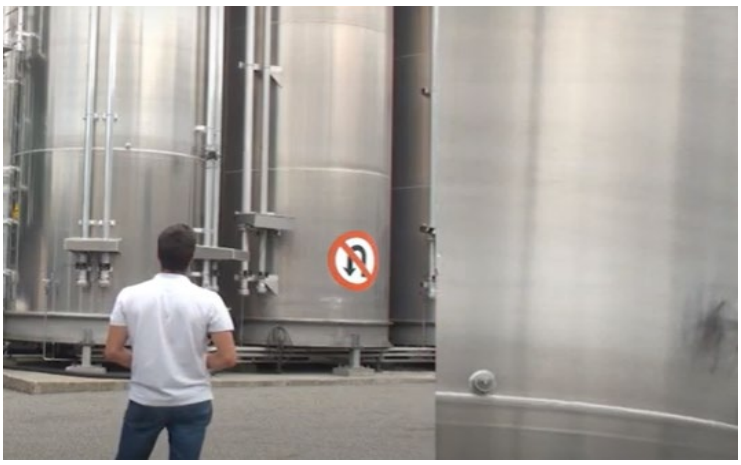

Figure 1: Drone at manufacturing plant [14]

It is difficult to apply drones fully in the manufacturing sector because of the limited space inside factories [15]. However, they can be safely used to inspect factory interiors that people cannot reach because of the buildings' height. According to Deja *et al*. [16], it is still difficult to apply drones practically in a manufacturing environment, and that most drone companies are focusing on applying drones outside, while manufacturing operations mostly happen inside factories.

Raj and Chirputkar [15] state that other sectors are benefitting from the application of drones, but that in the manufacturing sector it is still a challenge. However, drone use is expected to increase in the manufacturing environment in the next 10 years. Maghazei and Netland [17] argue that, in manufacturing, drones could be used to inspect equipment such as pipelines, drums, boilers, and tanks that are installed in high areas and underground in factories.

Table 1 below shows the application of drones in different areas, together with the relevant references.

Table 1: Drone applications and references

Area	Reference
Drones have been employed in multiple sectors such as for military, surveillance, recreational, scientific, and research purposes.	Tsiamis, Efthymiou & Tsagarakis (2019:1)
Drone applications include environmental protection, environmental law enforcement, and environmental crime prevention.	Bodecker & Wackwitz (2017:3)
Drones are being used to fight the poaching of elephant and rhino in South Africa, Namibia, Kenya, the Democratic Republic of the Congo, Zambia, Zimbabwe, and Tanzania.	Sandvik (2015:89)
In manufacturing, drones can be used to inspect equipment such as pipelines, drums, boilers, and tanks that are installed in high areas and underground in factories.	Maghazei and Netland (2019:1243)
The data generated by drones can be used for planning, to view construction sites for updates, analysis, and site progress monitoring, and to inspect projects [9].	DroneVisuals (2019)

2.3. Economic impact of drones on the South African market

The market for drones is slowly growing. A report by IndustryArc [11] found that the market for small drones in South Africa is estimated to reach R2.56 billion by 2025. Botha [18] conducted an economic assessment study of the South African drone industry that indicated that the industry has the potential to generate revenue of R4 billion a year and to create about 46 000 jobs. Botha [18] also suggests that commercial drones in South Africa would create jobs in security, agriculture, surveillance, and construction. In support of Polley [19], Chamata and Winterton [20] explain that drones have created opportunities to boost the economy, and that the industry is projected to generate considerable revenue and many jobs.

In 2018 the Gauteng infrastructure development MEC, Jacob Mamabolo, said that government would use drones to monitor the progress on construction sites in different provinces in the three years that followed, and revealed a project valued at R4.5 billion [21]. Given the above information, it is evident that drones have a positive impact on the South African economy.

There are issues of jobs in South Africa, especially with youth. Thousands of young people do not have jobs, and youth unemployment has increased. Drones are a technology that could contribute significantly to the creation of jobs in South Africa. Ayamga *et al*. [22] argue that drones could attract young people into venturing into agricultural businesses and improve production and farmers' returns on investment.

DroneVisuals [9] argues that drones provide services with highly accurate data and fast turnaround times, and generate data that can be used in areas such as identifying risk and tracking progress and activities. Commercial drones contribute to the economy and create jobs given their ability to integrate technology.

Therefore, it is crucial to ensure that the regulation of commercial drones is effective. Nelson and Gorichanaz [50] assert that there is a lack of research into the regulatory implications of drones and social acceptance. A study by Tsiamis *et al.* [1] found that the existing studies and publications on drones focus on specific groups of countries and on the use of drones for commercial purposes without the relevant legislation.

2.4. Drone technological growth

According to Kim [10], drones provide opportunities in several sectors such as private, government, and public companies. Hodgkinson and Johnston [23] estimate that the number of unmanned aircraft operations – that is, drones – will exceed that of manned aircraft operations in the next twenty years.

The growth of drone technology depends on the availability of capacity and the consistency of the technical components [24]. The authors [24] add that fast growth in the use of drones has already created problems for companies that rely on providing drone hardware solutions for their income. The drones carry out their mission by remote control or on autopilot through the controller, in which wireless communication technology is used [4]. The author [4] explains that wireless communication systems that can be used for civilian drones include the Institute of Electrical and Electronics Engineers (IEEE) 802.11 wi-fi (wireless fidelity) and the global positioning system (GPS). This shows that the growth of drones is evolving the software that is needed to communicate with them and the integration of wi-fi that includes GPS. DJI, one of the largest manufacturers of drones in the world, changed its business structure to focus on the design of third-party apps to increase its revenue [24].Table 2 shows the potential growth areas of the drone market, focused on four areas: entertainment, inspection, managing, and transportation.

Table 2: Potential growth areas of drone market [25]

Up to 2014	2015/2016	2017/2018	2019 onwards
Entertainment	Inspection	Managing	Transportation
Toys	Military	Situational awareness	Online retail
Hobbyists	Public safety	Operations management	Local stores
Aerial photographs	Mining	Asset tracking	Medical

Until the year 2014 drones were mostly used for entertainment. Between 2015 and 2018 drone operators started to employ them to inspection and management. Table 2 indicates that, since the year 2019, drones have been increasingly used in transportation. In Rwanda, for example, drones are used to transport blood to hospitals. Chamata [26] describes drones as devices that have an impact on the economy, technology, and decision making. Drone technology shows how the entire planet is changing and what can be expected from it in the future. Cunliffe *et al.* [27] are of the view that drones will have a positive impact on economies, connecting cities and countries, and that drones will overcome many challenges, such as transportation and lack of infrastructure.

There are no drone manufacturers in South Africa; all of the drones are imported by South African drone companies. This has led to inflated prices for commercial drones in South Africa; their value is based on the software and applications that are developed [30].

2.5. Challenges to growth of drone technology

According to Kim [10], several challenges need to be addressed to support the growth of drone technology. The biggest challenge that most countries experience is the development of drone regulations; a failure to regulate and control drones could lead to social confusion [10]. The challenges that affect the implementation of drone technology in Africa are regulatory, technological, economic, and social [31]. Insurance is required for commercial drone operators to ensure that they can pay for damage in the event of accidents. Some countries allow commercial operations without a licence; but in South Africa, third-

party insurance cover is required for each drone for a minimum of R500 000. South African regulations pose challenges to the development of drone technology in South Africa [31].

According to Kuschke and Cassim [32], it is expensive to start a drone technology company, and it needs high levels of capital. Furthermore, the capital needed depends on the size of the drone company: the larger the company, the more the capital that is needed. B-VLOS operations requirements restrict longer distance operations, which could be the direction in which drone technology needs to grow in South Africa. According to Levush [33], beyond visual line of sight (B-VLOS) operation in South Africa is only allowed with special approval from the Department of Civil Aviation (DCA), based on certain requirements.

2.6. Drone regulation

The drone industry in South Africa has been growing during the past 10 years. Zwickle, Farber and Hamm [51] are of the opinion that it is difficult for a governing body to regulate the fast growth of this new drone technology. Many countries have decided to regulate drones to prevent the risks and dangers associated with this technology, and are developing regulatory frameworks to cope with its growth [27]. The lack of drone regulation is experienced around the world, and each country is trying to regulate to the best of its ability. Drones that are not monitored pose a risk and a threat to air navigation systems and to manned aircraft transport [52].

In South Africa, the SACAA is mandated to regulate drones. The regulation was gazetted in May 2015 as the Eighth Amendment of the Civil Aviation Regulations, Part 101: Remotely Piloted Aircraft Systems, under the Civil Aviation Act No. 13 of 2009. Because of the fast-growing number of drones, the SACAA has established and published regulations to monitor the safety and security of the drone industry [8].

The Part 101 regulations cover various operations, such as visual line of sight (VLOS), beyond visual line of sight (B-VLOS), and restricted visual line of sight (RVLOS). Drone operators are rated according to the type of operation when they are approved or certified to operate a drone. B-VLOS means that a drone operator operates a drone beyond visual line of sight, such that the drone cannot be seen but is monitored via its camera. The B-VLOS zone in South Africa extends to drones with a mass of more than 20 kg. Countries such as Poland, the United Kingdom, China, Canada, and South Africa allow drone companies to fly B-VLOS [28].

Drone operators are required to operate in accordance with the issued licence and the stated requirements for a B-VLOS zone. Flying B-VLOS can be dangerous for the public because the drone operator cannot see the drone with naked eyes. According to the Part 101 regulations, no person shall fly B-VLOS unless approved by the SACAA's director in the company's operations manual [29]. B-VLOS is endorsed on the licence as a rating the pilot has met all of the requirements [29]. Therefore, it is evident that B-VLOS operation is likely to increase the drone market in the future.

2.7. Drone approval process framework

Figure 2 shows the drone approval process, known as the RPAS Part 101: High Level Process. The structure of the approval process indicates the applicable steps according to the type of drone approvals needed by the drone operator.

Commercial, corporate, and non-profit drone operators are also required to apply for a Remote Operator's Certificate (ROC), including its operational specifications. The ROC process involves the five phases of the certification process: pre-application, formal application, documentation evaluation, demonstration, and certification. The five phases are explained below:

a) Phase 1 – Pre-application: applicant makes contact and completes a 'letter of intent'. The applicant is then guided through the entire five-phase process.

b) Phase 2 – Formal application: submission of formal application for commercial operations, and attaching an Air Service Licence (ASL) issued by the Air Service Licence Council.

c) Phase 3 – Documentation evaluation: applicant submits all the required manuals to the SACAA for approval and a thorough review of the manuals. Thereafter it is decided whether or not the applicant complies.

d) Phase 4 – Demonstration: applicant demonstrates ability to operate. The demonstration and inspection phase involves onsite evaluations of documentation according to the regulations and OM.

e) Phase 5 – Certification: application is issued with an ROC, including the operational specifications.

South Africa's drone structure covers Part 101: Regulation and Part 101: High Level Process. To ensure that the rules and processes are followed to complete approval process, South Africa's drone structure should be followed

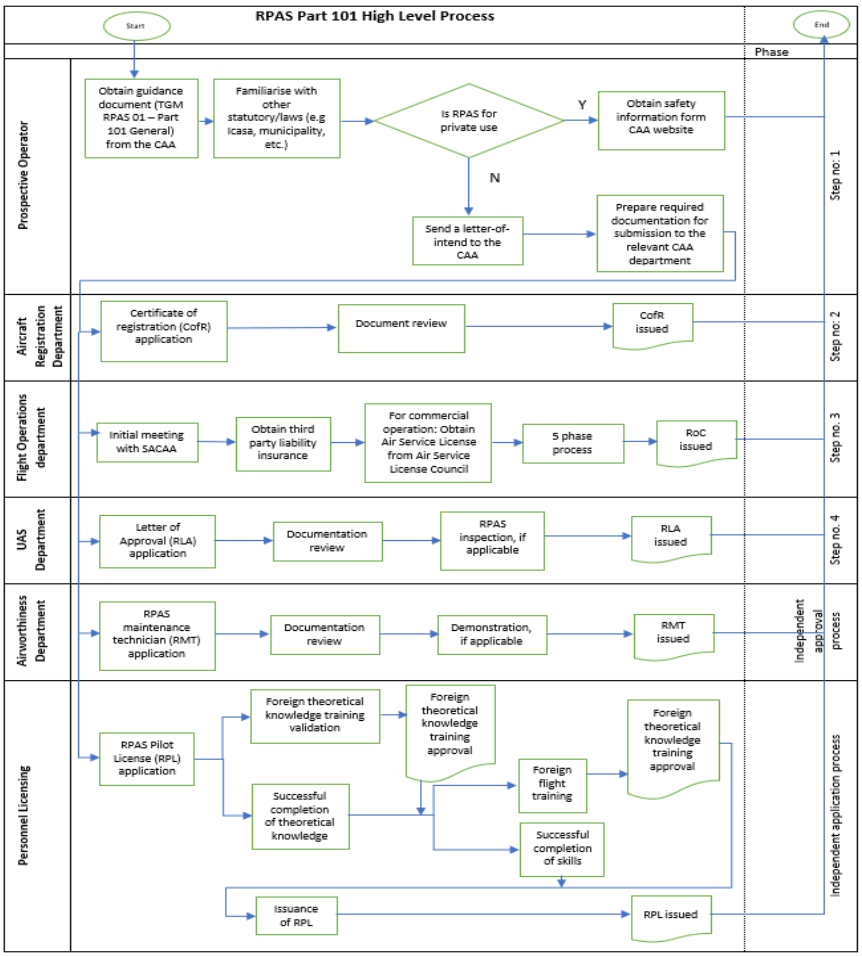

Figure 2: Part 101 high level process for drones

2.8. Elements affecting drone approval process according to the literature

Figure 3 displays the factors affecting the drone application and the regulation process, as identified in the literature. It also summarises the factors identified in this chapter together with the cited references. These are the factors that prevent various countries, including South Africa, from advancing their drone technology. The identified factors are the following:

a) Rapid growth

The rapid growth of the drone industry is impacting most of the countries that need to regulate drones owing to their technology [53]. The drone operators are struggling to control the growing number of drones; thus they encounter difficulties with the drone process and the associated regulations.

b) Increase use of drones

An increase in the use of drones is evident around the world, especially in developed countries. Most countries use drones in a range of applications – and most of the countries struggle to integrate drones into the regulations they have developed [1].

c) Regulatory framework

In most cases, complying with the regulatory frameworks that have been implemented is difficult [54]. Problems include the industry failing to comply with the regulations because of the limiting or stringent requirements that have been enforced, and regulations that are difficult to implement.

d) Slow adoption of regulations

The slow adoption of regulations negatively impacts most countries because drones keep on evolving [23]. Delays in adopting the regulatory framework create gaps in fully regulating this technology.

e) Illegal drone use

In other countries, as well as in South Africa, some drone operators have opted to use commercial drones illegally owing to the stringent requirements to operate drones legally [55]; [22]. This indicates that strong barriers could negatively impact enforcement of the regulations.

f) Ineffective drone regulatory framework

An ineffective drone regulatory framework is one of factors with which most countries struggle. Regulation frameworks are developed without sufficient consultation with members of the drone industry. This usually leads to the adoption of a poor framework [23]; [56]

g) Restrictive regulations and ineffective enforcement

Restrictive regulations and ineffective enforcement have led to most drone operators struggling to comply with the regulations. The regulations prevent some drone operators from meeting the stringent requirements [56]. Poor drone regulation awareness has also led to some of the drone operators being left uncertain about how to follow or comply with the regulations.

h) Manned aircraft requirements

It is difficult for drone operators to meet some of the manned aircraft requirements that other countries have included in their drone regulatory frameworks [23]. Many countries, including South Africa, that have adopted manned aviation regulations experience difficulties in enforcing them. Drones have different designs from those used in manned aviation; therefore, the two should not have the same regulations applied to ensure safety control and monitoring.

i) Lack of drone monitoring

It is essential to monitor the operations of drones through regulation. A lack of drone monitoring may pose a danger to the industry as well as society [57]. Adequate monitoring of drones is vital for the safety of the public.

j) Lack of drone control

Lack of drone control with its sophisticated technology is risky [52]. Therefore, it is important to have adequate regulations that efficiently control the operation of drones.

k) Lack of transparency and exclusion of stakeholders' interests

It is crucial to be transparent and to include the stakeholders when developing regulations. A lack of transparency and the exclusion of stakeholders' interests are some of the factors that render drone regulations inefficient [56]. This usually leads to people being sceptical and unwilling to comply with the regulations owing to insufficient consultation about and awareness of the new regulations. It is always difficult to enforce regulations in the face of resistance from the stakeholders.

l) Strict regulations

Countries with strict regulations are not winning with the regulation of drones. Only a few operators comply; most of the stakeholders do not comply because of burdensome requirements [58].

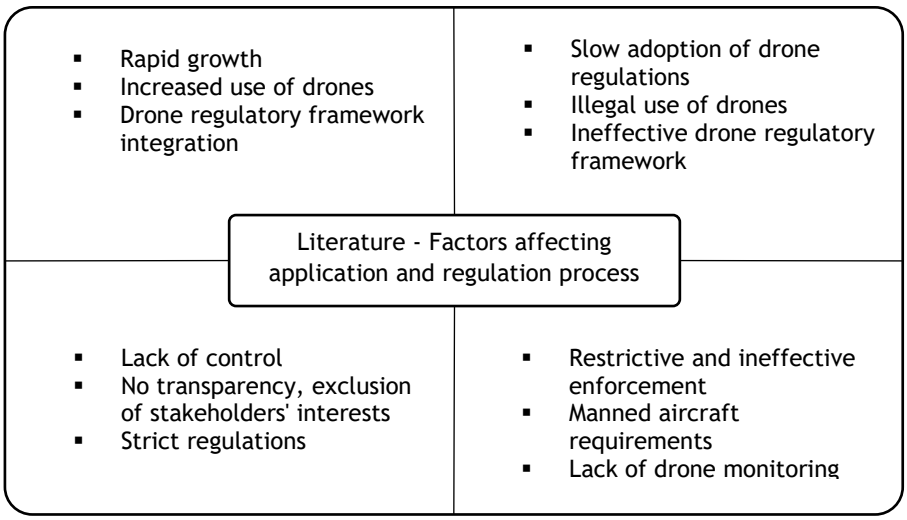

Figure 3: Implementation of application process

3. METHODOLOGY

Ritchie *et al*. [34] describe qualitative research as a naturalistic and interpretative approach that focuses on investigating events within limited boundaries. Guest *et al*. [35] define qualitative research as that which applies methods such as studying participant observations or case studies, leading to descriptive experience or practice. Another advantage of the qualitative research approach is that it allows investigators to apply open-ended questions during interviews [35].

3.1. Sampling and sample size

Mack [36] notes that the quota sampling approach includes a population that is associated with or has insights about the research or study. SACAA inspectors and drone operators are the stakeholders in the drone approval process. As a result, the researchers selected both SACAA inspectors and drone operators to participate in this study. Whitehead and Whitehead [39] argue that there are no formal criteria for determining an ideal sample size in qualitative research. Isaacs [37] gives a 'rule of thumb', that between 12 and 26 participants would be the right sample size for qualitative research, while Creswell and Poth [38] recommend that three to five participants are sufficient for a case study. In the light of these points, a sample of six approved drone operators and six drone operators awaiting approval was selected to participate in this study, totalling 12 drone operators. The sample of SACAA inspectors had six participants. The total number of participants was thus 18. The population of the drone industry at the time of the research was 65 drone companies.

3.2. Data collection

Whitehead and Whitehead [39] define structured interviews as a list of set and open-ended questions that are asked in a certain order. The interview questions were developed and provided to the participants beforehand. The questionnaire that was developed was structured in a certain order, and posed open-ended questions that allowed the participants to express their views freely and to elaborate on them. Clifford *et al.* [40] note that open-ended questions have a number of advantages: participants are not limited during the interview, can articulate their views in their own words, and can express their opinions and feelings. Two set of questionnaires were developed: the Part A set was designed for the drone operators, and the Part B set was for the SACAA inspectors. The drone operators' questionnaire included the company representative's information and experience, the application process, the turnaround time, and the operator's capacity. The SACAA inspectors' questionnaire covered their background, competency, capacity, and process management. The researcher recruited respondents who were interested to participate via telephonic interviews. Kothari [41] defines the telephone interview as a method of collecting data by contacting participants using the telephone. This method was selected owing to Covid-19 restrictions that limited in-person contact with others. The researcher recorded the telephonic interviews, and transcribed the recordings verbatim to avoid any loss of data.

3.3. Data analysis

Qualitative data analysis consists of tallying, coding, and analysis of the text and content of the collected data [34, 42]. The analysis of qualitative data helps to provide insight into the evaluated process [35]. This allows the researcher to interpret and clarify data and to compare common cases for analysis. To provide an understanding of the data, a descriptive approach was applied. The descriptive and interpretative approaches clarify the background of the collected data, what is vital in the analysis, and how it addresses the research question [43].

Thematic analysis (TA) is a method of detecting, analysing, and reporting re-occurrence in data in order to interpret different views of the researched subject matter [44]. TA was chosen because of its flexibility when using the qualitative approach, and because it helped to identify patterns in the data about the respondents' experiences and perspectives in order to understand their views of the SACAA's RPAS approval process.

4. RESULTS AND DISCUSSION

4.1. Results

In this section, the researcher sorts and analyses the collected data, and reports the research findings. A descriptive analysis approach was applied to describe and explain the data. The data was grouped using tables, graphs, and charts for interpretation, clarification, comparison, and understanding. Thirteen drone operators participated in this study. SACAA inspectors did not take part in this study, despite being included in the sample; the reason given by the SACAA was that it had no structure to accommodate applicants but that it would be developed to handle applicants' requests in the future.

Table 2 shows the sample size vs the number of responses received. The interviewees were a mixture of SACAA-approved drone operators and those awaiting approval.

Table 3: Sample size and responses

Participant	Company's participant	Sample size	Number received
SACAA-approved	P3, P4, P5, P6, P7, P9, P11, P12	6	8
Awaiting approval	P1, P2, P8, P10, P13	6	5
SACAA inspectors	0	6	0

Eight responses were received from SACAA-approved drone operators, exceeding the sample size by two. The researcher decided to accept the two extra respondents to strengthen the validity of the results. The final number of responses from drone operators awaiting approval was five – one less than the required sample size. Figure 4 presents the results obtained about perceptions of the implementation of the application process.

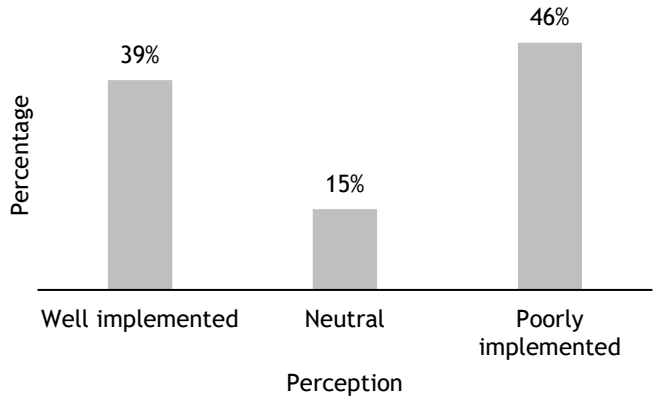

Figure 4: Application process implementation

Of the respondents, 39% believed that the current approval process was well implemented. The opinion of P2, P3, and P11 was that it was a good structure for the drone application process in South Africa, while 46% were of the view that the application process was poorly implemented. The participants thought that the process had problems with its administration and that there was a lack of resources. Fifteen per cent responded that it was neither well implemented nor poorly implemented, but agreed that it was a conservative and relevant process. The results suggest that most of the participants did not support the South African drone application process. This implies that the growth of drone technology in South Africa is at risk.

Figure 5 presents the participants' views of the structure of the application process in South Africa's drone industry, and indicates whether or not the application process had a positive outcome.

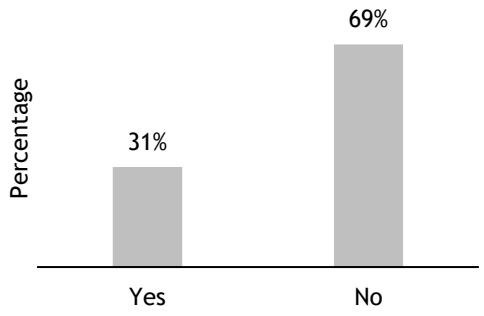

Figure 5: Application process structure: participants' perspectives

Of the respondents, 31% stated that the application process structure had a positive outcome. P10 and P11 mentioned that they supported the structure because drones needed to be regulated and because it allowed for legal operation to take place. Sixty-nine per cent of the participants stated that the application process structure did not bring a positive outcome to the South African drone industry. Some of the reasons for this view were that it was a frustrating process, that it favoured a certain class of people, and that the SACAA had failed to police illegal commercial operations. Based on the majority view, the current application process structure does not constitute a positive outcome. This has led some of the drone operators to break the law in avoiding compliance with the regulations. Table 4 presents the changes suggested by the participants.

Table 4: Participants' proposed changes

Participant	Proposed changes
P1	Change paper-based approach to digital system. Reduce number of payments. Streamline some of the processes.
P2	Train SACAA personnel to be effective.
P3	Improve ASL and SACAA turnaround time.
P4	Remove ROC, ASL, and RLA processes. Keep RPL and enhance registration process.
P6	Ease the regulation requirements. Make it accessible for young entrepreneurs to join the industry.
P7	Insurance should also insure drones that are not licensed. Allow drones to fly without radio requirements.
P8	Increase personnel.
P9	Remove ROC step
P10	Remove re-registration of aircraft/drone step. Reduce unnecessary costs.
P12	Improve the requirements so that they focus on drones and exclude requirements related to manned aircraft.
P13	Provide training to SACAA personnel.

The participants offered different ideas that could be used to improve the existing drone application process. These were noted, and some were found to be common to several of the participants. Participants P2 and P13 made the same proposal, that the SACAA should improve the training of its personnel. Removal of some of the steps from the application was proposed by participants P4, P9, P10, and P12. The remaining participants made individual proposals that were not made by the others. Based on the proposed changes, it is evident that numerous factors contribute to the failure of the drone approval process. In the light of the changes proposed by the participants (identified above) and the reviewed literature, the application process and the regulations restrict the growth of the drone industry and economic growth. There is a need to accommodate these proposals to save the drone industry. Figure 6 shows the percentage of ROCs issued to date (2023).

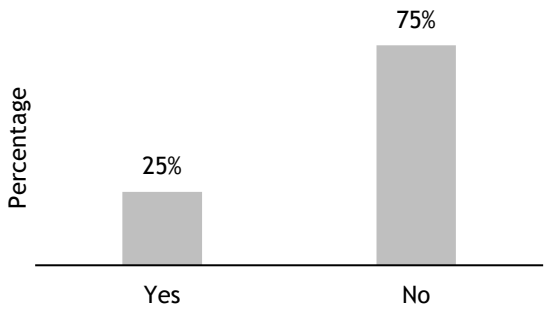

Figure 6: ROCs issued to date (2023)

Twenty-five per cent of the participants stated that SACAA had issued enough ROCs so far; of them, P7 said that it was sufficient. Seventy-five per cent of the participants said that the SACAA had not issued enough ROCs so far. The majority of the participants stated that, since the regulations had been gazetted in 2015, the SACAA had not issued enough ROCs and that the applications had continued to accumulate. This suggests that South Africa lags behind other countries in issuing commercial drone approvals. It also shows that only

a few drone companies are benefitting, while others wait for approval to operate commercially. This implies that the delays currently benefit drone companies that are SACAA-approved because the market competition is lower.

Table 5 presents the participants' ratings of the RPAS Part 101 regulations.

Table 5: RPAS Part 101 regulations ratings

Participants	RPAS Part 101 regulations ratings	n (%)
P1, P3, P4, P12, P13	1 – Bad	5 (42)
P2, P6, P9	2 – Fair	3 (25)
P7, P8, P10, P11	3 – Good	4 (33)

Of the participants, 42% rated the regulations 'bad'; 25% rated them 'fair'; and 33% rated them 'good'. Most of the participants were of the view that South Africa's drone regulation enforcement is bad because it is too strict to be complied with. Some of the participants stated that the regulations were good because they allowed safe operation. This addresses the research question about the factors affecting the management of the drone application process and the regulations, and their impact on the growth of drone technology in South Africa.

Figure 7 provides insight into the total cost required to start a drone technology business.

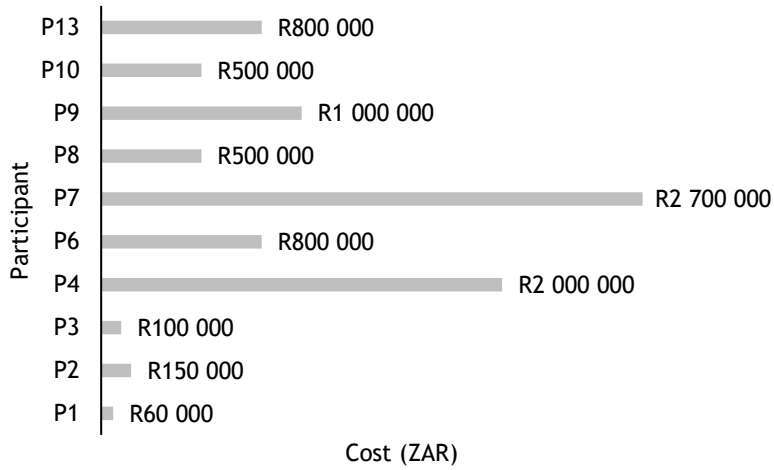

Figure 7: Total cost to start drone technology business

The results show that the participants spent different amounts to start a drone technology business. The minimum amount spent was R60 000, and the maximum was R2 700 000. Sixty per cent of the participants spent less than R500 000 to start their business; 20% spent between R500 000 and R1 000 000; 10% used about R1 500 000; and another 10% spent R2 700 000 to operate and run a full business. The previously disadvantaged class would struggle to participate in this business because of its high cost. This indicates that only big businesses with stable finances can sustain a drone technology business. The size of the company determines the capital needed to start a drone technology business. The bigger the company, the more money it would need to invest in the business.

4.2. Discussion of results

The findings reveal that, like other countries, South Africa struggles to control the rapid growth in the number of drones. South Africa is not the only country that has concerns about the regulation of drones. The approval process for drones frustrates and discourages drone companies. This shows that the management of the existing process is not good, that the drone industry is not satisfied with the process

[45], and that drone operators do not have confidence in it. The findings from the interviews revealed that all of the participants had experienced long delays. Some of them felt that it was keeping the South African drone industry from growing, that it favoured big companies by enabling them to succeed, that financial entry was too high for small companies, that the regulations were limiting, and that the process forced some drone companies to operate illegally.

The findings also indicate that commercial drone operators are being negatively impacted by South Africa's drone regulation structure and that it is holding the industry back. This situation shows the South African drone industry in a bad light. Other countries benefit from drone technology while South Africa struggles to adapt to the regulation of drones. The findings reveal that the participants preferred that the regulations be amended in order to be suitable for all, because drone operators believe that drones are over-regulated in South Africa. All of the participants said what they thought should be changed in the existing drone approval process and the regulations. Some of the proposed changes were that some of the processes should be digitised, the drone business should be made financially feasible, the regulations should be eased and the high barriers lowered, the manned aircraft requirements should not be adopted, and the training of drone pilots should be improved, along with the process, capacity, and turnaround time. Some of the participants argued that the existing 12-month validity period should be extended, since drone operators are required to renew their licences three months before the expiry date.

The view of the participants was that the process was a waste of time, it was too harsh, and that, if their certificate or licence were not valid, they could not operate. The findings reveal that the SACAA does not meet the three months set for the Turn Around Time (TAT).

Based on the results, this means that the drone industry continues to struggle because of the delays, and that its growth is being held back. Some of the participants' judgement was that the structure does not favour previously disadvantaged groups and young entrepreneurs, also contributing to the impact on the growth of drone technology in South Africa. The cost involved is another factor that limits the growth of the industry. The sentiment about the existing drone structure is that it impacts negatively on the growth of drone technology.

The drone regulators are struggling to control the increased development of drone technology. Furthermore, the lack of drone control and of communication in managing drone technology has negatively impacted the drone industry. Effective process monitoring would ensure that companies met their goals by continually checking the performance of the business process [46].

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

Currently there is a low level of competition in South Africa in the commercial operation of drones. This means that the growth of drone technology is affected by the lack of competition. This situation has led to slow growth in the drone industry and a slow development of innovations. Drones are already part of our lives, and are gradually becoming major contributors to the South African economy. Strategies to improve drone enforcement are needed as the number of drones grows in South Africa.

The growth of drone technology is impacted by highly restrictive regulations, the slow issuing of ROCs, the capital needed to enter the drone business, and restrictions on full participation. Furthermore, a robust discussion is still needed with all stakeholders about the development of the drone industry. The government and the South African Drone Council could play a vital role in transforming South Africa's drone industry.

The aim of this paper was to interview both drone operators and the SACAA's drone inspectors. Because the regulator (the SACAA) declined to participate in this study, the investigation was conducted and concluded on the basis of the drone operators' views and the existing literature. The findings in this study could assist stakeholders in the South African drone industry with effective decision making and the formulation of policies that would promote the technological growth of the industry.

The limitations of this study are that it relied on having access to the drone industry and to SACAA inspectors, and that it depended on recruiting participants and on the availability of the participants who had already confirmed that they would participate in this study. The factors stated earlier limited the researcher in achieving this study's objectives and necessary results and in analysing them. Given the non-participation of SACAA inspectors, the research findings were based on the drone operators' views only.

5.2. Recommendations

The recommendations of this study are as follows:

- There is a need to implement strategies that would enhance the growth of drone technology in South Africa.
- The government should intervene to ensure that drone growth is improved in South Africa, because drones contribute to the economy.
- High regulatory barriers should be reduced to allow more participation in drone technology.
- The capital required to enter the drone business should be reduced by engaging all of the stakeholders (the Department of Transport, the SACAA, drone operators, and drone technical committees).
- Other types of regulation, such as a risk-based approach, should be considered by engaging all relevant stakeholders.
- A structure to fund youth and young entrepreneurs should be established to accelerate the growth of drones in South Africa.
- Future work could consider the implementation of continuous improvement tools, such as the Lean Six Sigma technique, for the operational turnaround of the South African drone industry.

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APPENDIX A

Interview questions

Questions to companies with approved commercial drone operators and those who are waiting for SACAA Approval.

a) What is your perception regarding the application process steps?

b) Do you think the application process structure creates positive outcome? Yes/No, why?

c) What changes do you think should be made or proposed for improvement?

d) Since the regulation was gazetted in 2015, do you think SACAA has issued sufficient approval for ROCs?

e) How do you rate the South African regulation process from 1 to 3? 1:Bad; 2:Fair; Good.

f) What is the cost for the completion of drone approval process?