THE USE OF DRONE TECHNOLOGY TO EVALUATE AND REPORT PAVEMENT CONDITIONS IN SOUTH AFRICAN AIRPORTS

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ABSTRACT

Airports in South Africa are required by law to provide adequate maintenance to their pavement infrastructures as to ensure serviceability and operational safety at all times, for the continuity of their business and services. Runways are key facilities on the airport which should be maintained at times. In recent years, drone technology as a tool in the project life cycle has gained recognition by the civil engineering industry locally and internationally, as a potential technique that can be used by airport industry to aid the maintenance of its pavement infrastructure.

This research paper explores the possibility of introducing drones to the airport environment to aid the inspection and maintenance of airport pavements. The aim is to test the willingness of the industry to adopt the drone technology in the South African airport and to explore the approaches currently used for runway pavement maintenance. This was done by designing a survey questionnaire to be administered to selected participants that are based in 20 major airports in South Africa. The outcome of this research study will assist in the airport facilities environment to carry out scheduled pavement inspections on the airport in a speedy manner.

Keywords: Drone technology, survey questionnaire, airport pavement maintenance, South African Airports.

1. INTRODUCTION

In general, the current practice of airport pavement maintenance in SA involves the walk by technical personnel along a particular section of the airport pavement to gather information on possible distresses and defects that might have developed since the last inspection. Drone technology is perceived as a potential inspection alternative which can replace the traditional process more efficiently. Besides, with the increase of air traffic and aircraft axle loading, the traditional approach might be challenging in future in terms of time required to do the inspection, data recording, and processing before a sound maintenance decision can be made. As far as cost is considered, any new technology, e.g., drone inspection alternative, should be economically justifiable as compared to current available alternatives, however, accurate data in this regard is rare or does not exist.

This research study when implemented seeks to improve the current conventional method of conducting airport pavement inspections. The current practice in the South African airport environment is to inspect the pavement infrastructure visually for defects with the aid of a comprehensive inspection checklist by a suitably qualified civil engineer/technician from the Airport Civil Maintenance Section (ACMS).

The defect that will be observed during the on-site inspection is then recorded and fed into the Airport Pavement Management System (APMS) by a system operator using pre-set asset identification codes. The system operator would then generate a Work Order (WO) and a Request for Quotation (RFQ). Both the work order and RFQ mentioned above contain the full details of the defect as well as the recommended maintenance intervention required. This information is used to solicit a supplier or contractor who can carry out the task of repairing the recorded defect.

The envisaged approach of using drone technology when successfully introduced to the SA airport environment can offer a massive improvement to the systematic approach to conducting paved runway inspections by accurately and timeously supplying pavement condition data, which will directly feed on to the APMS from the drone's integrated system. In addition, drone technology can also form part of the asset management of other airport facilities, however, this falls out of the scope of this research. The innovative solution as compared to the current practice can save significantly in terms of time spent on maintenance interventions and therefore improve the level of operations on busy airports in SA. The increased operation through the use of drone technology for runway inspections is expected to have a positive impact on the airport environment in SA. This will allow the airports to better cope with the anticipated higher demand in terms of inspection due to future increase in both domestic and international flights which goes hand-on hand with urgently desired growth of the SA economy. The use of drone technology will ensure that SA keeps abreast with the current developing trends in the aviation environment worldwide.

Temme and Trempler, (2017) stated that "runway inspections should be carried out at least four times per day. Measurement of runway friction should not only be done under dry conditions, but also for slippery and ice conditions. The reason for these inspections to be carried out on a regular basis is the expectation that the runway surface will deteriorate over time and consequently change its characteristics". The South African aviation sector is currently faced with a challenge of innovation, as the current conventional method of conducting visual runway pavement inspections in an airport and the process that informs such method are at times not fully compliant with aviation regulations, as more daily inspections are required from the airport operators by regulatory authorities(SACAA).

According to the South African Civil Aviation Authority (SACAA), the acceptable uses for drones are as follows: For private use, the Remotely Piloted Aircraft Systems (RPAS) may only be used for an individual's personal and private purposes where there is no commercial outcome, interest, or gain and the pilot must observe all statutory requirements relating to liability, privacy, and any other laws enforceable by any other authorities. For all other use, an RPAS must be registered and may only be operated in terms of Part 101 of the South African Civil Aviation Regulations (SACAA, 2017).

The drone technology has been used in many Civil Engineering applications such as road pavement inspections (Schnebele et al., 2015) and bridge inspections (Aliyari et al, 2021). According to Hubbard et al. (2017), opportunities to utilize drones at airports include obstruction analysis, pavement condition assessment and inspection, airfield light inspections, wildlife management, security, emergency response and construction.

Absolon et al. (2015) mentions that, the advantages of the airport operating areas inspection by drones are greater flexibility and saved time.

Most airports worldwide make use of the APMS software to aid their pavement inspection and maintenance interventions. According to Covalt (2008), APMS can be applied at the network and project level. The network level takes into consideration all the pavement assets being managed by an agency. The project level is specific to a given pavement area that has been identified for potential rehabilitation.

This paper is a part of a larger study looking into the development of an innovative solution for the airport operators in South Africa that will augment the current conventional method of obtaining critical data from physical visual infrastructure inspections. The main objectives of this paper are: to evaluate the current practice in SA in terms of runway inspections and maintenance and examine the awareness and appetite of the local aviation industry in terms of drone use as an approach in the South Africa airport maintenance.

Survey questionnaire is used to collect and examine the responses of persons who work in airport maintenance. The results are promising in terms of drones use as a method that can aid runway inspections and maintenance.

2. SURVEY QUESTIONNAIRE

The research strategy used was the analysis of current conventional method of conducting runways' inspections through qualitative research methodology, whereby data was collected using a survey questionnaire administered to airport technical personnel.

The survey questionnaire was sent to airport civil maintenance technical personnel who perform inspection related activities or are part of the maintenance intervention team on that particular airport, and the sample size for this research study was 20 airports in SA. Although all pavements on the airport are critical assets for airport authorities, the focus for the purpose of this research paper will be around runways as they are key assets on the airport. The pre-testing method is applied to the survey questionnaire that was administered to participants, three participants were selected from the sample and these will consist of each represented function within the airport civil maintenance section.

The questionnaire contained a total of twenty-three questions with, eleven of those questions being close-ended questions and the remaining twelve being open-ended questions. The questionnaire was divided into four sections whereby:

- **Section 1:** The first section of the questionnaire was for the participant's information which included biographical information, contact details and the participant's work experience.
- **Section 2:** The operation section, which included questions relating to the number of movements on the runway and the operational procedures for that particular airport.
- **Section 3:** The technical evaluation section, which contains questions that relates to the pavement management systems, technical design and the use of pavement condition indicators as part of assessing their pavement for distresses.
- **Section 4:** The maintenance intervention section, which contains questions relating to the collection and analysis of data, the maintenance intervention thereof and the willingness of the airport to use drones for runway inspections in the nearer future.

As part of the survey, twenty airports were selected as part of the population sample, which were classified as follows:

- **Small:** Airports with runway lengths of 1199 meters and less or not having any scheduled commercial flights and only cater for flying schools.
- **Medium:** Airports with runway lengths between 1200 meters and 2000 meters, catering for scheduled domestic commercial flights or charter flights.
- **Major (large):** Airports with runway lengths of 2000 meters and more, having scheduled international flights and charter flights.

These airports were selected along with 20 participants stationed at each of these airports, the participants were requested to participate in the research study by completing the survey questionnaire. The following criteria was used for the selected sample of participants:

- The participants needed to have worked for a minimum of 1 year in an airport civil maintenance section or project management office.
- The participant needed to have an in-depth knowledge of the airport civil maintenance working procedures.
- The participant needed to be familiar with the inspection procedures in terms of airport civil maintenance.
- The participant needed to have knowledge of the technical design of the airport's runway/s.
- The participant needed to be familiar with the airport's pavement management systems.
- The participant needed to have minimal knowledge of the cost implication for conducting maintenance on the runway.

Due to the involvement of human an ethical clearance was obtained prior to sending out of the questionnaire. The questionnaire as well as the ethical clearance documents were sent to the selected respondents through their email.

3. RESULTS AND DISCUSSION

From the initial sample size of 20 participants, where by a survey questionnaire was administered to all the selected participants, only 14 responses were received from the participants. This meant that 14 airports responded to the study.

3.1 Participants

Figure 1 below represents the distribution in percentage of the category of airports that have responded to the survey and those that did not respond per category.

The response received included the following, zero (0%) response for the small airport, six (43%) response for the medium airports and eight (57%) response for the major airports. The percentages represented by the shaded orange colour indicates the percentages of participants who did not respond to the questionnaire per airport category. The non-response from the survey by the smaller airports may attribute to many factors, e.g. lack of resources, but further investigation is required.

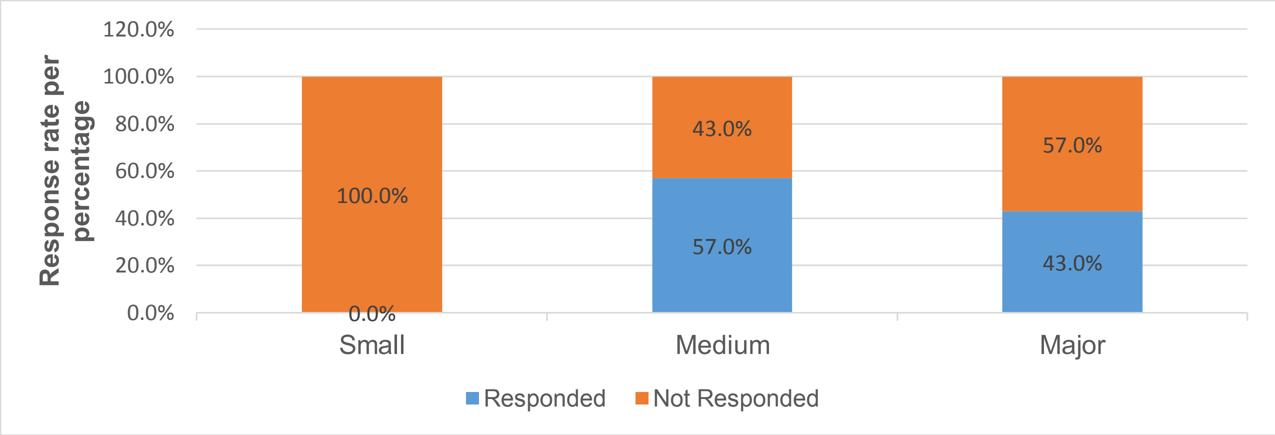

Figure 1: Response rate as per airport size

The responses received from different work designation within the airport environment was collected and analysed. Figure 2 below, represents the percentage of responses received per job tittle from the selected participants.

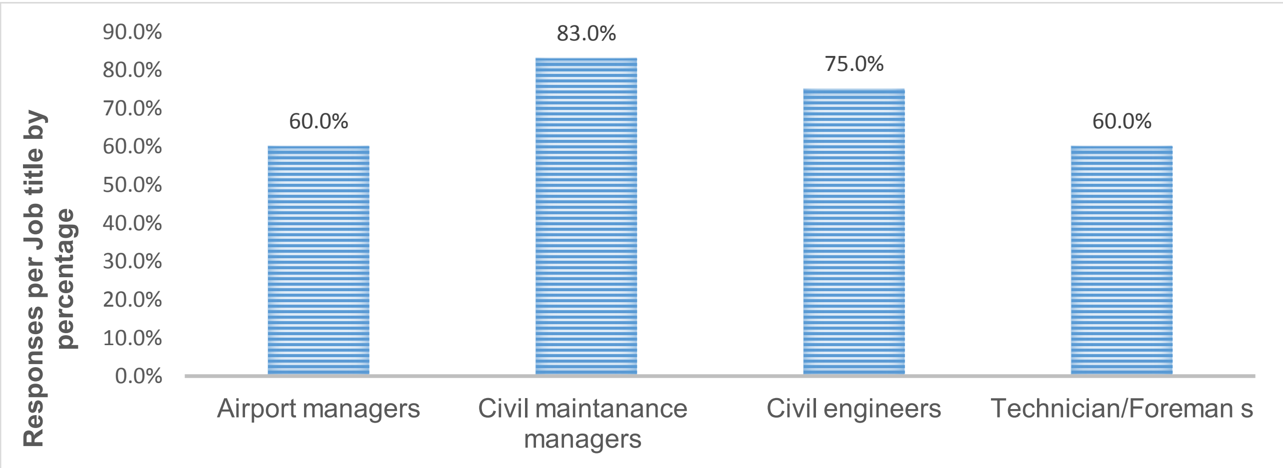

Figure 2: Respondents per job title

The analysis indicates the willingness to explore technological advancement among airport personnel in general. However, the civil maintenance managers had a higher respond rate of 83% as compared to the other working designation. In general, the results are suggestive of reasonable awareness of the drone technology and perhaps its benefit to airport among those who works closely with the pavement maintenance.

The number of years in relevant working experience from the respondents were received and grouped as follows: working experience of 1 year to 5 years, 6 years to 10 years, 11 years to 14 years and 15 years and more. Figure 3 represents the percentage of relevant working experience in the airport environment from the respondents.

The response received are indicative that the most interest on the drone technology is among the senior technical personnel who had more than 6 years of work experience within the airport environment. The questionnaire responses show that the experience category of 1 to 5 years are mostly technician who might not aware of the technology and the way it can help the maintenance task.

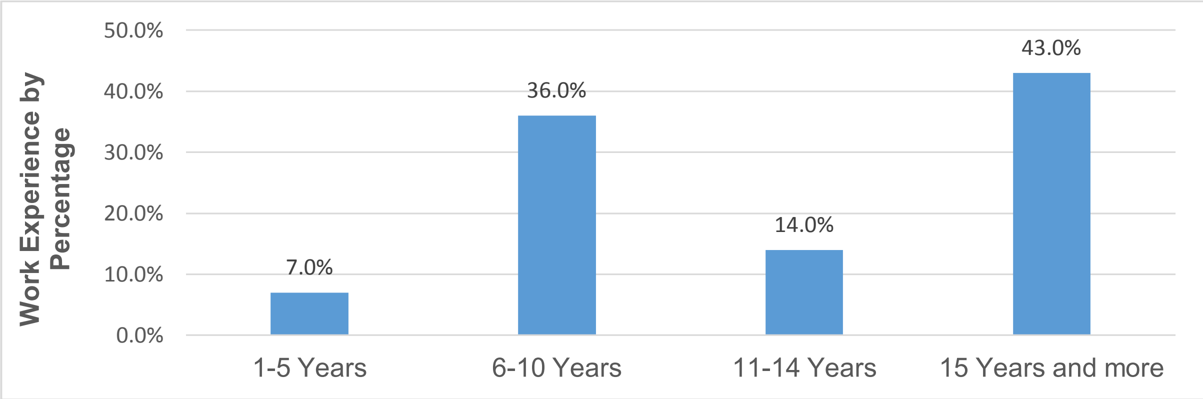

Figure 3: Respondent's working experience

3.2 Frequency of Runway Inspections

As far as the current practice is concerned, the frequency of conducting runway inspection per day for the different airports contributed to this study was grouped as follows; once per day, twice per day, three times a day and more than three times per day. The aim is to investigate the maintenance requirement per airport size. Figure 4 represents the percentage frequency of the inspections conducted on the runway per day at a particular airport.

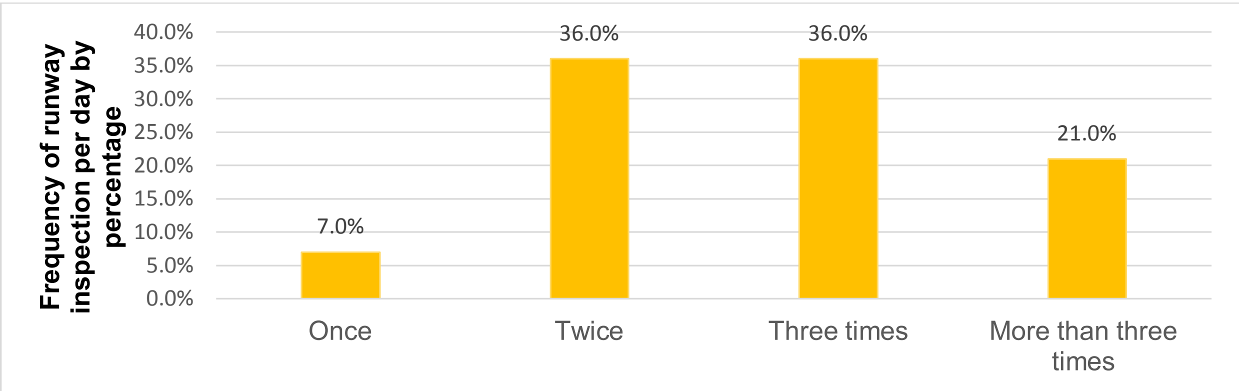

Figure 4: Frequency of runway inspections conducted per day

Based on Figure 4 and responses received majority of contributing airports conduct more than one inspection per day. One (7%) of the response for the once per day inspection conducted which represented a small portion of the medium airports, five (36%) of the response for the twice per day inspections conducted which represented the majority of the medium airports, five (36%) of the responses for the three times per day inspections conducted and three (21%) of the responses for the more than three times per day inspections conducted which represented the major (i.e. large) airports.

It's worth pointing out that these frequencies might have been lower than normal due to the COVID-19 pandemic which hit the aviation industry the hardest. Intuitively, the inspection frequency will increase due to the expected increase in flight traffic as well as due to the targeted economic growth. The higher expected frequencies may lead to current inspection process becoming severely interruptive to airport operation; hence, the drone inspection is a better tool.

Figure 5 shows the responses regarding runway inspection process including the records keeping and the tools that are used.

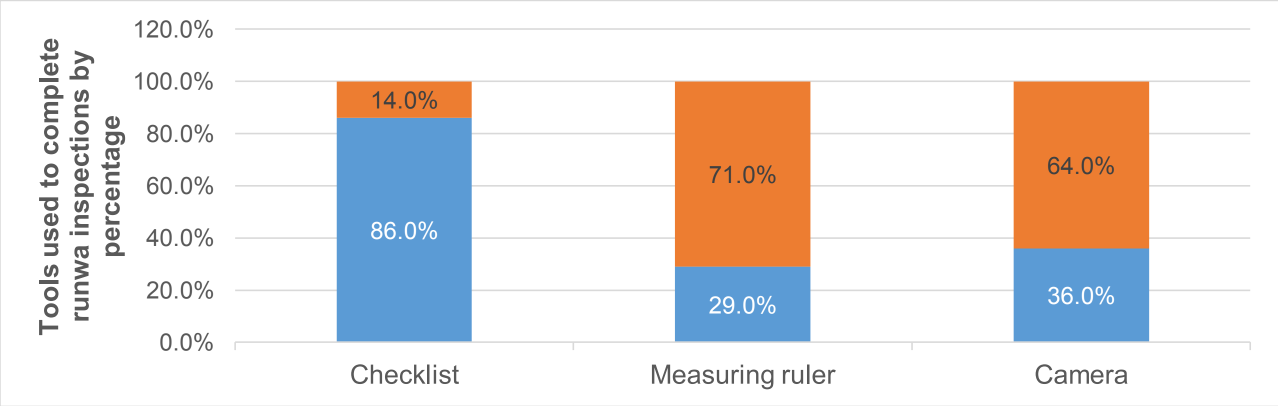

Figure 5: Current tools used to complete runway inspections

The data that received from the respondents regarding the tools they use to complete runway inspections indicated that, twelve (86%) of the respondents use a checklist to complete inspections whereas two (14%) of the respondents did not use a checklist (i.e. inspection is conducted visually but with no record keeping), four (29%) of the respondents use a measuring ruler /wheel to complete runway inspections (this is done mostly during wet conditions and/or when the structural integrity of the runway needs to be assessed for surface defects) whereas ten (71%) of the respondents did not use a measuring ruler/wheel and five (36%) of the respondents use a camera as part of a tool to complete runway inspections whereas nine (64%) of the respondents did not use a camera. The checklist option is found to be common in most of the contributing airports and it mostly was in combination with the option of using a camera during inspection.

With an image processing camera containing the pavement facility, the drone technology is capable of replacing the current process as it can serve as a tool for automated record keeping and also provides reasonable measurements of a runway distress. However, during adverse weather conditions, such as severe rain storms, the current tools used should be available, since drones may not be operated under those conditions.

Figure 6 represents the airports that implement APMS. The data that received from the respondents regarding the software they use to finalise runway inspection, the reporting thereof and the maintenance intervention ventured upon indicated that, eleven (79%) of the respondents use APMS in their airport and three (21%) of the respondents are not using APMS in their airport. The airports that do not use the APMS indicated that they use “the rule of thumb” to embark on the maintenance intervention when the need arises.

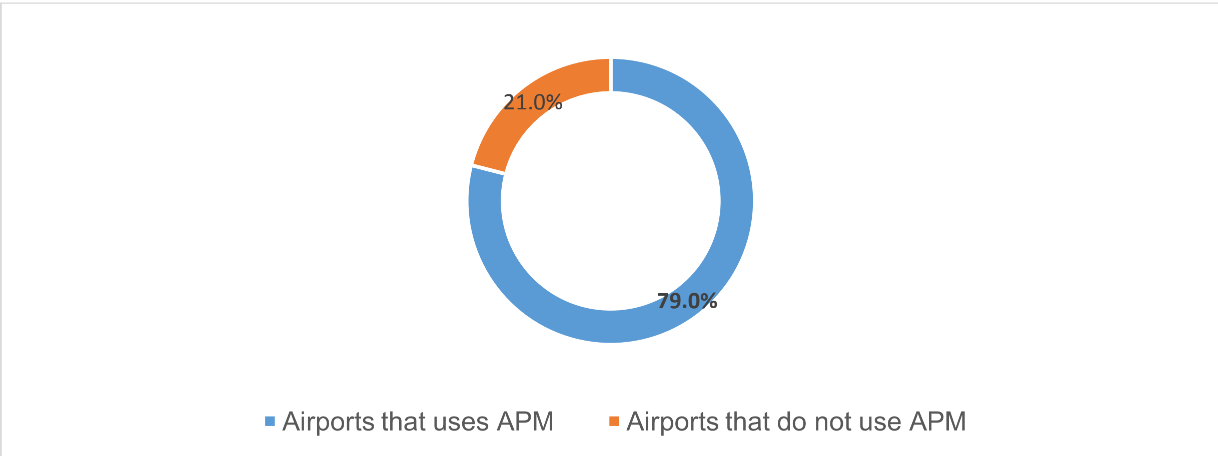

Figure 6: Airports APMS statistics

The results indicate that major airports have APMS in place to which the drone inspections can contribute significantly in a manner that can expedite the maintenance of their runways.

3.3 Introduction of Drone Technology

The last question on the survey questionnaire asked the participants if they are open to the idea of using drones as part of their runway inspection. Figure 7 represents the statistics for the participants in terms of the introduction of drones to the airport.

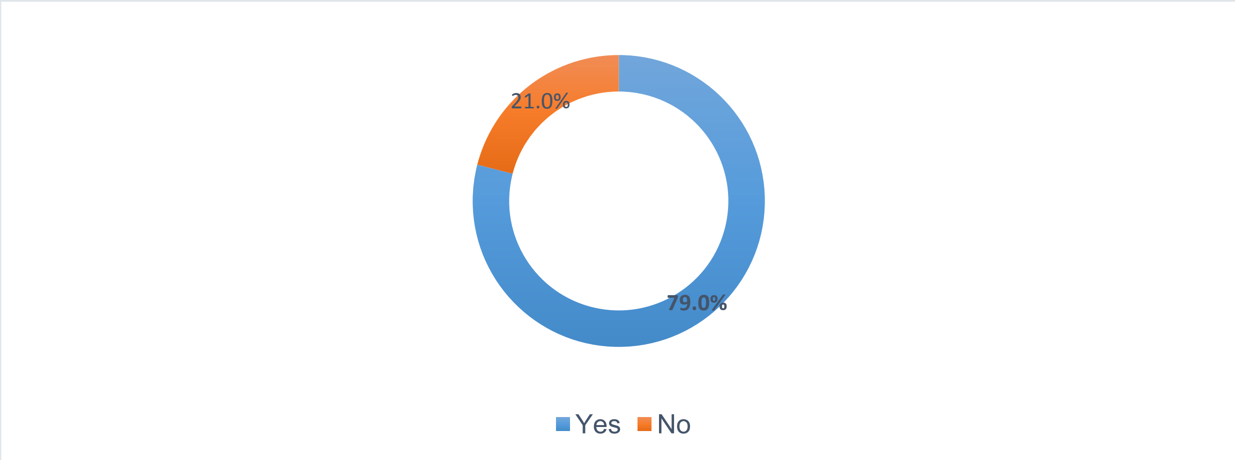

Figure 7: Introduction of drones' statistics

Out of the 14 respondents, eleven (79%) of respondents indicated that they are open to the idea of using drones to conduct runway inspections whereby this included all the major airports and majority of the medium airports that responded to the survey and three (21%) of respondents indicated that they are not open to the idea of using drones to conduct runway inspections which included the minority of medium airports who also responded to the survey. The statistic presented in Figure 7 correlates well with the findings presented in section 3.3. This means that airports that have APMS in places are the ones who are willing to use the drone technology in their runways.

4. CONCLUSION AND RECOMMENDATION

- The current practice in conducting runway inspections involves a relative lengthy process which mainly involves a check list and or a camera as a mean of record keeping and some measuring tools that provide information in terms of defect dimensions and location. The current process may not be fully adequate to address future developments within the airport environment while inspection frequencies increase.

- The research study shows that there is a high appetite from the airport environment to use drone technology as part of their runway inspections. The most interested airports are the major ones which that have APMS in place.

- Future research is recommended in order to assess the adequacy of drones as a method that can replace the current practice. Parameters such as time required and quality of gathered data can be evaluated. In addition, more research is required in the current local legislation in terms of operating drones within an airport environment and the cost thereof.

5. REFERENCES

Absolon, S, Huleck, D, Treslova, H & Skalova, M, 2015. “Runway Inspection by RPAS” *Magazine of Aviation Development*, 3(16):17-20.

Aliyari, M, Ashrafi, B & Ayele, YZ, 2021. Hazards identification and risk assessment for UAV–assisted bridge inspections. Structure and Infrastructure Engineering, Pg. 1-17.

Covalt, M. 2008. Implementation of an Airport Pavement Management System.

Hubbard, S, Pak, A, Gu, Y & Jin, Y, 2017. UAS to Support Airport Safety and Operations: Opportunities and Challenges. Journal of Unmanned Vehicle Systems

SACAA, 2017. Remote Piloted Aircraft Systems. Available at: http://www.caa.co.za/Pages/RPAS/Remotely%20Piloted%20Aircraft%20Systems.aspx#

Schnebele, E, Tanyu, B, Cervone, G & Waters, N, 2015. Review of remote sensing methodologies for pavement management and assessment. European Transport Research Review.

South African Pavement Engineering Manual (SAPEM) Chapter 10. 2014: Pavement Design, SANRAL.

Temme, M & Trempler, C. 2017. “Introduction of Unmanned Aerial Vehicles into Airport Ground Operations.” German Aerospace Congress 2017.