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ANALYSIS OF SMART SOLUTIONS IN THE FIELD OF AIRPORT MAINTENANCE WITHIN INTERNATIONAL AIRPORTS

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Abstract

The paper deals with the analysis of various smart solutions that can be implemented in airport maintenance. The aim of this paper is to compare the current situation in Slovakia with smart solutions that have been used in the world and to suggest which of the solutions could be implemented in Slovakia. The theoretical part describes the purpose of smart airports and conventional methods of airport maintenance. The next part of the paper is devoted to the description of the current state at the airport in Bratislava and a description of smart solutions used around the world. These may include: scaring birds with drones, snow removal with autonomous ploughs, mowing lawns with robotic mowers, inspection of the Instrumental Landing System ILS with drones and inspection of the Precision Approach Path Indicator PAPI with drones. The last part of the paper compares conventional maintenance methods used at the airport in Bratislava with their smart solutions used around the world. The evaluation includes a proposal for smart solutions which could effectively be used at Bratislava Airport.

Keywords

Scaring birds, Drone, Snow removal, Autonomous ploughs, Robotic mowers, ILS maintenance, PAPI maintenance

1. INTRODUCTION

Air transport is developing very fast and is being used by more and more people. New technologies are constantly being developed in airport maintenance to ensure high security, improved services, reduced costs and, finally, environmental friendliness. Some of the many types of airport maintenance are bird scaring, airport snow removal, lawn maintenance, ILS inspection and PAPI inspection. The aim of this paper is to compare conventional maintenance methods with their smart solutions and to suggest which of the smart solutions should be implemented at the airport in Bratislava. This paper describes selected types of airport maintenance. The next chapter contains the current situation at the airport in Bratislava and presents the possibility of using smart solutions in the field of airport maintenance on examples of those used at various airports around the world. The airports where smart airport maintenance solutions have been used are Brussels, Oslo, Victoria, Zurich and Geneva. The final part of the article is devoted to the comparison of conventional and smart methods of airport maintenance and their evaluation.

2. THEORETICAL BACKGROUND OF THE PROBLEM TO BE ADDRESSED

2.1. Scaring birds

The occurrence of birds varies from airport to airport and depends mainly on the local habitat, weather, or season. In Europe and North America, seagulls, swans, geese, gray herons and cormorants are the most common [1,2].

The method of scaring birds has to be adapted due to the presence of different species. The following methods can be used for scaring:

- Trained birds of prey and dogs, which are most effective in focusing on a small area with a specific goal, but their disadvantage is the high cost of training and breeding.
- The use of pyrotechnics is one of the most used tools. Propane cannons work similarly, but shotgun shots are also used.
- Playing sounds, whether artificial or predator, can create a zone in a strategic deployment, where most birds are uncomfortable to stay.
- Hand-held lasers, despite the enormous threat to aviation safety, can be very effective if used correctly [1,2,3].

2.2. Snow removal

When removing snow, machines are used that can, at first glance, resemble those used on roads. Equipment includes ploughs, brooms, ploughshares, blowers, or vehicles with chemical tanks. However, the difference is in the method of cleaning. The snow plough is the same as the one used on the roads, but the left snow is additionally swept by a roller broom, blown by a stream of air and then the surface is finally treated by applying a defrosting agent [4,5].

2.3. Grass surface maintenance

The grass surface must be carefully maintained, and not just because of its appearance. The grass must be mowed regularly

at airports so as not to block the visibility of the runway and the lights placed. The grass must also not be so long as to prevent pilots, who do not know the aerodrome terrain thoroughly, in visual contact with the taxiway navigation elements, which are the various guidance signs. Tall grass can even affect the transmission of data communication data between the aircraft and the ground. Several types of machinery are used for mowing. These can be mowers of various shapes and sizes, wide-area mowers, or mowers with the option of grass collection and cleaning [6,7].

2.4. ILS maintenance

The quality control of ILS signal transmission must be checked regularly for security reasons. To maintain ICAO ILS certification, airport operators, subcontractors, or government agencies must perform dynamic measurements. Calibration, testing, or inspection of radio navigation equipment may be performed by ground or flight inspection. Flight inspection is performed using a manned aircraft, which requires preparation for ground measurements to optimize flight intervention [8,9,10].

2.5. PAPI maintenance

In order to maintain the operating conditions and accuracy of the system, their maintenance is performed either by ground lifting equipment or by air control. The system is very precisely set to the required angle and deflection can occur, for example, due to the expansion of the structure due to a change in outdoor temperature. Routine visual inspections are performed daily and, if necessary, the external parts must be cleaned of dust or other impurities. The optical parts of the unit must be inspected approximately once a month to confirm that they are free of mechanical damage. At the same time, the correct attachment of the unit to the base is checked. Once a year, a detailed system check is performed, the angles are set correctly, and the optical parts are cleaned [11,12].

3. CURRENT STATE OF THE SOLVED PROBLEM IN SLOVAKIA AND ABROAD

3.1. Current situation at Bratislava Airport

Smart solutions have not yet been used at Slovak airports and therefore the situation in Slovakia will be described at the airport in Bratislava.

Conventional methods are used here for maintenance. Falcons or shotguns are used for scaring birds, ordinary plows and other vehicles are used for snow removal, mowers and tractors are used for mowing grass and a calibration aircraft is used for ILS and PAPI calibration.

3.2. Drone scaring birds at Brussels Airport- Zaventem

A bird control unit in Brussels regularly scares flocks to eliminate aircraft-bird interaction, but their vehicles are unable to reach all parts of the airport. In order to explore the possibilities of innovative use of drones, they organized test days when drones were used to scare birds in safe conditions. The tests did not affect the operation of the airport and the use of runways. The drone was piloted at a safe distance from the aircraft and only in the period between take-off and landing of the aircraft. During the test days, the drone was used to control the birds, which includes their detection, monitoring and, if necessary, their guidance outside the dangerous areas of the airport. Ideally, Brussels Airport will train the staff of the existing bird control unit for drone flying, as they already know the local terrain thoroughly [13,14,15].

3.3. Snow removal with autonomous ploughs at Oslo Airport- Gardermoen

Autonomous snowploughs have shown great potential for cost reduction during testing. With a length of 20 meters and a width of 5.5 meters, they had sufficient capacity to be able to clear an area of 357,500 m2 per hour from snow. Robotic vehicles are also able to perform airport maintenance in formations, with several vehicles cooperating with exceptional accuracy, regardless of the weather. The new solution meets high security standards. The system is developed with the possibility of condition monitoring, where a complete overview of the condition of equipment and possible service needs is provided. Following a series of successful tests, it is planned to expand the snow removal machines with plough, brush, blowing and spraying functions to the ten largest airports in Sweden, while the machines will be equipped with the latest technology for autonomous operation [16,17,18].

3.4. Lawn maintenance with robotic lawnmowers at Victoria Airport

There are several advantages to using robotic lawnmowers. Automating the lawn maintenance process eliminates some of the risks to staff, and thus mowing in critical areas, helping to reduce the number of employees who have more time to deliver value-added services to Victoria Airport and become technicians in new, innovative facilities. One of the main advantages, therefore, is the resulting cost reduction. The time required to inspect and maintain the robotic lawnmower and its peripherals, including charging stations, is negligible compared to the time required for conventional mowing. Last but not least, it is necessary, especially today, to take into account the production of carbon dioxide emissions. Fuel requirements cannot be underestimated with conventional mowing methods. The introduction of an electric alternative makes it possible to radically reduce the airport's carbon dioxide emissions and carbon footprint [19,20,21].

3.5. Maintenance of the ILS system by drones at Zurich Airport

The idea of a systematic and automatic comparison of ILS flight checks and ground measurements in order to reduce the frequency of flight checks in Switzerland dates back to 2002. Along with the rapid advances in drone technologies, their use for measurement purposes began to be considered. The first step was to test whether the drone could carry the required load, which was almost 8 kg. A positive factor was the first assessment of flight stability and the ability to manoeuvre with the load. After successful tests, a measuring receiver and antennas were mounted on the drone. The positive evaluation of the new measurement method was concluded by positive results in terms of repeatability and accuracy. It was no longer just the idea of using a drone, but this new method of measuring techniques became a reality [22].

3.6. Maintenance of the PAPI system by drones at Geneva Airport

The PAPI drone calibration solution began to be commercialized in early 2018. Since then, we have seen positive feedback on the use of drones from the affected markets. At the end of 2019, Drone Canard successfully inspected visual aids at Geneva Airport in Switzerland. In addition to the PAPI control, the Canard solution was also used to inspect the approach lighting system on both sides of the runway in real time. With the least impact on the normal operation of the airport, Canard cites the possibility of flying a calibration drone day and night as an example of flexibility. The planned window for the flight at Geneva Airport was set between 00:00 and 05:30, with all activities ending by 2:30. The actual occupation of the runway took only a few minutes [23,24].

4. WORK RESULTS AND EVALUATION

The following part compares the current situation at the airport in Bratislava with smart solutions that are used or tested at airports around the world. Subsequent evaluation of the work contains a proposal for solutions that could be effectively implemented at the airport in Bratislava.

4.1. Comparison of bird scaring methods

As it was during flying with drones found, drones act on the animals disruptively. After several attempts and efforts to replicate birds of prey by remote-controlled models, it turned out that a classic drone can be used for this purpose. For more efficient scaring, it can be equipped with a speaker that replicates the sounds of predators that act as a deterrent. Compared to the classic method of scaring with predators, it brings several advantages as an additional tool to support biological protection units. In addition to immediate deployment, the advantage of using a drone is that it can be operated from a bigger distance and biological protection units do not have to be transported often to inaccessible places within the airport. As demonstrated during testing at Brussels Airport, the drone does not pose a threat to the flow of air traffic when flying in safe conditions.

4.2. Comparison of snow removal methods

One of the advantages of using autonomous snow ploughs is that they can perform airport maintenance in formations with great accuracy in any weather. The result of the ability to ride in formations together with their width of 5.5 m is their ability to clean a large area from snow in a short time, which results in a reduction in the number of ploughs and a reduction in the number of ploughs results in reduced environmental burden and operating costs. As a result of the introduction of autonomous operation, staff do not have to be exposed to adverse weather conditions and can monitor the whole process from the control station, communicating with the control tower staff and selling them up-to-date information on the state of the track. The orders are sent from the control station to the autonomous ploughs based on current information and permission to perform work from the control tower.

4.3. Comparison of grass surface maintenance methods

Lawnmowers drive internal combustion engines and are therefore not the optimal solution in an active effort to reduce the burden on the environment. Driving lawn mowers is provided by airport staff, who are exposed to the risk of a collision with the aircraft during work. The solution can be the use of robotic lawnmowers. Unlike conventional vehicles, robotic lawnmowers are fully autonomous and airport staff only assign tasks to the lawnmower through the application. Easy operation helps to reduce the number of employees whose job is no longer to drive, but to take care of the maintenance of the mower and its peripherals, which is less time-consuming than manual mowing. The reduction in the number of employees also results in a reduction in personnel costs. Autonomous mowers are also able to work during the rain, which can be an unpleasant factor for airport staff. Because robotic lawnmowers are powered by an electric motor, they run quieter and can work at night. At the same time, electric propulsion reduces the airport's carbon footprint.

4.4. Comparison of ILS maintenance methods

In order to reduce the number of required flights, it is possible to be inspired by the use of a drone at Zurich Airport. This allows the preparation of the calibration aircraft before its flight. The result of using drone is the saving of costs for expensive and time-consuming operation of the calibration aircraft. At the same time, as the drone is incomparably smaller than the aircraft, the overall process noise also decreases. As a result, the measurement activity can also be performed at night, and during low traffic times, which results in the elimination of unpleasant events in connection with the need to temporarily decommission the ILS system. Another important fact is the reduction of carbon dioxide emissions, as the drone is powered by electricity compared to the internal combustion engines present in the calibration aircraft. As it turned out, progress in the design of drones can ensure trouble-free drone flight capabilities in the event of a load in the form of a measuring system and antenna. The solution therefore appears to be a suitable way to extend the performance of control measurements.

4.5. Comparison of PAPI maintenance methods

Drone testing of PAPI system is less time consuming than flying a calibration aircraft. It only takes a few minutes to occupy the runway during a drone inspection, which is reflected in the shorter time required to take the runway out of service. Due to the lower drone noise compared to the noise of the calibration aircraft, the inspection can be performed even at night, when the operation is less busy. The electric drive of the drone, as mentioned earlier, reduces the total production of carbon dioxide, which is not negligible when using a calibration aircraft. The present software allows the control to be performed with a high degree of automation, which reduces the intervention of the crew.

4.6. Evaluation

To evaluate the aspects of the implementation of individual smart solutions at airports, it is necessary to compare the number of passengers handled at airports, which may reflect their initiative in development. The table shows the number of

passengers handled per year before the outbreak of the COVID-19 pandemic, so that the data as accurately as possible reflect the reality and not be affected by different measures to prevent the spread of the disease in each country.

Table 1: Number of passengers handled at airports in 2019. [25,26,27,28,29,30, processed by the author]

Airport	Number of handled passengers
Bratislava	2,2 mil.
Brussel	26,4 mil.
Oslo	28,5 mil.
Victoria	1,9 mil.
Zurich	31,5 mil.
Geneva	17,9 mil.

In the case of evaluating the effectiveness of autonomous snow ploughs and their possible introduction at the airport in Bratislava, it is also important to compare the average amount of precipitation in the form of snow in Bratislava and Oslo.

Table 2: Characteristics of snowfall in Bratislava and Oslo. [31,32, processed by the author]

Airport	Average amount of snow precipitation	Length of snowfall period in months
Bratislava	7 cm	4
Oslo	22 cm	6

In most cases, smart devices are used at busier airports than Bratislava Airport. An exception is Victoria Airport, where robotic lawnmowers were used. The efficiency of robotic lawnmowers does not have to be conditioned by the large number of checked-in passengers, which is associated with the airport's efforts to implement innovative maintenance methods. Their deployment can therefore be very advantageous in Bratislava as well. As pointed out, they offer several advantages, and their implementation does not require extensive preparation or demanding training for staff.

Another smart solution that would positively affect the operation of Bratislava Airport is the deployment of drones to scare away birds. Drones are more reliable than birds of prey used at Bratislava Airport. In the case of Bratislava airport, the use of a drone would be a good way to expand the methods of scaring birds.

The last smart solution that could be implemented at the airport in Bratislava and would show efficiency is the use of a drone to inspect the PAPI system. As the method of inspect using a drone would completely replace the need to carry out the flight with a calibration aircraft, this inspect could be carried out by the airport itself. As with the use of a drone to scare birds, airport staff would be trained to measure with a drone.

The inspect of the ILS system with a drone is only a pre-flight preparation of the calibration aircraft, which is still necessary. Although the use of a drone will speed up the measurement and reduce the required number of flights performed by the calibration aircraft, it is only an additional factor in the inspect of the ILS signal and does not have much potential at the airport in Bratislava. The investment in a drone to inspect the ILS system in the case of Bratislava Airport is not as advantageous as in the case of using a drone to inspect the PAPI system.

Of the selected smart solutions, the use of autonomous snow ploughs at Bratislava Airport is the least efficient. Compared to Oslo, where autonomous plows are used, there is a period in Bratislava when precipitation in the form of snow can be expected by two months less. Like the shorter length of the snowfall period, the amount of precipitation is a key factor. In the month with the highest amount of precipitation in the form of snow, which in the case of Bratislava and Oslo is January, about a third of snow falls in Bratislava compared to Oslo. Climatic conditions remain the main reason why the use of autonomous snow ploughs in Bratislava is not efficient.

5. CONCLUSION

Rapid advances in technology enable the introduction of new and innovative solutions also in airport maintenance. New smart solutions can speed up the maintenance process, reduce costs and reduce the burden on the environment, which is currently in high demand.

More and more new, smart solutions for airport maintenance are being used around the world, especially at large international airports. However, there are also solutions that have found application at smaller airports, which are at a similar level in terms of the number of passengers handled per year as the airport in Bratislava.

The potential to introduce new smart solutions in airport maintenance in Slovakia is undoubtedly. Some smart solutions are less suitable, while others show a favourable level of compatibility with local conditions. Robotic lawnmowers have proven to be the most suitable smart solution in the field of airport maintenance in the case of Bratislava Airport. At the same time, there is an opportunity to examine whether the use of robotic lawnmowers would be suitable at other, not only international but also regional airports in Slovakia. With a strong emphasis on streamlining processes, increasing safety, and reducing the burden on the environment in air transport, it is only a matter of time before we see more and more similar smart solutions used in Slovakia.

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