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NEW TECHNOLOGIES IN MANAGEMENT OF GROUND MOVEMENTS AT THE AIRPORT

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Abstract:
Modernization and implementation of the most modern technologies in the process of air transport management is one of the most effective solutions that need to be clarified in the process of developing the airport and its capacity. The aim of this article is to characterize the basic activities of aircraft ground handling and the processes of automation of ground operations, to describe current ground movement control technologies in airport areas and to present the components of an optimal ground movement control system at regional airports. This article investigates the limited adoption of advanced ground movement management technologies in regional and small airports, attributing the hesitation primarily to financial constraints. The study reveals efforts toward modernization for enhanced operational efficiency and passenger satisfaction. However, financial limitations pose challenges, especially for smaller airports lacking regular flights and passenger volume. The research emphasizes key priorities for regional airports, including accelerating the check-in process, improving overall airport efficiency, and minimizing operational costs. The article concludes by emphasizing the critical role of such technologies in improving airport safety, efficiency, and overall air transport quality, urging airport management to consider their integration for a transformative impact on operations.

Key words:
ground handling, aircraft, management system, regional airports

1 INTRODUCTION

Aviation has become a key component of infrastructure in today's modern society. As air transport becomes more financially affordable, fast transportation in the comfortable spaces of the aircraft is a great attraction. Transporting cargo from one place to another no longer seems unaffordable thanks to air transport. However, the air transport is not just about aircraft. Airports are essential for their smooth operation, service, cargo, and maintenance. Since airports as a whole form a basic element of the entire aviation infrastructure, it is impossible to leave them out of the overall process. It is therefore necessary to consider airports in the development of aviation. Necessary equipment, proper coordination of movements, and smooth management of all activities without unwanted delays or errors keep the airport and its position in the best possible degree. Modernization and implementation of the most modern technologies in the management process is one of the most effective solutions that need to be clarified in the process of developing the airport and its capacity.

Currently, several technologies can make airport check-in processes more efficient, shorten check-in time, eliminate possible clashes in airport areas, save money, and facilitate the work of airport staff. Systems such as A-SMGCS, the ground traffic management system, or the autonomous ARIWS system can significantly improve the quality of check-in processes at the airport, facilitate the activities of management staff, and optimize all activities at the airport. A monitoring and tracking system that could track the position of all moving objects at the airport, including operating technical equipment and personnel, is also seen as an interesting concept.

A regional airport serves the population living in its vicinity to connect one place with another, thus providing them with mobility. These are important places that can supply the given areas, allow passengers to be transported over medium and shorter distances compared to large airports, help the economy of the given region, and provide jobs and overall growth. In some cases, their goal is to create the economic background of the given area, transport raw materials, goods, and, last but not least, residents (Airport Suppliers, 2022). Even though smaller airports do not have such mechanisms, technologies, and modernizations as large airports, their control and system management are equally necessary (Banchik et al., 2021). According to the applicable regulations, regional airports must comply with the same requirements as large airports, namely in the area of safety, operability, readiness, and quality, but also the efficiency of the entire transport process (Kazda et al., 2017).

Since the speed of air transport depends on the time of equipment at airports and the next possible departure, ground handling in the process of management and control plays a significant role in the overall concept of organizing individual activities. The time required to perform individual activities needs to be minimized without degrading the quality. Automation processes not only improve the quality of the system, but also facilitate individual steps, assist in the precise localization of objects, guidance and monitoring of individual mechanisms, and control of their activity.

This article will introduce the basic activities of aircraft ground handling as well as the automation process and control systems that are performed on airport aprons. Next, we will focus on the current options and technologies that are used to manage movements in airport areas. The final part elaborates on the possibilities of an effective ground movement management system at regional airports and the possibilities of implementing some current technologies into the concept of regional airports.

2 GROUND HANDLING

By the term "ground handling" we understand a wide range of activities and services that are provided for aircraft at airports to simplify the overall process of preparing for the flight, moving these flying colossi on the ground, until it stops, as well as services on the apron or passenger services (SKYbrary Aviation Safety, 2023a). It includes activities such as boarding and alighting passengers, loading and unloading luggage or cargo, filling with fuel, loading catering, balancing cargo, or cleaning the cabin (Pruša et al., 2008). Ground operations are closely related to operation in airport areas and servicing of aircraft equipment. This operation must be carried out with the fulfillment of all safety measures that are necessary to maintain the operability and safety of air transport. It is necessary to focus attention on the prevention of collisions of large aircraft with smaller ones in active areas, take into account the movement of aircraft in areas with mechanisms performing ground handling activities, supply the necessary amount of fuel of the required quality, take into account the use of technical means in case of icing and others (SKYbrary Aviation Safety, 2023b).

The initial activity performed after the arrival of the aircraft at the destination airport is guiding it to the apron by various methods, which is called Marshalling. It can be guided using a guidance car with the inscription Follow Me! to a pre-allocated parking space. Further, guidance is performed either by electronic devices or by ground staff (SKYbrary Aviation Safety, 2023a). At large international airports, a unique automated guidance system called VDGS - Visual Docking Guidance System, began to be used. This system consists of an electronic screen located at the airport gate in the field of vision of the pilots, which provides instructions for parking and stopping the aircraft. The instructions are displayed when the system automatically detects the position of the aircraft and calculates the correct position to stop (A.L. Team, 2020). The ApronVision concept also proves to be an interesting system. The A-VDGS - Advanced Visual Docking Guidance System can direct the cockpit crew to the exact position where the aircraft can stop. In addition, the ApronVision system can be grouped with fully automatic actions and thus manage aircraft turns as efficiently as possible. It also provides oversight of most site activities, helping to manage all site activities. The viewing angle of horizontal tracking is up to 360°, which ensures parking guidance for multiple runways and obstacle tracking with the cooperating A-VDGS system. Cooperating with other systems creates safer control of the aircraft on surfaces and its guidance in real time (TK Elevator, 2023).

After bringing the aircraft to the stand area, the staff is ready to perform all the necessary actions that were planned and necessary. The so-called throttles or safety wedges are fastened by workers to the front landing gear leg. The following activity is already carried out after agreement with the pilot, after mutual communication with the ground handling staff. It is necessary to agree on the connection of electricity to the aircraft. For this, the GPU ground power unit is used, which maintains the necessary onboard systems in the entrance after the engines are switched off. At some airports, however, we can also see this system as a fixed unit on the boarding bridge (A.L. Team, 2020).

Activities related to unloading luggage are also closely related to passengers getting off the plane and transferring them from the plane. These are activities necessary for the correct unloading of luggage and cargo, most often with the help of special equipment, namely conveyor belts, forklifts, and others. In the case of dangerous goods, it is necessary to proceed correctly in accordance with the instructions [1].

As it is possible that the passengers who get off the plane may be waiting for the next flight at the given airport, and therefore it is not possible to be in a hurry to unload the luggage, the employees of the belt loaders are already approaching the plane from which the passengers are getting off. In the case of narrow-body aircraft, belt loaders are usually used, in the case of cargo or wide-body aircraft, where there is a much larger number of passengers, cargo loaders

are used to unload luggage - Cargo Loaders that can hold much more luggage, thus increasing the efficiency of the entire process (SKYbrary Aviation Safety, 2023a).

Cleaning the aircraft, cabin, toilets, and areas intended for the preparation of meals and refreshments is also a must after each arrival. In the event of an aircraft turning around and preparing for its next flight, meals and snacks for passengers are replenished - catering. Food brought in supply carts is placed in food preparation areas, the so-called on-board galleys. For this process, the so-called Catering Truck is used. There is also the supply of drinking water and activities related to toilet cleaning, i.e. the removal of waste from toilets, and if necessary, their repair or routine maintenance. For this toilet waste removal process, a toilet service vehicle is used to empty the waste tank and prepare it for the next flight (SKYbrary Aviation Safety, 2023a).

Refueling has its process and sequence of individual actions, which cannot be omitted or changed. Since checking the remaining amount of fuel and subsequent replenishment is an essential part of every flight preparation, it is one of the most important activities performed by aircraft ground handling personnel to ensure a smooth flight and maintain safety (Joshi, 2022).

In winter, de-icing and anti-icing are some of the most important activities performed when necessary. Depending on the capabilities of the given airport, the process of de-icing or anti-icing on aircraft is carried out in predetermined areas (SKYbrary Aviation Safety, 2023a). Tanks filled with de-icing and anti-icing mixtures are brought to the aircraft in sufficient proximity, with all safety conditions being maintained, and then the application to the fuselage and wings of the aircraft is started (A.L. Team, 2020).

After the successful completion of refueling, all equipment used for ground handling activities leaves the apron and the vicinity of the aircraft to avoid a dangerous collision with other mechanisms that follow. The boarding process of new passengers begins using the attached boarding bridge. While the crew checks the number of passengers, the flight crew begins flight preparations, and the GPU system is already removed from the vicinity of the aircraft. The process already uses the APU system, an auxiliary power unit that supplies the necessary power to the aircraft and allows workers to start one of the aircraft's engines using a high-pressure air truck. After starting one of the engines and starting the last phase on the apron, namely pushing the aircraft off the stand using the push-out mechanism - Aircraft Pushback Tractor or by the power of its engines. Subsequently, taxiing of the aircraft and preparation for take-off starts (A.L. Team, 2020).

Ground handling workers do not always have to stay only in the stand area where the aircraft is docked, they also move around in other parts of the airport, where they perform other activities necessary for ground handling, such as handling passengers' luggage, moving it on a conveyor belt, moving the aircraft to another stand or using tractors to tow the aircraft (A.L. Team, 2020).

Since the improvement of ground handling services is directly related to the necessary operating costs, it is essential to systematically improve the processes and minimize the time required to carry out all necessary activities, thereby demonstrably reducing costs. It seems most advantageous to automate the processes.

2.1 Current technologies of ground control

As air transport is moving forward as well as the technologies related to it, airports and airlines are considering the implementation of various more cost-effective solutions that would improve the quality of the processes. It is essential for proper functioning and cooperation between activity management and execution to pay attention to initial planning, which will significantly influence what is needed for a given aircraft and airport and which can speed up all activities without harming the overall quality of services provided.

Advanced surface movement guidance and control system A-SMGCS

A-SMGCS can improve the movement of ground handling equipment and raise the ability to serve aircraft in sufficient numbers. When using the A-SMGCS, and its application to movement control systems at airports, consistency should be maintained from runways to aprons and vice versa. When using and introducing the system into the overall control system, the most advantageous is control, provision of the necessary spacing and distances, their control, and also the overall coordination of movements, for which the ATC center is responsible (Eurocontrol, 2020). This guidance system draws attention to the safety of the overall air traffic, taking into account external environmental conditions, including weather, airport infrastructure, and its layout. The principle of operation of this control concept directs attention to the precise direction, control, and guidance of aircraft and ground handling equipment while maintaining an adequate speed of movement even in adverse weather or under the influence of other external factors. Thanks to cooperation with other systems, it contributes to the so-called full traffic tracking coverage. The system provides connectivity to the airport system using data services and GPS services to track objects and their movement in a given time. It can signal their position and trigger a warning whenever the system detects a transition from one surface to another, for example from a taxiway to a runway or vice versa. The offer of applying the A-SMGCS concept to the airport management system is possible at the highest level, but also at a lower level, the main goal of which is to highlight the situational awareness of management staff about what is happening on a given runway or airport area in a better way than observation from the control tower. At the highest level, the system offers recognition of possible collisions and dangerous situations, displaying the location of possible suspicious objects (ICAO, 2020).

Autonomous Runway Intrusion Warning System - ARIWS

To be able to anticipate and, above all, prevent the possible intrusion or occupation of runways or taxiways currently in use, the ARIWS system is seen as very interesting. It is a concept of independent detection of possible intrusion and subsequent warning to the crew members as well as the operator of the given vehicle. This system is mainly based on monitoring. It was designed to be placed it on taxiways. It is usually given that the ARIWS system consists of an automatic tracking system, primarily a radar device, cameras designed for multi-faceted tracking of objects, and another danger signaling system, consisting mainly of lights. These specialized technical devices are connected by a processor, which can provide the supplied information directly to the crew in the aircraft, but also to the personnel of other mechanisms and vehicles, but independently, without ATS activity (Ifatca, 2020).

HONEYWELL GTM technology

Another interesting concept in the process of modernization and automation of individual processes of aircraft ground handling is the Honeywell GTM technology - ground movement control system. Its main task is to guarantee the high safety of all mechanisms located in all areas of the airport, their movement, and transfers to and from the aircraft, to increase the efficiency of the operation of all systems intended for ground handling with an emphasis on the growing need for ground services. This system works closely with the A-SMGCS system. It is an automatic system providing the crew with all the necessary information about the currently scanned view and its position on the runway, also in bad weather conditions, and poor visibility such as heavy fog. The functions of this concept consist in the creation of the most appropriate and calm path from the transfer from the stands to the preparation for take-off, but the route of the given proposed path in the current operation. After the subsequent approval by the ATC center, this system lights up the green signaling light along the length of

the center line of the taxiway that has been determined, which perfectly assures the worker of the towed mechanism to push the aircraft and direct it correctly (Raghu, 2019)

3 The effective management of ground movements at the airport

The reason why regional and small airports are not so involved in the implementation of the latest ground movement management technologies is primarily financial. Brno Airport in the Czech Republic and Rzeszów in Poland consider the implementation of ground movement control technologies a necessity, and thus as their plan of action, as the modernizations they add to their airports bring at least positive responses not only from passengers and their satisfaction with check-in processes but also from the point of view of employees and all workers who have facilitated ground clearance processes and other activities in which new technologies have been inserted to increase efficiency and optimize most activities. Regional airports in Slovakia and the Czech Republic are trying to advance in the process of modernizing not only technology but also equipment. Piešťany Airport is also considering the gradual digitization of some activities and procedures, but the insufficient number of passengers and the irregularity of flights are not sufficient to cover the financial capital that would correspond to the implementation of technologies that would make the aviation process more efficient at this airport. The goal of the Milan Rastislav Štefánik Airport in Bratislava should be to introduce a mobile application into the check-in process at the airport. The main function of this system would be to increase the speed of handling passengers at the airport, but the exact time when the airport will incorporate this system into its handling process has not been determined. Žilina Airport has confirmed its efforts to implement modern technologies, but its problem is the initial costs, which the airport cannot cover. As the goal of every such airport is satisfaction with the transportation process for passengers, the crew itself, and other subjects, the main priorities are:

- acceleration of the check-in process
- increase of the efficiency of the airport itself
- minimization of costs necessary for operation

Tab. 1 *Digital technologies at the airports of Žilina, Bratislava, Brno and Ostrava*

Digital technologies	Žilina	Bratislava	Brno	Ostrava
A-SMGCS	X	X	X	X
A-CDM	X	X	X	X
Self-service check-in system	O	X	O	O
Self-service baggage handling	O	X	O	X
Biometrics	X	X	X	O
E-ticketing	O	✓	✓	✓
Online check-in system	O	✓	✓	✓
Mobile application for travelers	O	X	X	X

Source: (Plško, Remencová, 2022)

Table 1 shows data from 2022 on the technologies used and future technologies that regional airports such as Brno, Ostrava, Bratislava and Žilina want to include in their operations in the process of modernization. The sign X in the table means that the given system is not used at the airport and is not planned. The sign ✓ means that the given technology is used at the airport and the sign O means that the system is planned to be implemented.

At the end of this investigation, it therefore appears that regional airports in Slovakia and the Czech Republic largely lack the most modern technologies and digitization of the

check-in process. Regional airports aim to implement modern information technologies in their passenger and aircraft handling process, but cannot cover the high initial costs. Regional airports do not have as high transport capacities and regular flights as large airports near capital cities, so they cannot cover the finances required for possible planning and changes (Plško, Remencová, 2022)

Regional airports themselves serve as transportation hubs that connect the market and improve economic activity and development of the surrounding area. Not only do they support regions and cities, but they also contribute to a relatively well-functioning transport network that opens up the regional market and opens it up to the world. They can also alleviate congestion at large airports, which are already reporting insufficient capacity during this period. It is, therefore, necessary to point out the modernization of these regional airports, which, after automation and modernization, would be able to meet all needs, and thus satisfy the demands for high-quality, efficient, and safe air operations to the necessary extent. However, the most frequent problems in terms of finances of regional airports are the high fixed costs of operation. From this point of view, it is not possible for the airport to easily purchase guidance systems or other tracking and monitoring devices that would facilitate the work not only of the management staff but also increase the level of the airport itself.

In the event that some regional airport decides to purchase the A-SMGCS system, the following funds and operating costs are required for their purchase and implementation:

1.let's assume that the airport already has one radar intended for movement monitoring,
2.for level 1: necessary purchase of a multi-lateration system (receiver + transmitter), data fusion sensor, controller positions and equipment of vehicles with transponders,
3.for level 2: two additional systems are needed to detect false information and alarms.

For automation related to luggage, cargo, or mail loading areas, palletized, i.e. automated loading of cargo is proving to be interesting. However, this is not possible, not only from the point of view of the necessary economic resources but also the fact that this option is not feasible for several aircraft, they are not adapted for such loading. For example, the Boeing 737, which is one of the most used aircraft in the world, does not have a cargo area adapted to accept the ULD mechanism, the so-called unit equipment for loading cargo into aircraft compartments. Automated opening of cargo doors and access panels from an appropriate distance, or automatic connection of systems and tools would also be convenient and desirable. The ideas that arose in the process of simplifying and automating ground handling processes are also improvements in the area of supplying refreshments and the necessary equipment for the next flight. It would be a concept of exchanging the entire vans, parts of galleys - modules that would be suitably adapted for exchange and there would be no need to deliver catering in carts (Tabares, Mora-Camino, 2017).

The activities planning the development of regional as well as large airports is not a simple and short-term activity. It contains innumerable steps to ensure the most efficient management procedure and execution of activities with a view to the optimal utilization of all spaces, runways, or the terminal. Milan Rastislav Štefánik Airport in Bratislava, which has divided its development plan into four quadrants, is also in the process of creating optimal management and use of airport efficiency. Since the airport is aware of the shortcomings regarding ground handling, specifically the fuel warehouse, which is located outside the airport area, these changes have been incorporated in quadrant one. It would involve building a warehouse for fuel inside the premises, which would ensure fast transportation of fuel in case of need. The next step would be the completion of other necessary buildings and spaces intended for service equipment and all the mechanisms necessary for the ground handling of aircraft as well as the maintenance of the airport and its premises. The completion of additional hangars is also included in the changes. Quadrants two and three mainly concern take-off and

landing runways, which are largely in need of maintenance, as they are limited by their lifespan. The fourth quadrant describes the changes that should contribute to solving the problem of traffic situations in the Vrakuňa district. In the process of preparation and anticipated development, there are also starting sleeves, the so-called aviabridge. Baggage systems are automated at the airport, and baggage palletizing is also used, which greatly helps to optimize the use of airport and terminal capacity (Marko, 2023).

The system of coordinated movement that is in the areas of the airport is shown in some proposals for a systematic operation to be comparable to the currently used movement system, but other restrictions on the movement of mechanisms, precisely determined movement routes, determination of zones of possible entry or transfer would apply. As the rules of speed of movement or circulation would be preserved, changes would occur only in the coordination of vehicles, which can significantly disrupt the systematic operation of ground handling services (Tabares, Mora-Camino, 2017).

Movement rules:

1.GSE mechanisms proceed along precisely determined trajectories,
2.corridors of operating mechanisms moving up and down - on the sides of the plane - blue color in Fig. 2,
3.surrounding routes – green color, they connect the surroundings of the aircraft for operating mechanisms,
4.a specially designated area under the wings for refueling tanks.

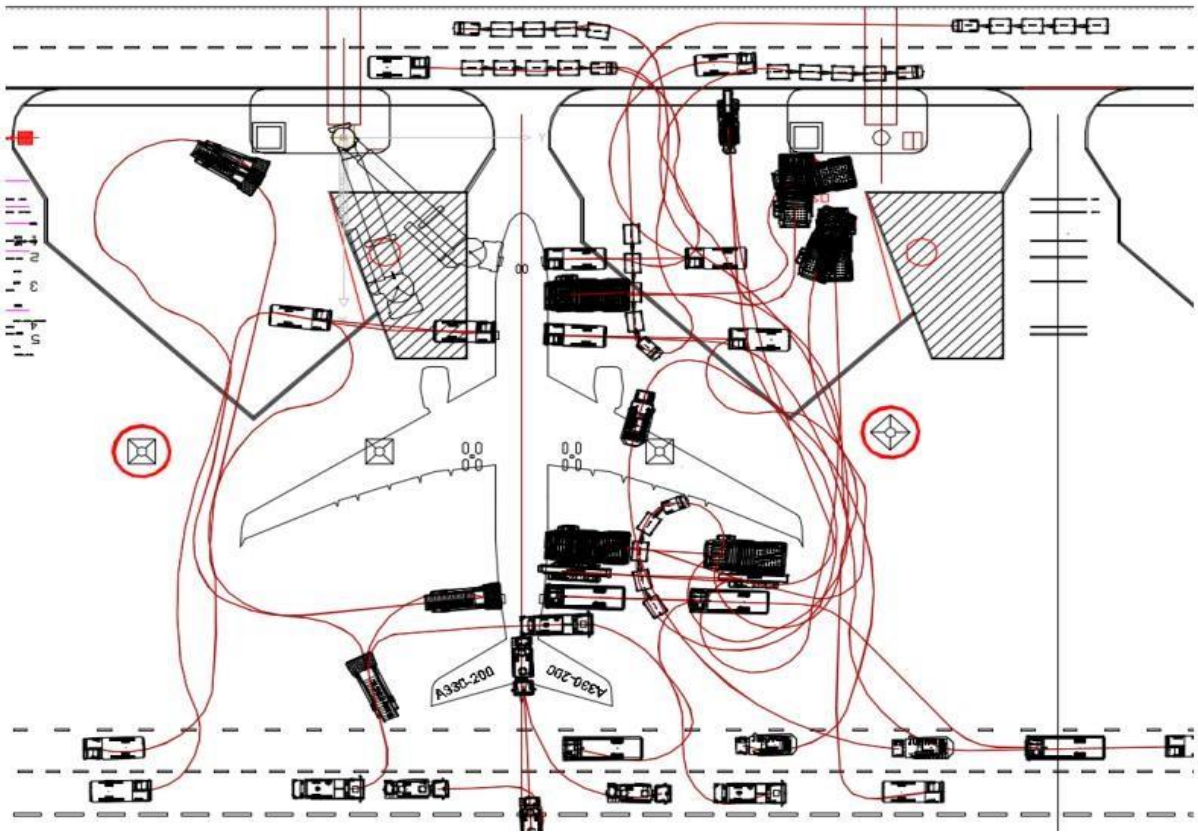

Fig. 1 *Demonstration of the scheme of ground operations performed on the aircraft during a turn*
Source: Tabares, Mora-Camino, 2017

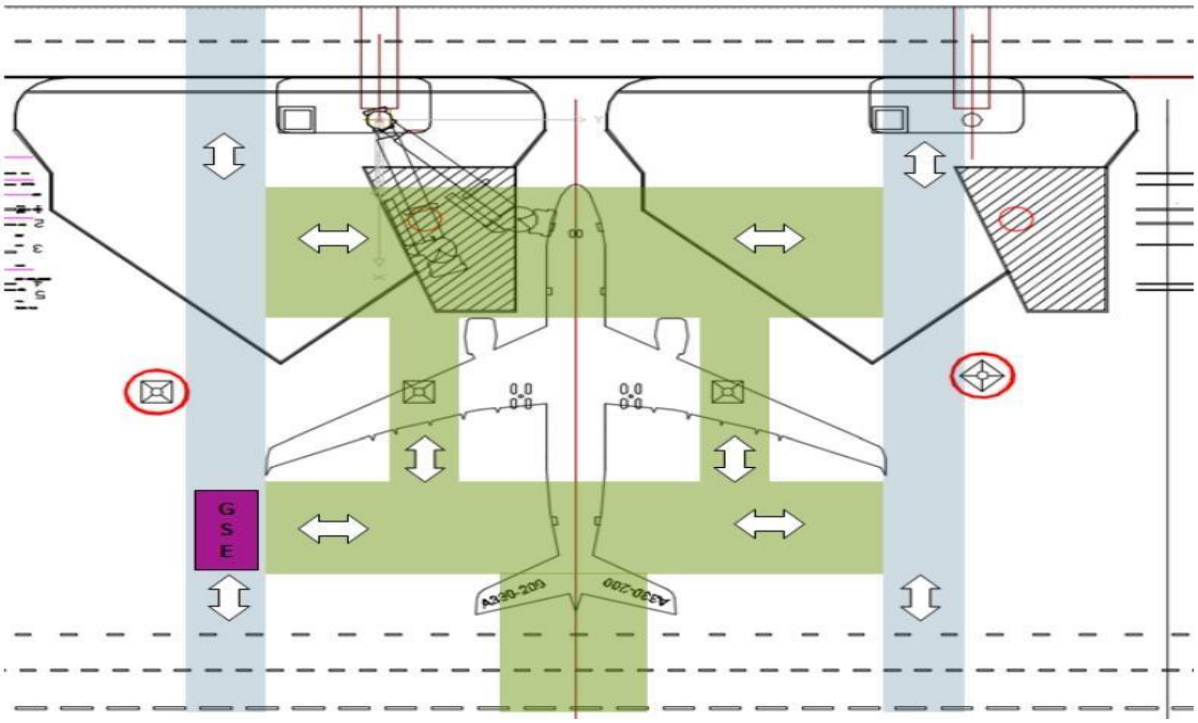

Fig. 2 *A sample of the scheme of the plan of ground movements of aircraft operators with precisely defined rules of movement*
Source: Tabares, Mora-Camino, 2017

With the use of such organized movement and equipment movement routes, the movements are smoother, more systematic, and more efficient compared to unsystematic movement and deviating from the given routes. The idea of this coordinated movement is not new in management systems, but its introduction at all airports, including regional ones, is welcome. To facilitate some tasks, several ground operators also use systems that, thanks to vehicles designed for the transport of cargo, can move entire filled systems from one place to another, which not only saves time but is also very efficient. As it turns out due to the process of modernization and automation of individual operations, ground clearance activities will remain manually controlled for some time, it will be necessary to streamline the handling of individual mechanisms and manage them in such a way that the concept of managing individual related areas is not disturbed. An effective solution is to introduce movement sensing and localization sensors into all mechanisms at the airport, which would be able to monitor movement on surfaces even by mechanisms that will have to deviate from the predetermined path and not disturb or even cause a collision. If the airport would also use the possibility of applying these sensors to the navigation process, it would be useful for the driver of the given mechanism to also perceive the position of other mechanisms and be sufficiently cautious and be able to avoid or possibly make room for another driver who enters the area of his performance activities. The mutual compliance and efficiency of activities would highlight the preparedness and training of the individual participants of ground handling, which would lead not only to fewer collisions and collisions but also to saving time until the participants report a discrepancy or collision on the area or stand and subsequent informing of the control worker and waiting for further instructions and permission to move. Sensors that would work on the principles of the GPS and its location monitoring and position sensing at the airport. It would also be useful to detect and warn of direct obstacles in the vehicle's route, the presence of persons and other workers in the area, who would have a GPS sensor in, for example, a service phone, so that human life and the property of airports and airlines would not be

endangered. The organization and control of individual mechanisms and their positioning thanks to sensors will be from the operations center, in cooperation with the design of the so-called A-CDM management at the given airport. It is a concept whose main activity is the improvement and improvement of operational efficiency, primarily for all participants in air transport (Witrisal et al., 2021).

According to the principles of the A-CDM concept, the task of this operation center will be the following:

- allocation of individual mechanisms to operate the given aircraft, according to the assessment of accessibility and distance to it,
- granting the necessary time to perform the given activity by a precisely allocated mechanism,
- tracking the exact position of all objects on the surface,
- determination of the exact route of movement of individual devices,
- online monitoring and resolution of possible clashes and conflicts,
- coordination of operations with air traffic controllers and others.

As this effective management of ground handling improves the quality of the airport as a whole, it also contributes to the economic prosperity of the airport, specifically by saving fuel and energy consumption, minimizing the workload of the crew and other workers, thus contributing to reducing the burden and excessive stress, as well as to the protection of people and airport property. By using just such concepts and plans, in the future aviation can expect, for example, the re-design of individual ground facilities, whether from the point of view of size, compatibility, efficiency, or equipment. When several inefficient and time-consuming discrepancies are detected, it is necessary to record and resolve all suggestions and apply new proposals that contribute to the quality of air transport in the world through their gradual incorporation (Tabares, Mora-Camino, 2017).

Determining the location of an object using a radio signal is one of the most used options for tracking and navigating objects - airplanes in air transport. Global navigation satellite systems, otherwise known as GNSS, were created to track military objects, but today they are used for civilian cargo tracking purposes and others. However, this system shows errors or signal losses, especially in densely populated areas and cities where the so-called signal blocking. A successor that could track objects without outages or other limitations should be a 5G mobile communication system created as wireless communication for the fifth generation, which could withstand not only heavy traffic in big cities. As airports in the world are expanding and the volume of air traffic in the world has an increasing tendency, the tracking and monitoring of all objects in the areas are proving to be one of the best options for ensuring the operability and safety of all areas, buildings, and objects at the airport. The need to monitor objects in airport areas is very necessary, as it would be possible to monitor the position and displacements on the runway in the case of planned routes, which would be carried out in the case of objects being moved in the processes of ground handling of aircraft, which would be able to inform the driver as well as the control worker about a possible change tracks or deviations. As safety is in the first place, in this way the airport would be able to prevent several collisions that could occur in the areas and prevent them in time (Witrisal et al., 2021)

Tracking the position of ground mechanisms and ground personnel during the performance of aircraft maintenance activities turns out to be one of the reasonable solutions that could not only resolve safety issues but also expend considerable effort in the process of solving the efficiency and optimality of the movements performed by these vehicles. The RavTrack system, which deals with such monitoring and positioning thanks to GPS, seems

interesting. The monitoring coverage would be the entire part of the airport, its grounds, all runways, aprons, and other areas such as the terminal, warehouses, and hangars. This complex monitoring with the help of GPS transponders - trackers and fast updates can monitor every movement of an object in the monitored area. In the case of the airport, the basic rule is to track objects in real-time, which can prevent multiple collisions, if the control worker warns of possible events or objects that stand in the way of the object being tracked. The display of the objects would be on a map that the control worker would watch on the monitor screen. It is questionable whether the monitored objects would use a mobile operator and the associated service mobile phones, or whether the GPS transponder from the RavTrack company would be used. In the case of workers, mobile phone monitoring would be effective, in the case of mechanisms and vehicles using a GPS tracker, which is a small device with easy installation. Since it is possible to apply notifications and changes related to steering management to the system, this system is more than effective. It is not necessary to draw attention to regular or planned movements of objects, but to movements that deviated from the planned movement. The system can also be configured to detect speed or inactivity, track airport logistics, and thus create the most efficient transfers and movements (RavTrack, 2018).

The advantages of the Raveon system are therefore:

- localization of monitored objects and personnel in real-time,
- identification of the worker with inactive objects
- warning in case of exceeding the permitted speed of vehicles or violating of the planned path of the object and others.

Determining the location of a mobile phone would be possible even if every employee had a work phone. The location where the given staff is located could therefore be determined using the network infrastructure, namely with the help of the provider of such services. Position tracking would be performed by a GPS that would be able to record the scanned objects, their movements, and their exact position in real-time. The use of the services of a mobile operator and the use of SIM cards in the airport's service phones would already be in cooperation with the airport and its control and management, but recording the movement and location of the equipment and operating personnel at the current time would greatly improve the management of activities, their planning and overall safety and efficiency of the activities performed. The advantages of these monitoring means are therefore mainly speed, efficiency, and accuracy (RavTrack, 2018).

Fig. 3 *Demonstration of placing the Micro Tracker in aircraft ground handling vehicles*
Source: Abeeway, 2023

A concept that uses the monitoring and tracking of vehicles and other objects on the surface is also a system called SQUID, which is applied and performs its inspection activity at Amsterdam Schiphol Airport. It is a modern broadcasting unit that can improve security at the airport by broadcasting the location of the given object using the ADS-B squitter - an automatic and dependent broadcasting and tracking system that works on the GNSS principle. The unit was designed for the simplest possible integration with the system and the performance of all functions to perfectly record movement on surfaces. The advantage appears to be cooperation with the A-SMGCS system, operation and monitoring in all weather conditions, increased situational awareness, eliminated risk of runway intrusion, and more. The unit that needs to be applied to the monitored object is easy to fix and relatively small. It contains antennas and other electronic devices that transmit position to receivers. By monitoring every movement at the airport and all its surfaces, the system can minimize collisions that could occur between handling vehicles and aircraft. The SQUID system and the NEO system belong to the VTS system - a system for tracking and monitoring vehicles in airport areas, which is intended for management personnel. By purchasing these systems, the airport can maintain the operability of its reserved parts and areas, prevent unexpected collisions, and last but not least, make the work of air traffic control easier (ERA SQUID, 2023)

The NEO system, also known as a surveillance multisensor system, belongs together with the SQUID system to relatively well-known systems that help with the monitoring and control of tracked objects on runways. The benefit of this system is mainly the safety and reliability of the system, the creation under internationally accepted regulations and recommendations, and also the fact that it is possible to gradually increase the modular system (ERA ATM Solutions, 2023)

Fig. 4 *SQUID device*
Source: ERA ATM Solutions, 2023

The management of movements at the airport appears to be one of the reasons that could be addressed in the most efficient sense. The airport must take the proposal of monitoring and tracking the location of objects to solve security, which is one of the most important tasks in air transport. It has been proven that the prevention of possible collisions and conflicts not only on the track but also on other surfaces can be prevented precisely by timely notification and recording of the track, which is monitored by the monitoring system and warns of changes in time. It is about facilitating the work of not only the manager but also about eliminating dangerous situations that could occur in the airport area. It is only up to the airport management whether it can implement these application proposals into its management concept and whether the invested funds will bring the appropriate result, which will improve the quality of not only air transport as a whole but also the operation of the airport and its infrastructure in the perception of passengers.

4 CONCLUSIONS

Optimization processes contribute significantly to the efficient running of activities at the airport, to a thorough process of monitoring, planning, and, last but not least, management. The need for digitization contributes to the facilitation of all activities to an appropriate extent. The use of modern digital technologies consists of ensuring the main priority, namely the safety of the aircraft, the airport, all areas, runways, as well as personnel and attendants. By properly controlling activities and managing ground movements, the infrastructure at the airport can be made more efficient and easier, the costs required for operation can be reduced, ground movements can be managed and monitored, thus preventing dangerous collisions to a large extent, and thus maintaining the operability of the airport at the highest level.

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