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# Improving safety with progressive methods to decrease risks during Ground handling at the airports

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**Abstract**: The article deals with the technical handling of the aircraft from the point of view of safety, as well as the possibilities of streamlining processes using progressive methods. At the beginning of the article, the authors define technical handling and its processes, as well as the view of technical handling from the airport. The following article deals with the view of air carriers on technical handling and ensuring safe handling of aircraft. The third chapter is devoted to the potential streamlining of processes using progressive methods. In conclusion, the authors point out the areas that need to be addressed in future research.

**Key words**: safety, ground handling, aviation

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# 1. Introduction

The safety of ramps is a significant safety issue in the aviation field. Obviously, since the airport's ramp area contains a considerable number of events and movements from different aircraft, vehicles, equipment, and individuals. It accommodates staff and contractors from various stakeholders, such as airport operations and maintenance staff, airport police, emergency services, airport and airline engineers, managers, and other regulatory and security personnel, all conducting regular activities and tasks [1]. Ramp safety rules and procedures increase safe ground handling. All personnel who do the work at the apron (ramp) must always comply with an airline, local airport, and authority regulations to understand the main safety rules and procedures [2].

Aircraft damage can be dangerous for passengers, personnel, aircraft and also have a negative effect on safe airline operations. Small scratches, dent, or any uncontrolled impact to the aircraft fuselage can cause a serious accident. Ramp incidents are known to be one of the industry's biggest problems and are a significant concern for all airports nowadays. Experts agree that ramp damage, usually caused by collisions between ground service vehicles and parked aircraft, is estimated to result in airline losses of more than $5 billion a year [3]. It can also occur in delayed flights, the worst canceled flights resulting in lost revenue from tickets, passenger lodging costs, and extra overtime maintenance costs.

A systematic, pragmatic approach to minimizing the risk and severity of aircraft accidents/incidents on the airfield is provided by the airport safety management system (SMS) [4]. An SMS can have an airport's ability to predict and fix security concerns before they lead to an accident or incident. An SMS also offers management the opportunity to deal efficiently with incidents and near misses to apply useful lessons to increase safety and performance. The SMS strategy decreases losses, increases efficiency, and is typically good for business. Airports, along with airlines, airlines, and aviation service providers, are essential components of the aviation industry. Accident rates will only decrease if each of these components takes measures to improve protection. A connection between safety professionals (focused on accident prevention) and operators is given by SMS (focused on production). This partnership is essential for security enhancement.

## 1.1 What is SMS or Ramp safety from an airport perspective

The ICAO describes a safety management system (SMS) as a systematic approach to safety management, including the organizational structures, accountability, policies, and procedures required. SMS is a method for translating the safety concerns of an organization into effective hazard mitigation measures. An SMS is a business process that differs from other safety systems because it includes:

- Ownership by senior management;
- A risk-based security approach;
- and Incorporation into the organization's entire business structure.

The four fundamental SMS pillars (components) described in ICAO Doc 9859 (figure 1) are policies and objectives, management of safety risks, security assurance, and promotion of safety. There are several elements in each pillar, each representing a particular SMS feature essential to the system. This structure helps to organize and make it easier to understand the SMS functions. Binding these foundations and elements together lead to establishing a positive safety culture in the airport organization. For an effective SMS, a positive safety culture would be more comfortable for the airport to develop [5]. At the same time, a positive safety culture will help establish an effective SMS.

There are two principal objectives of an SMS. The first is to reduce safety risks to a level as low as reasonably practicable for passengers, aircraft, staff, and property (ALARP). The second is to support executives with their ongoing task of managing costs, activities, and protection. Hazards are detected and evaluated with SMS to bring about safety goals and projected costs for those required to handle the threats. Risks are rated, and it is time to match the number of operations with the level of safety when considered unreasonable.


**Figure 1** SMS fundamental pillars

It is wiser to stop operations under those conditions and clean up a movement area with foreign object debris (FOD) than to resume operations. Airport ramps are naturally dangerous and undoubtedly not due to a single risk. Unlike highway staff, wherever traffic is moving in only two directions is usually isolated from the danger. Airports ramps are multidimensional workspaces that have dozens of moving components literally, and those move nonstop. It is always dynamic and always moving place [6]. However, if one factor in almost all accidents is a weak link, it is poor communication. This aspect is typically similar to the root cause, whether it is a total lack of contact between workers or a breakdown of existing communications.

An SMS offers reliable information that allows airports to identify and prioritize safety needs and choose cost-effective strategies to improve their operations' safety. One size does not suit all in safety management. To understand their individual needs, interests, goals, and capital level, airports should customize the implementation process [7]. The SMS may be viewed as a tool or a set of techniques to assist in management's decision-making process. Based on actual conditions, it aims to provide consistent and accurate details. It is the connection between the management of airports and the world of security data available to support their decisions. Airport management will decide which ones should be handled first to the threats it has found. Besides, managers can find out when and how to take steps to reduce these risks. SMS's idea grew out of the Plan-Do-Check-Act (PDCA) method, also known as the continuous improvement cycle of Deming. Initially, the term represented in Figure 2 was used in quality control and formed the current ISO 9001 international quality standard.

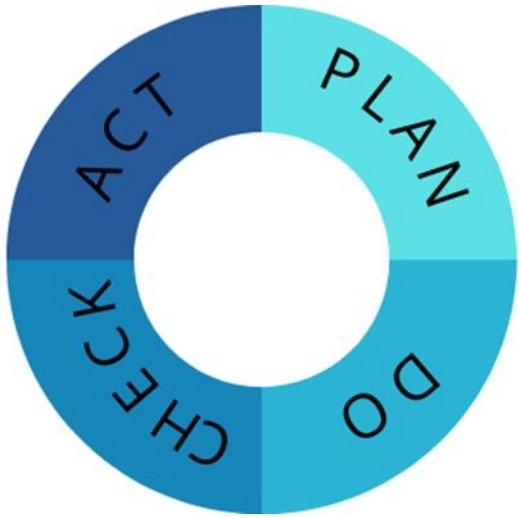


**Figure 2** PDCA cycle

A safety management system provides airport staff with a comprehensive way, when properly implemented, to continually track and optimize procedures and activities that impact both safety and operational efficiency at the airport. It is actively running and needs all airport staff to be engaged. If built on existing practices and adapted to the scale, complexity, form of service, safety culture, and operating environment of the airport, an SMS will be most successful. It is necessary to recognize the SMS processes that airports already have before developing SMS; this is called gap analysis. Airports could be surprised to discover out how much at the airport they already have. Besides, as part of the required regular self-inspection, they already have some proactive hazard detection procedures [8]. There are systems of paper and records management in many situations. Some airports also have more extensive management systems, such as environmental and wildlife management systems, which can be modified or created using similar processes to deal with safety problems.

Some airports may limit the SMS scope to airside operations and later expand the capacity to landside and terminal operations. Other airports can, from the very outset, identify their SMS scope for all airport activities. In both cases, the initial performance of the SMS is crucial to a strategy and a comprehensive approach for implantation.

A safety policy is a clear indication of dedication to safety by management. It should be published widely. The safety policy should be sufficient for the airport's size and complexity and should usually include at least the following elements:

- A commitment to make safety the top priority
- Senior management's commitment to implementing SMS
- A commitment to constant improvement in safety
- Employees' encouragement to report safety issues without fear of reprisal
- A commitment to providing the necessary safety resources
- A commitment to comply with all airport operational, regulatory requirements

When we are aiming at a target, most of us respond to a challenge and perform better. Practices in the management system understand this and require organizations to set goals for themselves. Such aims need to be measurable or have corresponding goals. In addition to airport and SMS best practices, these priorities and targets help focus the management system. An objective is a statement of the desired outcome. It is possible to determine

whether the airport made the expected progress with an established purpose. It will be able to monitor progress in certain instances as the airport move towards the goal. Management needs to know the current situation before setting a goal or target, which may require some data or statistics. Since these targets need to be observable, a safety performance indicator (SPI) associated with the objective needs to be established. An SPI is any variable used for the calculation of safety level shifts. The overall airport goals can also be accomplished by meeting different tax objectives and targets from departments and parts of the airport. The application of SMS at the airport, even for ramp operations, is essential from many perspectives.

## 2. Ramp safety from an airline perspective

The airline station manager at the airport needs to manage the prevent damage to the aircraft, do and move forward actions that are specially made to increase ramp safety, personnel instructions about hazards on the ramp and related safety regulations, briefings of personnel, and awareness on-ramp safety and correct reports and subsequent inspections of all incidents that have a negative effect on-ramp safety. Main safety measures in general for all ground handling personnel including the third party involved in aircraft handling must be made aware of their responsibilities. During the handling procedures only adequately trained, qualified and authorized personnel are permitted to operate equipment and vehicles.

Each parked aircraft has unmarked security zones known as "safety circles" (figure 3) designed to prevent ground service equipment (GSE) damage. The outer safety circle stretches from the plane five meters forward. Before crossing this hypothetical boundary, vehicle drivers must test their brakes. The inner safety circle is 2 meters from the aircraft and shows where drivers are expected to stop their vehicles at a slow pace before resuming their approach to the plane.

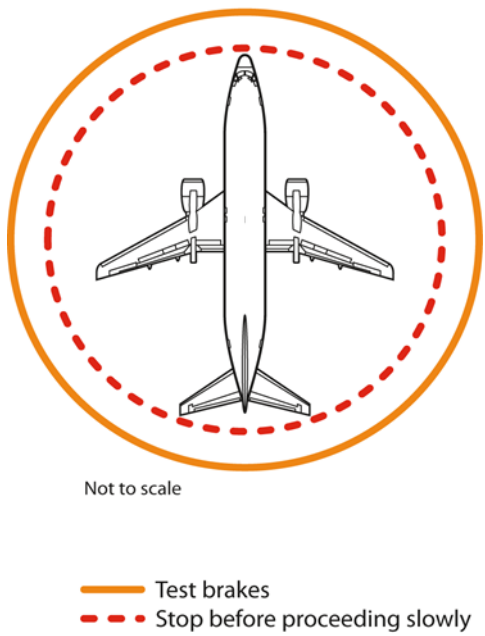


**Figure 3** Safety circle

Equipment Restraint Area (ERA) is defined as the area at the apron in which the aircraft is parked during ground operations and it may be indicated by a painted line. Figure number one provides an example of the markings and areas. Also, is very important to prevent accidents, injuries of persons, or damage of aircraft and equipment that are

caused by oil, ice, snow, or Foreign Objects Debris (FOD). The personnel needs to check the ramp surface frequently and remove any contamination immediately. The second step is also to check the aircraft if all compartment doors and doorframes show no visual damage during unloading. The handling personnel needs to check also the compartment floors, walls, ceiling, panels lock, etc. to show no visual damage.

### 2.1 Danger areas

There is a particular risk of blast damage or injury from the exhaust or intake of an aircraft engine. The risk increases more if an aircraft stops, then give the necessary thrust to break away and continue to maneuver. For ground handling personnel is very important to adhere to the main rule when the aircraft engines are still running and anti-collision lights are on, personnel, vehicles, and equipment must remain clear of the aircraft danger areas.

Before or during aircraft arrival and departure never stay or place the equipment in these danger areas until the engines have been switched off, are spooling down and anti-collision lights are off.

Location of danger areas:

- Engine blast areas,
- Engine intake areas,
- Propeller rotation areas (Propellers must come to a complete stop),
- Fueling safety zone (FZS).

The dimensions of these areas vary for each aircraft type. When we give an example the engine blast area in a turboprop plane (ATR72) is smaller than in a classic jet engine (Boeing 737). The explanation is simple in the power of the jet engine which is more powerful than the turboprop engine. Figure number 2 shows the intake and engine blast area for jet engine aircraft.

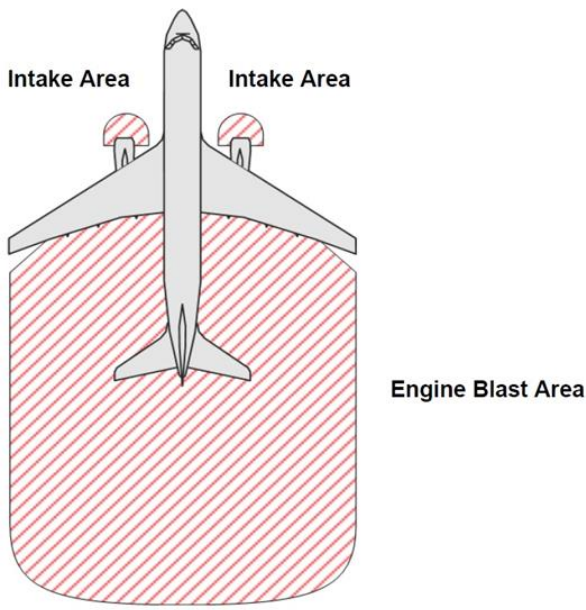


**Figure 4** Apron markings areas

The engine intake area is the hazard zone in front and sidewards of the inlet of the running engine. The suction can be sufficiently strong to pull a person of objects towards the inlet.

Engine blast area is the exhaust area at idle and roll-off thrust behind the aircraft engines. The engine thrust can vary according to weather conditions (wind, ice, and snow), tarmac surface (inclination), and the velocity of the aircraft. Objects which can pose a danger to the safety and integrity of an aircraft and which must not be left in any area where they would constitute a hazard is called FOD the Foreign Objects Debris (examples plastic bags, tools, and equipment, nuts, rocks, wood, baggage handlers or wheels, etc.). The main aim for all personnel is to keep the risk of damage to the aircraft by FOD to a minimum. The main caution sign that belongs to these problems is the safety cones which indicates the dangerous areas for handling personnel in any procedures on the ramp. Safety cones are used to establish protective zones around specific aircraft areas, especially engines and wingtips, and to prevent ground accident damage Also, the safety cones are used for drivers to hold the necessary safety clearances. Figures 4 and 5 show the main position of safety cones and positions of safety cones after arrival.

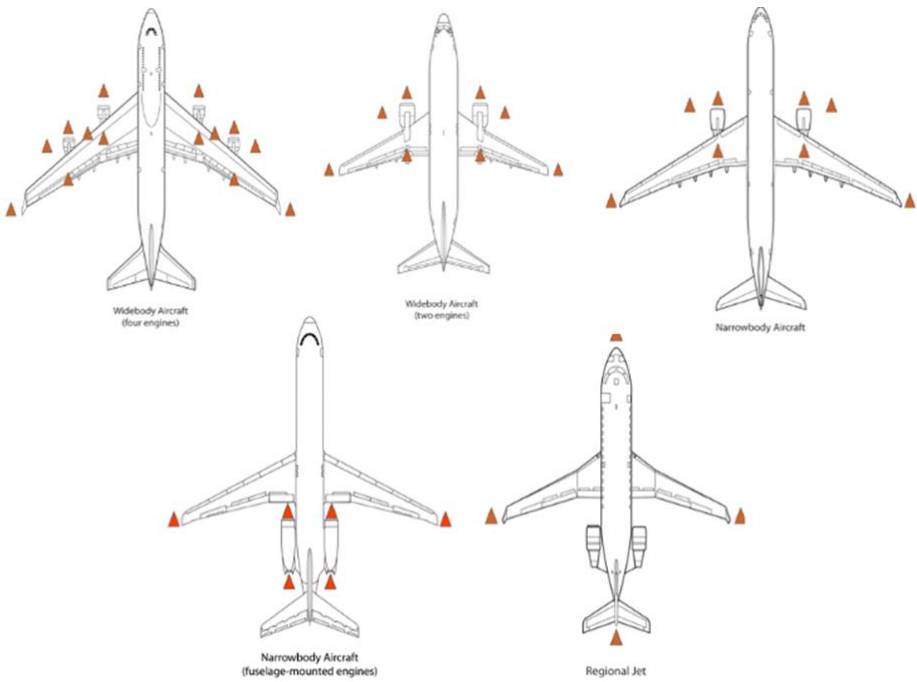


**Figure 5** Safety cones positions

After aircraft arrival, the handling personnel needs to place the cones in prescribed places for aircraft protection. They have to place the cones at sensitive parts or areas of the aircraft (ramp traffic, equipment flow), minimum at wingtips and engine inlets. When the plane is ready for departure the safety cones must be removed when all Ground Support Equipment has finished the activities around the aircraft. All safety cones must be designated in a safe storage area and also a safe distance from the aircraft.

### 2.2 Ramp safety rules

For all operations on the ramp, the following rules apply:

- Always be careful of your surroundings.

- Always wear personal protective equipment (PPE)
- No smoking.
- No alcoholic beverages or other substances that are likely to impair efficiency or judgment, legal or illegal,
- No rough or noisy play; practical jokes can cause injuries or injury.
- Report any injuries, equipment failures, and near-collisions to a supervisor.
- Do not operate any equipment declared to be unserviceable.
- Keep the ramp area free of debris from foreign objects (FOD).
- Only a qualified operator can drive or use the controls of a vehicle.
- Still respect speed limits.
- Never try to get on or off a moving car; wait till it stops.
- Never carry co-workers on vehicles unless seats are available.
- Do not operate vehicles or equipment under the aircraft's fuselage and wings in the no-drive zone. Loading/unloading of some narrowbody containerized aircraft can involve vehicles or equipment between the inboard engine and the fuselage; great care must be taken to prevent engine or fuselage contact.
- Never drive over static leads or fuel hoses.
- With the rear van body lifted, reducing the distance a high-lift vehicle is pushed.
- Never turn a vehicle back toward an aircraft unless there is a marshaller and the view is clear.
- Near moving aircraft, be very careful; they have the right-of-way.
- Avoid aircraft engine intake and exhaust zones.
- When walking under any part of an airplane, use extreme caution.
- Wait until the anti-collision beacon on the aircraft is off before approaching the plane.
- If the aircraft's anti-collision beacon is on, never attempt to load late-arriving luggage.

## 3. Utilization of progressive methods in the ground handling area

In the field of technical handling of aircraft, there is a noticeable constant effort to constantly develop and implement progressive techniques to ensure the highest possible level of safety. Ensuring the maximum level of safety can be considered a top priority in aviation. As the technical handling of the aircraft involves the movement of airport staff or the company that provides this technical handling in the vicinity but also the aircraft, as well as the handling of the aircraft, there is an increased risk of security breaches. Individual tasks require precise execution and comprehensive training of employees, which will provide employees with the necessary knowledge and skills for flawless handling. The experience of the employees who perform these activities also plays an important role here. These are, of course, obtained through many years of experience, thanks to the implementation of progressive methods within the training and education of employees, selected technologies to provide an alternative. At the same time, the most well-known technologies govern virtual and argued reality.

Virtual reality finds the greatest application not only in aviation but also in many other sectors in the field of training. This is a revolutionary tool that, if implemented correctly, can significantly increase the qualifications of workers. The biggest advantage is that the user is immersed in the virtual world. The degree of immersion depends on many factors, such as hectic or sonic sensations, but a combination of several factors is usually used to achieve full

immersion. According to the degree of immersion, ie immersion, we can divide virtual reality systems into several subsystems. These are shown in figure 6.

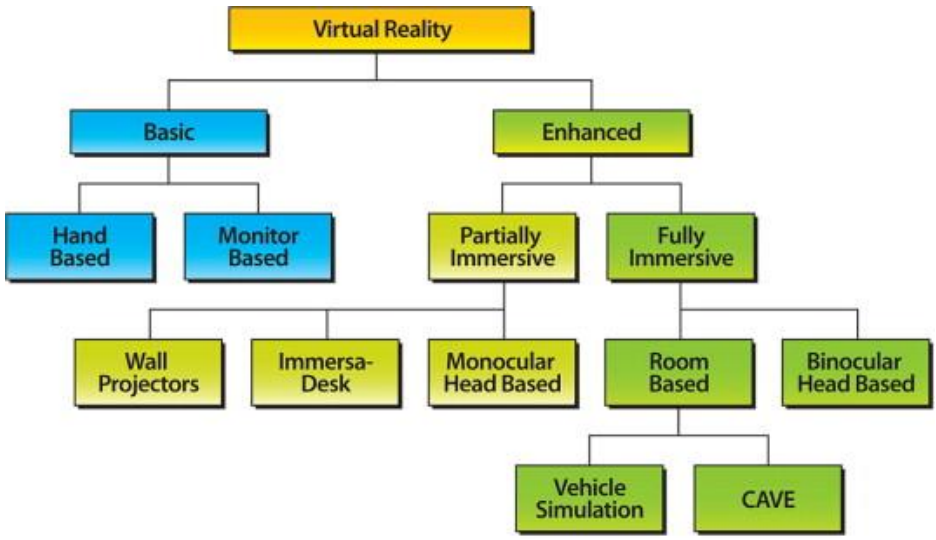


**Figure 6** Typology of VR system based on the level of immersion

For use in this particular case, technical handling, the head-mounted device, (HMD), is important. It is a headset with an implemented display that allows the user to immerse themselves in the virtual world. In training, this will help especially in the fact that workers can practice various situations, including those with which they would really come into contact only very unlikely. Another advantage is the feeling of security for the user. He is aware that even in the case of an error that would in reality mean high damage to aircraft, in the virtual world, such an error has no real impact. Since in the real world, each error has the potential to cause operational irregularities, for example, if the aircraft is damaged during handling, the flight may be canceled as a result, the work of technical handling is also psychologically demanding. Since stress and psychological stress have a negative effect on the human factor in aviation in general, not only in technical handling, newcomers in this industry may make mistakes more often in training or coaching, or there is more room for error. With the use of virtual reality in staff training, this problem could be minimized or eliminated, because any interaction of staff with the aircraft in a virtual environment is safe. Awareness of this experience helps the mental well-being of employees, who do not have to be under constant pressure. They can practice individual situations reliably and only when they have mastered them can they perform them safely in real situations. However, this method of training also has negative aspects. Because employees are freed from unnecessary stress when training in a virtual environment, this can deter them from being vigilant when experiencing these situations and activities in a real environment. This risk can be eliminated by implementing a system of evaluation of employees during training, which leads to healthy stress, as small and manageable doses of stress can increase the performance of human workers, or are more vigilant and thus perform individual activities safer.

As for augmented, and therefore augmented reality, its use in the field of technical handling is much more practical. Many global hub airports already use these technologies, especially in the field of maintenance but also in technical handling. In augmented reality, based on the integration of digital information and stimuli into the real world, usually through glasses or other media on which this information can be reflected, the spectrum of use is much richer. A fundamental problem in the past, which has hindered the full use of AR in many industries, is the need to introduce guide marks, so-called markers, for individual objects. These markers are also currently needed in some species and subsystems of augmented reality. Markers as guide marks, for example also in the form of a QR code, serve to elicit the desired reaction in a system that uses augmented reality and sensors to detect this mark. For

example, if a guide mark has been placed on an aircraft wheel, the system is capable of generating a digital wheel model along with associated information from the sensors of that particular aircraft wheel.

The glasses thus display the digital parameters received from the server to which this data is sent by the on-board computer of the aircraft. However, the need to place markers was a significant limitation, especially since if the marker was damaged, the system failed to elicit the correct response. It is also impractical to introduce markers on various pieces of aircraft and aircraft parts. However, with constant technical development, a solution has emerged. It is an augmented reality that does not need guiding marks. It works on the principle of connecting to a server that receives data about the surroundings and objects captured by the user using a camera and then uses a contour detection system to retrieve an object from the observation system. In practice, this works by the system scanning the scanned object, analyzing it, and then evaluating its parameters. From the database of the server, its digital model is selected, which is selected based on the evaluation of dimensions and other parameters. This greatly simplifies the process of receiving information from employees. In technical handling, it is thus possible to use augmented reality to call up, for example, data on the number of passengers and arriving luggage only by scanning, for example, the designation of a given line. Subsequently, the information that is displayed to the user on the augmented reality glasses is extracted from the system. This information can be enriched, for example, by the number of passengers with specific requirements or passengers in need of assistance. One of the most well-known technologies with implemented augmented reality is AR glasses called hololens. These are shown in Figure 7.


**Figure 7** HoloLens

They can be precisely calibrated and adjusted exclusively for the needs of the client, meaning that each glasses are specifically programmed for use in a specific sector. They will thus significantly facilitate the performance of individual activities for technical handling workers, especially by minimizing the time for the transmission of information. In this work, adherence to the time horizon is a key element that has an impact on the safe and smooth operation of the airport. In case of delayed transmission of information, this can have a negative impact on the overall operation of the airport, which can have a so-called domino effect, where a delay of one flight can cause delays of others, or delays at airports to which the route had a destination. . The use of AR would eliminate this problem, as all information transfer would be fully automated, with individual information being displayed automatically from the server. Glasses with implemented augmented reality technology can also be controlled by voice, so the user can request the display of a wide range of information that he needs at the moment. This also helps to make a correct and timely decision when the user is provided with the necessary information almost immediately. The disadvantage of this system is that in the event of a network failure or network error, the overall use of the system is minimized, or

information retrieval is impossible. However, the advantages of the AR system far outweigh its disadvantages. A practical example of use is marshaling or guiding an aircraft to a stand. Using a specific algorithm, the employee is shown data about the assigned stand, as well as the route to it right on the glasses, so he does not need to obtain information from the dispatcher.

## 4. Conclusion

Most airports believe that the measures they have taken have been adequate to enhance ramp safety. But that belief could be ill-founded unless they have implemented a safety management system (SMS). When ensuring security at airports, it is necessary to think globally and focus on the entire airport, not just on the selected ramp area. All airports should have a Safety Management System (SMS) in place within their organizations. The SMS ensures safety in air transport by proactively identifying and mitigating or decreasing safety hazards. Furthermore, the SMS pilot studies and the large number of safety incidents occurring in the non-movement area support extending SMS to the non-movement area to ensure air transport safety [9]. An SMS is an approach that differs from other safety programs because it includes control by senior management, a risk-based approach to safety, and integration into the organization's entire system. Safety management systems differ amongst organizations, but they all involve the following key components: planning, documentation, safety oversight, risk management, and program surveillance and control. All these components provide a quality system that can support each process and ensure its safety. The airport can effectively integrate the SMS programs into the ramp area, provide implementation plan efforts, and apply the four SMS parts, including Safety Policy, Safety Risk Management, Safety Assurance, and Safety Promotion. Ramp safety is a significant safety matter in the aviation industry [9]. The reason is simple: the airport's ramp area involves many activities and movements from aircraft, vehicles, equipment, and people. Considering the level of aircraft activity, the complexity of work tasks, and the tools used in servicing aircraft, ramp operations, and workers can face various safety concerns and hazards. Still, a safety management system is an acceptable form of improving the whole ramp service and ensuring safety without risks and accidents.

At the article beginning, we focused on clarifying the issue of maintaining safety during ground handling procedures at the airport. Most airlines are represented at the airport in the form of an airline station manager, who oversees compliance with procedures and safety during handling. Airports shall comply with the markings required to maintain safety at the apron [10]. The essence is to monitor any anomalies in the area that could cause damage to the aircraft and endanger lives. During the aircraft handling processes each employee needs to know the zones where and under what conditions in the vicinity of the aircraft he can perform his activity. The basic rules define access to the aircraft after turning off the engines and turning off the anti-collision lights. The most dangerous zones are the engine intake area and the engine blast area, which define safety distances for different types of aircraft. The article's main aim is to discuss safety rules during the technical handling of aircraft regard to work safely and avoid damage to aircraft.

Regarding the progressive methods and their implementation into the technical handling and ground handling processes of aircraft at the airport in general, this direction represents significant opportunities to streamline individual processes and at the same time increase their safety. In the performance of individual activities and the handling of aircraft, augmented reality represents the greatest benefit in this area. With its help, immediate transfer of data and information from databases and servers directly to the user's glasses is possible, which has a great impact on the overall duration of the process. Virtual reality as the second most potential progressive method can be used in staff training. Within the framework of training and guidance with the help of virtual reality, it is possible to remove negative stress factors affecting participants and subsequently streamline the entire training process. Without the influence of stressors, trained workers will be able to learn new knowledge more easily and thus prepare for its real implementation. However, further research is needed in this area and its implementation in aviation processes.

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