Anita Linka
Mgr inż.
Politechnika Poznańska, Wydział Maszyn Roboczych i Transportu,
Katedra Techniki Cieplnej
Anita.d.linka@doctorate.put.poznan.pl

Agnieszka Wróblewska
Dr hab. inż.
Politechnika Poznańska, Wydział Maszyn Roboczych i Transportu,
Katedra Techniki Cieplnej
Agnieszka.wroblewska@put.poznan.pl

Increasing safety level of airport ground operations by implementing an autonomous system of supervision and security

Abstract: This article describes the Ground Safety (GS) system and shows the possibilities of its use. System is dedicated to the supervision of the airport's ground space. GS enables comprehensive control and traffic management on the entire port area. In addition to real-time supervision, it is possible, among another, to archive and restore data preserving its integrity, two-way communication, and also bulk messages broadcasting. The equipment of the airport guests in the transmitter allows constant access to its basic parameters and current position. The article describes the possibilities of reducing the risk level of occurrence dangerous and undesirable incidents. It also shows how to increase the overall security of the unit.

Keywords: Safety of aviation; Airports; Satellite systems
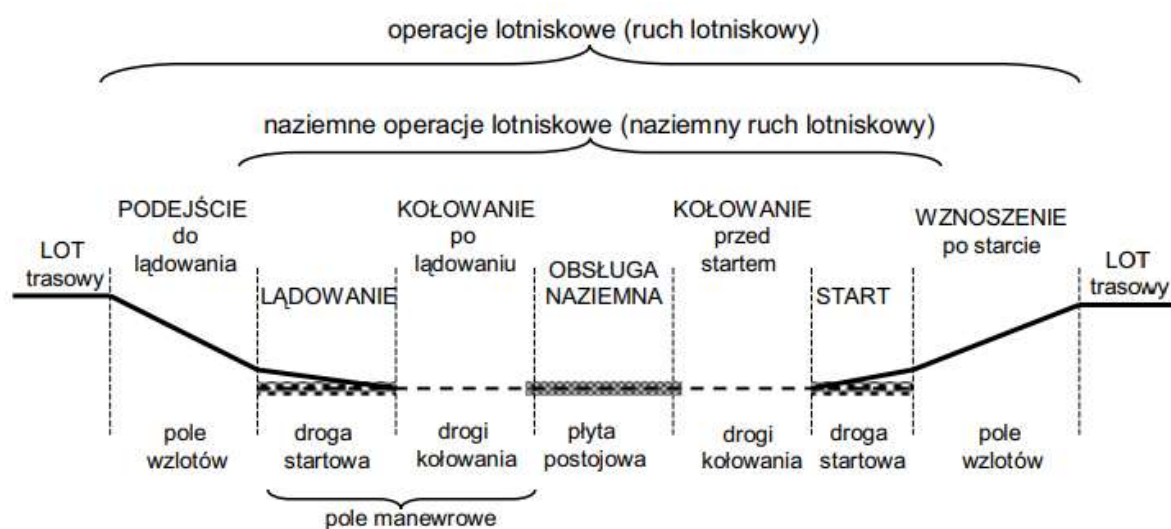
Introduction

The authorities and institutions of every type of civil aviation (including linear, general or sports aviation), as well as the military as the main priority of their activity, are the safety of all air and ground operations that make up the success of an aerial task. The proactive policy currently used most often in organizational units consists of preventing and preventing dangerous situations. A proactive method is a new approach to avoid losses in people or equipment as well as minimized environmental damage by using safety management systems [14]. Hence the necessity to thoroughly control each stage of the aviation task being prepared. Starting from the technical condition of the aircraft, through its transport to the plate, loading up to the flight itself. It is extremely important to carefully examine every aspect that may be the cause of an event that will lead to undesirable events.

Airport ground operations

When describing the scope and area of execution of airport ground operations, it is necessary to start by providing several definitions. This will allow you to organize general knowledge in the discussed area. Starting from the most general, but necessary to further consider the definition of "airport", and ending with a detailed discussion of the types of ground activities performed in its area.

Airport in accordance with art. 2 para. 4 of the Aviation Law Act (Journal of Laws 2006 No. 100, item 696, as amended) is a separate area on land, water or other surface, in whole or in part, intended for take-offs, landings and above-ground aircraft movements, including with permanent building objects and equipment, entered in the register of airports

[6]. The airport consists of two basic areas, i.e. air and service. The aerodrome part of the airport in accordance with art. 2 para. 6 of the Aviation Law Act (Journal of Laws of 2006 No. 100, item 696, as amended) is a permanently designated area for take-offs and landings of aircraft and for related aircraft traffic, together with devices used to service this traffic, to which access is controlled. This area is thus: a field of ground air traffic (maneuvering area) and parking aprons. The service area, on the other hand, is the total of airport services (including flight control towers, fire brigade, and others), parking lots, terminals, fuel facilities, and communication systems. The maneuvering area is called the area intended for traffic associated with the takeoff, landing, and taxiing of aircraft [6]. The airport operations (Figure 1) are referred to as any movement in the maneuvering field and near the airport, i.e., among others, takeoffs, landings, taxiing, as well as ground handling [9]. Air Traffic Services (ATS) is called a set of activities and services performed by appropriate authorities, the purpose of which is to ensure the safety of crews and passengers of aircraft during the flight and maneuvering at airports. The authority responsible for the management of air traffic services is the Polish Air Navigation Services Agency (PANSA) acting under the authority of the Minister of Infrastructure [13].

1. Schematic summary of airport operations [9]

Ground operations airport means all activities carried out in the maneuvering area, aprons and taxiways. Such activities include many activities of services supporting the work of the airport. These services often move in the maneuvering field. Pursuant to the Regulation of the Minister of Transport, Construction and Maritime Economy of 19 November 2013 on ground handling at airports, 11 categories of ground handling services can be distinguished.:
1. Service in the field of ground administration and supervision,
2. Passenger service,
3. Baggage handling,
4. Service of goods or mail,
5. Disc service,
6. Aircraft service,
7. Service in the field of supplying aircraft with propulsion materials,
8. Maintenance in the field of aircraft maintenance,
9. Operation in the field of air operations and administrative activities related to the crew,
10. Surface transport,

11. Service in the field of on-board supplies of aircraft with food and beverages (catering) [2].

All the above-mentioned services move more or less around the airport's maneuvering area. Therefore, it is necessary to accurately plan and coordinate all their movements to reduce the dangers. As part of one flight operation, many services must reach the plane. An example may be tracing the handling of the Airbus A 320 passenger plane at Balice Airport from 07/23/2012. The deck is filled with 183 passenger seats, and the machine itself is powered by two 2 x CFMI CFM56-5B4 / P engines. Upon arrival with almost full local occupancy, the plane taxied to the designated parking space. The first vehicles that appeared next to the machine are traps (stairs for passengers) at the front and rear doors and two empty buses that will transport travelers to the terminals. To the right side of the plane, they drive a service car of the company that runs comprehensive handling services for the carrier at this airport. In addition, there are 4 vehicles transporting passengers' luggage (Figure 2). The next vehicles appearing next to the machine are the fuel distributor and fire brigade, which will secure the refueling process. After emptying the plane from the passengers another bus comes - with other travelers. There is also a tractor vehicle (so-called pusher). Two more buses arrived - a total of 170 people. When everyone takes their seats, the plane is pushed out by an airport tractor, which is supervised by an additional employee observing the surroundings and being in contact with other services and crew (the so-called marshaller). The whole procedure, from the start of unloading to the start of the runway, took 38 minutes [7].

2. Ground passenger service of a passenger aircraft [7]

As you can see, not only many vehicles, but also numerous employees moving on the maneuvering field take part in ground-based services. Coordination and supervision over the whole movement are therefore difficult and impossible to document or reconstruct. Often the only medium connecting employees at various levels are walkie-talkies or simply visual impressions consisting in observing the surrounding terrain. It can not be forgotten at this point that man is the most unreliable element of aviation [8], [1], [5], so his actions should be controlled and supported most precisely.

Security and surveillance systems for airport ground space

Flight safety is defined as a set of properties of a given system, which creates a relatively small possibility of occurrence of events that prevent flight performance (including air accidents and incidents). Pursuant to Article 134 of the Aviation Law of July 3, 2002, "an aviation accident is an event related to the operation of an aircraft that has occurred since any person has come on board with the intention of flight are until all persons on the aircraft have left this aircraft and during which:
1) any person has suffered a fatal injury (...),
2) the aircraft has been damaged or its structure has been destroyed (...),
3) the aircraft has been lost or is in a place where access is impossible ". Under the Act, an "incident" is an event other than an aviation accident associated with the operation of an aircraft that affects or could affect its safety [12], [4].

Security according to Gen. Jerzy Lewitowicz is conditioned by a set of factors between which one can be mentioned:

- failure-free aircraft and ground-based measures to secure flights,
- susceptibility to repair, repair and maintenance of SP,
- professional liability of flying personnel and ground maintenance personnel,
- providing flying and ground personnel with necessary information on the condition and parameters of SP systems and instrumentation,
- the efficiency of flight control and radio communications,
- the efficiency of meteorological security measures,
- equipping with emergency and rescue measures,
- jobs preparation,
- the load on flying and ground personnel during the working day [10], [11].

The start of intensified work on the creation of the airport space control system took place after a fatal collision, which occurred in 1977 at the airport of Tenerife. In this disaster, two personal Boeing 747 Jumbo collided with each other, and a total of 583 people were killed. The accident was hailed as the most tragic in the history of aviation. The causes of the event were given a combination of several factors, including human, technical and environmental (bad weather - low visibility on the disc). This accident has affected airports managing organizations and legislators. As a consequence of this disaster, communication systems and regulations governing air traffic in bad weather have improved [3]. Since then, ways of managing and supervising the terrestrial space of airports and airstrips have been constantly developed. An additional factor motivating actions in the area of supporting airport traffic is the desire to optimize the capacity of the port. Moderation of its size is closely related to the number of operations performed, and hence the financial revenue for the port. The increasing demand for the use of air transport has encouraged the search for new methods of time management, safety, and precision of air and ground operations.

In aviation, safety is a particularly important phenomenon. The risk and threat are constantly present in the flight safety system, and the criteria for the construction of technical equipment and actions are taken for safety are usually exacerbated only after an accident or a serious air incident. Interesting both the passenger and the crew of the aircraft. The methods of ensuring security are largely determined by the success of civilian and military systems [4].

An autonomous system of supervision and security of ground airport operations
In 2013, a team of scientists and pilots started working on the creation of a system that will enable ongoing control of the airspace, in particular during the performance of aerobatics. At the end of the project, the authors noticed the changing needs and requirements of airports. In response, they developed the first prototype of the system, which was to control, register and visualize the current position of all areas of the communication port. The software was called Ground Security. The software optimization process did not stop after the completion of the

project co-financed by the National Center for Research and Development and the European Union. To this day, a team of specialists is working on creating a system ideally suited not only to the needs of modern aviation but also going to many other industries. The new version of the system was called Ground Safety (GS).

The idea behind the system is to send real-time information about the location and basic parameters of vehicles, people and aircraft in the area of the observed location. Data packets are sent by radio from transmitters to receiving stations. The most popular ISM bands 868 MHz and 433 MHz, as well as 2.4 GHz, are used depending on the current signal propagation conditions. The proprietary communication protocol protects information using the latest methods of strong cryptography using hardware cryptographic coprocessors embedded in transmitters. Especially for the needs of the system, a new method of securing historical data was introduced, based on the Blockchain method, practically preventing any interference with the integrity and credibility of the stored information. The data is also collected in 3 independent warehouses: in the system database, in the data carriers of the receiving stations and data carriers embedded in the transmitters. The advantages of the GS system over other airport space surveillance systems are many. One of the most important is certainly the small infrastructure and low implementation and operation costs. Compared to expensive radar systems, GS operation in a minimal configuration is sufficient to install the receiving antenna together with the base station, equip the vehicles and employees with transmitters, and connect the system to the Internet. This solution allows the implementation of an excellent tool for the comprehensive supervision of the entire space with minimal financial and infrastructure investment. Of course, the system can be installed autonomously in a closed network when needed.

As mentioned earlier, the components of the system are mobile transmitters, a receiving station with a set of antennas and a system console in the form of an application working in a web browser (Fig. 3).

The most important functions of the system are:
- Real-time visualization of the position and basic parameters of employees, vehicles and guests
- Ability to play historical record
- Possibility to designate zones within locations of any shape
- Possibility to assign restrictions for created zones (e.g. speed limit, no entry for an employee or group)
- Ability to reproduce the image on mobile devices and outside the location
- Logging in to the application only for authorized users
- Possibility of mutual communication with employees (sending text messages to individual employees, groups or all active in the zone, receiving messages from employees, sending an employee's SOS signal)
- Data archiving within servers (via the application) but also within the memory card of transmitters and base station memory cards
- The signal sent from the transmitters to the base station is encrypted with the original method - no possibility of interception or data tampering.

3. An application that visualizes the position of vehicles and airport employees.

The transmitters are equipped, among others, with radio antennas for LoRa bands, Bluetooth, GPS, IMU sensor with 10 degrees of freedom, equipped with an accelerometer, magnetometer, and gyro-compass. The whole was closed in a sealed housing that complies with the IP56 standard. Modules can be placed in vehicles or in multifunctional vests, which are equipped with all people working in the area of airport traffic. In the case of visits of people and vehicles outside the port, every guest present at the airport would also have a transmitter, thanks to which it would be possible to control the route of their movement.

As part of the application, it is also possible to visualize the position of aircraft by retrofitting the receiving set with an ADS-B antenna. The integration of all vehicular traffic significantly increases the level of security of airport ground operations. The controller supporting the application may not only observe the entire airport, but it will also be informed lightly and audibly in the event of danger (minimizing the risk of overlooking unauthorized movements). He can also delegate responsibility for individual areas to subsequent managers. Thanks to the inclusion on the Internet, it is possible to restore the application in any place and time (after logging in at that time).

Registration of dislocations takes place simultaneously and independently through three sources:

- application - recording on servers,
- memory card - recording within the memory card placed in the transmitter,
- base station memory card - recording data from transmitters in its range.

Summary

Aviation is a specific area in which changes and restrictions of regulations are often the results of accidents or incidents that have occurred and have not been predicted. Therefore, authorities around the world are trying to tighten laws and regulations so as to ensure the greatest possible safety for passengers, crew and ground handlers. One of the most current requirements introduced by air traffic management units in Europe is the need to supervise ground airport traffic. An ideal tool for civil aviation is the Ground Safety system, which has

been completely designed in Poland. The software allows not only to carry out real-time control but also to register all events, restore them and make the view available to all mobile devices. Safety is not a matter of chance - it is a series of preventive measures aimed at effectively reducing the level of risk of adverse events.

Source materials

[1] Compa T., Kozuba J., Pila J., Czynnik ludzki a poziom bezpieczeństwa realizacji zadań lotniczych. Logistyka 6/2013, str. 72-83

[2] Dziennik ustaw Rzeczypospolitej Polskiej, Warszawa dnia 25 listopada 2013 r., poz. 1378, Rozporządzenie Ministra Transportu, Budownictwa i Gospodarki Morskiej z dnia 19 listopada 2013 r. w sprawie obsługi naziemnej w portach lotniczych

[3] https://artelis.pl/artykuly/22790/Teneryfa-1977---Najwiekszy-Wypadek-w-Historii-Lotnictwa-Cywilnego

[4] https://docplayer.pl/20907206-Naziemny-system-detekcji-pasow-startowych-i-drog-kolowania-asde-a-bezpieczenstwo-w-ruchu-lotniczym.html, dostęp 20.07.2018

[5] https://dyskusja.biz/gospodarka/najslabsze-ogniwo-to-jednak-czlowiek-2-50343, dostęp 20.07.2018

[6] https://www.polot.net/lotnisko_ogolnie_czesc_1, dostęp 13.07.2018

[7] https://www.polot.net/lotnisko_ogolnie_czesc_4_plyta_postojowa_i_inne_obiekty, dostęp 16.07.2018

[8] Ilków A., Czynnik ludzki w systemie bezpieczeństwa ruchu lotniczego. Prace Instytutu Lotnictwa, Warszawa 2011, nr 211, s. 99-119

[9] Kwasiborska A., Malarski M., Prace Naukowe Politechniki Warszawskiej, 2009, z. 71, s. 113-136

[10] Lewitowicz J., Dragan K., Laski A., Michalak S., Zieja M. Problemy badań i eksploatacji techniki lotniczej. Wydawnictwo Instytutu Technicznego Wojsk Lotniczych, nr 9, Warszawa 2016

[11] Siergiejczyk M., Krzykowska K. Koncepcja wdrożenia nowoczesnych systemów naziemnych detekcji sytuacji ruchowych dla wybranego lotniska. Logistyka-nauka, nr. 4/2011

[12] Ustawa Prawo Lotnicze z dnia 3 lipca 2002 roku

[13] www.kontrola-ruchu-lotniczego.com, dostęp 13.07.2018

[14] Zieja M., Gołda P., Wybrane aspekty systemu zarządzania bezpieczeństwem. Logistyka 4/2014, str. 2600-2602