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

DOI: 10.35117/A_ENG_18_09_01

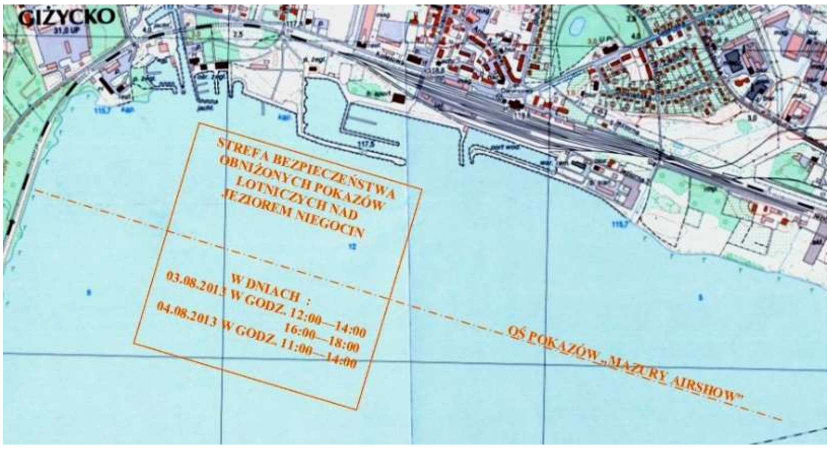
Intelligent system of airspace surveillance and security in the real time

Abstract: New technologies are more and more often used to increase the level of securing humans work as well as many processes from various areas of industry or transport. Intelligent systems not only support work while optimizing it, but also minimize the risk of dangerous situations for human life. It is the man who is still considered the weakest link in most processes, and it is the human factor that causes many accidents and disasters. Therefore, its activities should be controlled at every stage of the task being performed. This publication describes the use of intelligent technology in the process of training pilots and performing aerobatics.

Keywords: Safety of aviation; Aerobatics; Security and surveillance systems

Introduction

Both aerobatics and glider aerobatics are sports disciplines that require pilots and judges to have high precision and experience. New methods and systems are constantly being sought, which will enable the support of processes related to the proper assessment of such flights. Shows and flights within the competition take place in a strictly defined three-dimensional zone that sets the limits for pilots. While during the competition they are a matter of correctness of the flight and obtaining the appropriate number of points, in the context of shows such limits are set mainly for the safety of the gathered audience. An example of the zone is shown in the Figure 1.



1. Designated allowed aerobatic zone as part of air shows [1].

In the case of aerobatic competitions, any crossing of the zone is associated with obtaining penalty points. In the case of shows, however, in special cases, the pilot may even lose his license exceeding the set limits. Despite the knowledge of the consequences, however, there are many cases (especially as part of the demonstrations) of the participants breaking the rules. Such bravado may end in an unfortunate accident. An example of such a catastrophe may be the most tragic event that occurred on July 27, 2002, during air shows at Skniłów (Lviv) airport. As a consequence of too low a flight, Su-27 fighter fell on the crowd of people. The main causes of the crash are the engine failure and the pilot's recklessness which, wrongly assessing the height above the ground, caught the wing with a different machine. As a result of the investigation, it was considered that the blame for the disaster was borne by the crew who ignored the information transmitted by the onboard computer and thus violated the security rules. At the moment of impact, both pilots aboard managed to catapult, but the falling machine killed 77 people, and another 543 were injured. An additional factor affecting such huge losses in people was the poor organization of space for terrestrial viewers. The area for the public was not far enough from the closed zone of the shows so that so many viewers were in the place where the plane hit the ground [2] [3] [4]. As part of the air shows, there were several more tragic accidents, where the human factor is given as the main cause. So far, however, it has not been decided to introduce additional forms of flight security and exhibition zones through the use of new surveillance techniques. One such system is AeroSafetyShow Demonstrator + PL (ASSD + PL), which was developed by a group of scientists and pilots just to increase the level of flight safety, pilots and ground audience.

AeroSafetyShow Demonstrator + PL system

The system, which was developed as part of a project co-financed by the European Union, has been used since 2014 to support mass events of national and international importance. ASSD + PL aroused great interest among both pilots and judges, but also among the representatives of the highest aviation authorities and the aviation aerobatics committee. The system's unique functionality on a global scale enables its comprehensive use during training, demonstrations and aerobatic competitions. So far, the system has been used for many events, including but not limited to:

- <u>2014</u>
  - World Championships in Glider Aerobatics, Poland
  - Polish Aerobatic Championships, Poland
- <u>2015</u>
  - IV Zielona Góra CUP, Poland
  - Polish Championships in Glider Aerobatic, Poland
  - European Air Acrobatics Championships, Romania
  - Glider Aerobatic World Championship, Czech Republic
- <u>2016</u>
  - World Championships in Glider Aerobatics, Hungary
  - Polish Championships in Glider Aerobatic, Poland
  - Polish Aerobatic Championships, Poland
  - Polish Airplane Aerobatic Cup, Poland
- <u>2017</u>
  - World Championships in Glider Aerobatics, Poland
  - The World Games 2017, Poland
  - Gdynia Aerobaltic 2017, Poland
  - Air Show Radom, Poland

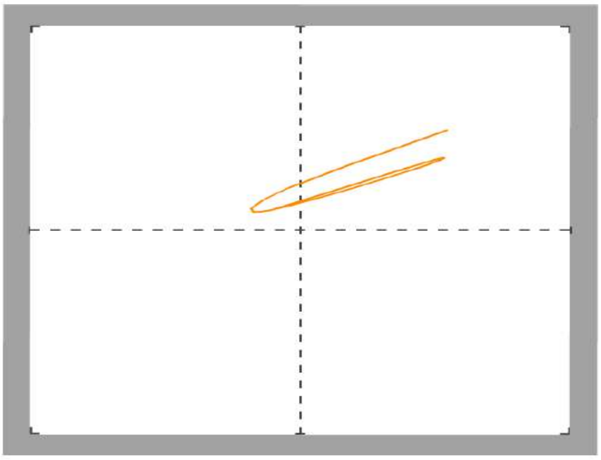
As part of the World Cup, the system has been included from 2016 in the regulations of the competition. In 2017, AeroSafetyShow was also used from the organizers to secure mass events such as Gdynia Aerobatics and The World Games. While playing the latter, the view of the main application screen (3D visualization) was broadcast to a wide audience – Figure 2.

2. Broadcast view of the FlyMonitor application to the public as part of The World Games 2017.

The ASSD + PL system among its functionalities has, among other things, the possibility of observing the designated space in 3D, but also allows you to change the perspective according to the observer's preferences or for the needs of thorough flight analysis. Figures 3-5 present the views that can be selected as part of the FlyMonitor visualization application while the flight element is being executed (the loop passing the lower zone of the box). The graphics show the moment of performing the same figure in order to illustrate the capabilities of the system. The operator/terrestrial instructor has the full ability to change the view at any time. Also after the flight has access to reports and historical record, thanks to which it is possible to perform a more comprehensive and detailed analysis. Different view modes allow you to assess the correctness of the figures and the position in the zone. In the "sport" mode, from the times after the competition flight finishes, three reports are automatically printed, including the altitude graph (with the indication of border crossing), top projection (with visible outputs outside the zone) and compilation of time spent outside the designated area. Such reports are immediately forwarded to the judges, who on their basis give the player penalty points.

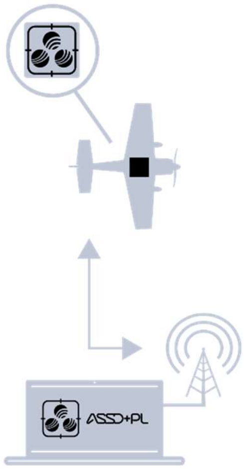
3. The main screen, three-dimensional application FlyMonitor ASSD + PL.

4. Graph display of flight altitude of application FlyMonitor ASSD + PL.



5. Top view projection screen for the flight being performed, marking the aerobatic zone in the FlyMonitor ASSD + PL application.

The basis of the system operation is the transmission of data packets in the current time from transmitters located in aircraft to the receiving station located on the ground. The Figure 6 illustrates the functional scheme of the ASSD + PL system.



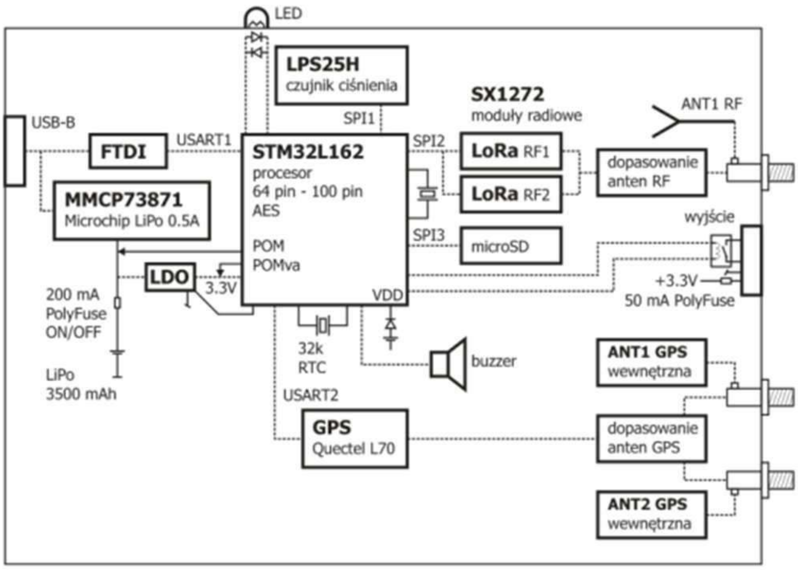
6. The scheme of the ASSD + PL system operation.

Components of the ASSD + PL system

There are several key elements to the proper functioning of the system. First of all, the basis of the operation is the proprietary radio transmission protocol. Data packets are sent in real time at up to 10 times per second. Thanks to this, even with the most complicated aerobatics the application visualizes the flight route with high accuracy. In addition, the signal is encrypted, which makes it difficult to intercept or falsify. All information is saved not only within the receiving station by the application itself (servers), but also the data is archived by a memory card located in the transmitter (mobile module). Information on the memory card is saved even without the antenna range. What's more, they are free from any transmission errors or interruptions so in case of doubt it is possible to read them and reconstruct them and compare them with the real-time record. At the same time, in every non-authorized traffic situation, the application informs the user/operator about its occurrence by means of real-time light and sound messages. The main components of the system are therefore:

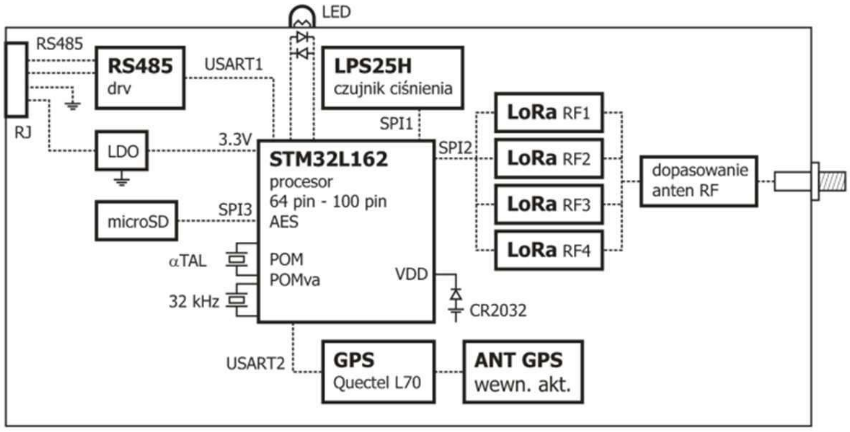
- Mobile module (transmitter)
- Base station
- FlyMonitor visualization application

Transmitters have been designed so that their placement is possible in any aircraft, regardless of its construction. The main functional elements of the mobile module are a processor, 2 pieces of RF radio module, RF radio antenna, GPS receiver, 2 pcs of GPS antennas 2 pcs, the slot with microSD card, buzzer, pressure sensor, LiPo battery with the charging system. The modules' own power supply allows them to be operated in the air for about 12 hours without having to be charged. During the tests, an additional external dipole antenna was introduced made in the technology of a flexible sticker permanently attached to the windshield in the cockpit, which significantly improves the range of radio communication. The schematic diagram of the transmitter is shown in the Figure 7.



7. Schematic diagram of the ASSD + PL mobile module.

The base station allows receiving and processing data from transmitters. The schematic diagram is shown in the Figure 8.



8. Schematic diagram of the ASSD + PL base station.

The following differences with respect to the mobile module should be indicated:

- 4 LoRa radio modules (in place 2 in the mobile module),
- lack of internal RF antenna,
- external RF antenna on the SMA connector,
- RS485 serial communication module with RJ connector,
- single active antenna of the GPS module,
- lack of LiPo batteries (power supply from RJ RS485 connector),
- no battery charging module MCP73871 [5].

Between the application (PC) and the base station, a USB / RS485 converter is installed. Communication between the converter and a PC is done via a USB cable. Due to the limitations of the USB interface, the converter is located in close proximity to the PC. Communication between the converter and the base station is carried out using a serial interface in the industry standard RS-485 in half-duplex mode (twisted-pair cable 8 wires), which allows for a longer cable length (in the system over 10 meters) [5].

The FlyMonitor visualization application is another element necessary to reproduce the data packets. The dedicated application is the only program enabling the reproduction of

data sent from transmitters. The basic functionality of the application is to visualize several dozen aircraft at the same time and the ability to track a selected one by displaying flight parameters. It is also possible to program the selected observation zone and define boundary parameters (maximum allowable altitude, buffer zone, etc.). The application in use is intuitive and user-friendly. Its broad possibilities allow it to be used also in aviation schools, where the ground instructor is not always in the aircraft with the student.
Wide functionality of the application and the entire system allow its use to systematically improve flight safety and eliminate inappropriate behaviors from aerobatic and demonstration flights.

Summary

Both in the process of training pilots and during the performance of air aerobatics, it is extremely important to precisely determine the position of the aircraft (SP) and its basic parameters. The increasing number of incidents and air accidents resulted in the emergence of a system requiring real-time flight control, an immediate intervention of an instructor or flight coordinator, as well as an analysis of the record of the flight made. AeroSafetyShow Demonstrator + PL is such a system, which as a Polish product is a unique phenomenon on a global scale [5][6].

Source materials

[1] https://mazuryairshow.files.wordpress.com/2013/07/mapa_bezp_2013.jpg.
[2] http://www.smartage.pl/katastrofa-na-pokazach-lotniczych-na-lotnisku-sknilow/.
[3] https://zik.ua/pl/news/2016/07/27/lww_wspomina_ofiar_katastrofy_na_lotnisku_skniw_728142.
[4] http://histografy.pl/katastrofa-na-lotnisku-sknilow/.
[5] Krupa W., Górzeński R., *Aerosafetyshow Demonstrator+PL. Inteligentny system nadzoru i bezpieczeństwa operacji lotniczych w czasie rzeczywistym*, Poznań – Lotnictwo dla Obronności, str. 273-288, Wydawnictwo Politechniki Poznańskiej, ISBN 978-83-7775-428-3.
[6] Krupa W., Linka A., Ciałkowski M., Wróblewska A., *Bezpieczeństwo operacji lotniczych w szkoleniu, zawodach oraz pokazach akrobacyjnych.,* Poznań – Lotnictwo dla Obronności, str. 273-288, Wydawnictwo Politechniki Poznańskiej, ISBN 978-83-7775-428-3.