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CONCEPT OF APPLYING ASG-EUPOS AND AEROSAFETYSHOW DEMONSTRATOR+PL SYSTEMS FOR MONITORING AIRCRAFT'S POSITION

The AeroSafetyShow Demonstrator+PL project was created in response to the lack of a comprehensive solution for general aviation, which would make it possible to control aircraft flight parameters in real time. The system determines the aircraft's position using, among other sources, the Global Navigation Satellite Systems. In order to increase the attractiveness and the level of safety of the proposed solution, the possibility of enhancing the measurements with corrections generated by the Active Geodetic Network EUPOS was taken into consideration. According to the proposed concept, which will be further verified, the final navigation solution would not be determined in the receiver unit, placed within the aircraft, but at the Mobile Controller ASSD+PL, to which autonomous measurement data and corrections would be sent.

Keywords: Global Navigation Satellite Systems, GPS, ASG-EUPOS

1. INTRODUCTION

Air traffic control services use different systems enabling them to track the aircraft position, which in turn enables them to manage airspace effectively and to provide appropriate level of flight safety. Those solutions are dedicated to flight operations limited mainly to flying along the determined path and to approaching to land. However, there are no tools enabling to supervise some tasks performed within frames of the General Aviation. Control of flight parameters during flight training, aerobatics or air shows is a problem demanding in-depth analysis.

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A system which seems to have prospects for improving the quality and safety of the considered operations is AeroSafetyShow Demonstrator+PL (ASSD+ PL). It allows to determine parameters describing the aircraft flight in real time. One of them is an aircraft position calculated with the use of, among other tools, the Global Navigation Satellite Systems. To obtain the best as possible accuracy of the aircraft positioning, some test with the usage of the Active Geodetic Network EUPOS focused on aviation needs will be conducted. Characteristics of the mentioned systems and a proposal of their integration are presented further on.

2. AERO SAFETY SHOW DEMONSTRATOR+PL

AeroSafetyShow Demonstrator+PL system is designated for monitoring aircraft's flight parameters. It provides data on the position, flight direction and flying speed, among others. One of functions that the ASSD+PL application offers is the possibility of creating so called 'box', i.e. the pilotage area. If the aircraft leaves this area, it is signalled acoustically and visually, as shown in Fig. 1. This system is used during air shows, aerobatic competitions and flight trainings as a tool allowing not only to control flight in real time but also to reproduce the course of the already-finished flight.

Fig. 1. Breaking the pilotage area
[ASSD+PL Archives]

Measuring modules operate autonomously. It means that calculations are not made based on data delivered by systems and devices being part of the aircraft. Generated data are transmitted by radio to the Mobile Controller ASSD+PL, presented in Fig. 2, where they are processed. In the simplified solution, the vehicle with a specialised equipment may be replaced by a small base station.

Fig. 2. Mobile Controller ASSD+PL
[ASSD+PL Archives]

3. ACTIVE GEODETIC NETWORK EUPOS

Active Geodetic Network EUPOS (ASG-EUPOS) is one of ground-based systems supporting GNSS (Global Navigation Satellite Systems) measurements. Owing to the network of reference stations located across the whole country and in border regions of neighbourhood countries it is possible to make adjustments allowing to determine the aircraft's position with greater accuracy. In case of the autonomous measurement, the position is determined with an error of a few or a dozen metres. If calculations are supported by adjustments from the ASG-EUPOS system, it is possible to obtain the accuracy of centimetres.

Architecture of the ASG-EUPOS system consist of the reference, management and a user segment. Reference segment is created by stations responsible for monitoring signals transmitted by GNSS satellites and for transmitting data from observations to the Management Centre. Due to the fact that receiving stations measure the position in places for which this position was determined with a great accuracy, it is possible to determine adjustments to calculations [Graszka et al. 2013].

Data gathered by the reference stations network are transmitted to the management segment using information and communication technology. Management segment consists of two centres located in Warszawa and Katowice, being respon-

sible for evaluation of RTK/DGNSS adjustments and for making them available to subscribers to individual services of the system. Users may receive observation data from individual monitoring stations and send results of their own measurements to determine the position precisely. Process of generating and transmitting calculated adjustments works automatically [Graszka et al. 2013, ASG-EUPOS].

Next segment of ASG-EUPOS comprises the users of the system who, having receivers with communications module, are able to determine the positon with a great accuracy. Measurements may be recorded using a single frequency or two-frequency receivers making calculations based on data received from GPS and GLONASS systems, and also from GALILEO system in the future. In the post-processing mode users send data from conducted measurements to Management Centres and then they receive a report from calculations taking into account adjustments generated by the system. It is also possible to receive data in real time using the GPRS connection [Graszka et al. 2013].

ASG-EUPOS system offers an access to six basic services to its users. Three of them distribute data in real time, next two enable receiving data in the postprocessing mode, and the last one is used as a technical support. Characteristics of services responsible for making corrective data available are presented in table 1 [Ryczywolski, Oruba i Leończyk 2009].

Table 1

ASG-EUPOS services [Oruba et al. 2008]

Type	**Name**	**Method of measurement**	**Data transmission**	**Accuracy**
Post-processing services	POZGEO	static	Internet	(0.01–0.10 m)
	POZGEO D	static, kinematic		
Real-time services	NAWGEO	kinematic (RTK/RTN)	Internet, GSM	up to 0.03 m (horizontally) up to 0.05 m (vertically)
	KODGIS	kinematic (DGNSS)		0.2–0.5 m
	NAWGIS			1–3 m

4. APPLYING ASG-EUPOS SYSTEM FOR AIRCRAFT'S POSITIONING

Applying the Ground Based Augmentation System (GBAS) for the AeroSafetyShow Demonstrator+PL project would influence positively on the accuracy of positioning, however not many airports in Europe use this technology. Solutions of that type require special infrastructure dedicated to a given airport. In Poland, an equivalent of the GBAS system is the Active Geodetic Network EUPOS covering

the whole country. In this case, however, adjustments are transmitted not by VHF links, as defined by the International Civil Aviation Organization (ICAO), but by the Internet/GPRS connection [International Civil… 2012].

Already conducted tests on the ASG-EUPOS system show that using the GSM network for the aviation purposes is pointless since at the level of approx. 350 metres there are problems with signal availability, and it should be remembered that aerobatic flights are performed even at the level of 1500 metres [Ciećko et al. 2011]. Additionally, it was observed that during rapid changes of the aircraft's position the receiver does not receive data including adjustments to the measurement. Worrying is the fact that unavailability of adjustments to measurements results in decreasing of the accuracy below the level that is obtained using autonomous measurements [Grunwald, Ciećko i Oszczak 2010].

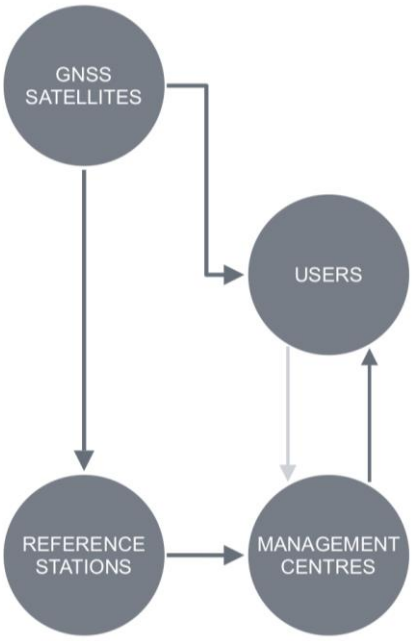

Fig. 3. Simplified scheme of information flow in the ASG-EUPOS system

Fig. 3 presents a simplified scheme of information flow in the ASG-EUPOS system. Signal transmitted by satellites of the Global Navigation Satellite Systems reaches the users' receivers. At the same time, it is monitored by the reference stations network, sending the gathered data to the Management Centre using the information and communication technology. Next, those data are processed and based on them adjustments are generated. There are two ways of accessing to them. The first one enables transmitting observation data gathered by the user to the Management Centre where a report determining exact position is generated auto-

matically. Unfortunately, this solution cannot be applied to the ASSD+PL system since data are not delivered in real time. Second way provides such possibility since receivers communicate with the management segment using the Internet/GSM connections. However, as it has been mentioned above, in case of aviation this solution does not bring desired results since the GSM connection does not guarantee non-stop transmission. Due to that some changes in information flow between some elements of the system architecture were done, taking into consideration the ASSD+PL system.

Due to the uniqueness of the AeroSafetyShow Demonstrator+PL system, it is possible to use the Active Geodetic Network EUPOS since there is no need to deliver corrective data to the module installed in the aircraft. Pilot does not receive detailed information on his position. What is more important, data on exact position should be delivered to a Mobile Controller, whose personnel monitor and supervise the performed operations. Therefore, some actions aiming at developing a method of measuring the position which would allow to create a final navigational solution in the Mobile Controller instead of in the GNSS receiver were undertaken. It means that data from autonomous measurements (GNSS receiver) and from the Management Centre (GBAS system) will be transferred to a vehicle having special equipment. Based on these data the aircraft's positon will be determined taking into account adjustments calculated by the ASG-EUPOS system. Fig. 4 presents the scheme of information flow including the Mobile Controller.

When the flight is performed, the ASSD vehicle remains in the same position, hence there is a minimal risk that it would come to an area without telecommunications coverage. The question of receiving data generated by the module installed in the aircraft often performing rapid manoeuvres, will be solved by application of the radio transmission. The solution ensuring its stability has been already developed within the frames of the ASSD+PL project.

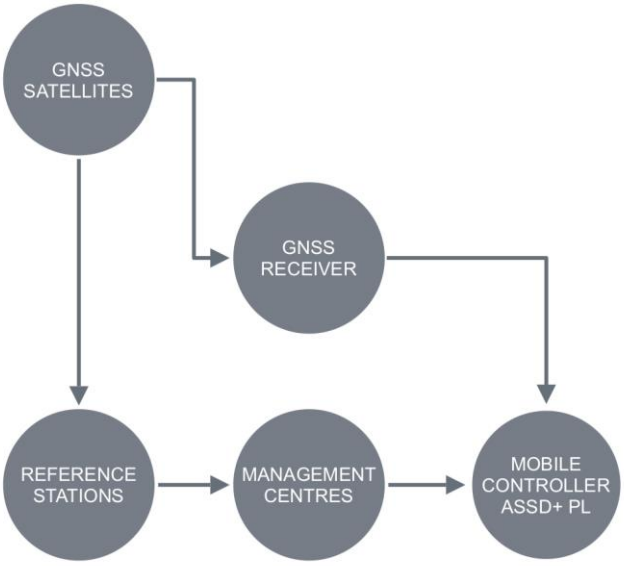

Fig. 4. Concept of information flow in the ASG-EUPOS system including the Mobile Controller ASSD+PL

5. CONCLUSIONS

Currently, some research works on implementing modifications enabling to receive ASG-EUPOS data by means of the AeroSafetyShow Demonstrator+PL infrastructure are carried out. When they are complete some tests verifying this concept will be conducted to carry out in-depth analysis of the influence of adjustments generated by the Active Geodetic Network EUPOS on the accuracy of aircrafts' positioning. Research works will also enable to resolve the problem of the motion dynamics for the considered example, since tests will be conducted on drones and aerobatic aircraft flights.

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KONCEPCJA WYKORZYSTANIA SYSTEMÓW ASG-EUPOS I AEROSAFETYSHOW DEMONSTRATOR+PL NA POTRZEBY MONITOROWANIA POZYCJI STATKÓW POWIETRZNYCH

Streszczenie

Projekt AeroSafetyShow Demonstrator+PL jest odpowiedzią na brak kompleksowego rozwiązania w lotnictwie ogólnym, które pozwoliłoby kontrolować parametry lotu statków powietrznych w czasie rzeczywistym. System wyznacza pozycję m.in. na podstawie Globalnych Systemów Nawigacji Satelitarnej. Celem zwiększenia atrakcyjności oraz poziomu oferowanego bezpieczeństwa podjęto analizę możliwości wsparcia dokonywanych pomiarów poprawkami generowanymi przez Aktywną Sieć Geodezyjną EUPOS. W odniesieniu do koncepcji, która zostanie poddana weryfikacji, ostateczne rozwiązanie nawigacyjne nie będzie wyznaczane w odbiorniku umieszczanym w statku powietrznym, lecz w Kontrolerze Mobilnym ASSD+PL, do którego przesyłane będą dane z pomiarów autonomicznych oraz korekty do obliczeń.

Słowa kluczowe: Global Navigation Satellite Systems, GPS, ASG-EUPOS