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ANALYSIS OF AIRCRAFT DELAYS IN FIR WARSAW IN THE CONTEXT OF RADIONAVIGATION SYSTEMS

Summary. The paper contains an analysis of the causes of aircraft delays at the main airports in Poland. Due to the fact that for several years there has been a large increase in the volume of air traffic, generates operational and organisational problems related to aircraft servicing, both at the airport and in the air. Due to the PBN STAR procedure, it is possible not only to make more efficient use of the airspace, such as route layout, reduction of flight time by at least 2 min, reduction of separation but also to reduce the amount of harmful substances produced by the aircraft. When performing RNAV GNSS air operations, an aircraft saves approximately 275 kg of fuel per flight, which has a significant impact on environmental protection.

Keywords: aviation, PBN, radionavigation systems

1. INTRODUCTION

Aviation is one of the most dynamically developing areas of transport. For several years now, there has been a large increase in air traffic both in Europe and all over the world. The emergence of new air carriers, the creation of new international or intercontinental connections generates operational and organisational problems related to aircraft maintenance at the airport and in the air. These problems affect the punctuality of air operations. However,

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delays are also generated by independent reasons such as the weather. Unfavourable weather conditions contribute more than 50% to the change in the flight schedule of aircraft. A bad meteorological situation can disrupt or even paralyse air operations. The aircraft take-off and landing procedure depends on the state of the weather. By reducing the impact of operational factors, the aim is to increase air capacity. As a result, programmes have been formulated in Europe for the efficient management of air transport. One such project was the Single European Sky (SES) initiative and the creation of the Single Sky Committee (SSC). The SSC consists of civil and military representatives of the Member States, whose primary objective is to assist the European Commission in the implementation of the SES project. Based on the effect of unsatisfactory results, the programme was modernised several times by establishing SES II and SES II+. The programme, inter alia, strengthens the network management function, enhances the competence of EASA in the context of safe airport operations and traffic management, and introduces interoperability of the European air traffic management network. SES II also introduced a new traffic surveillance programme, SESAR (Single European Sky ATM Research). Its main objective is to develop Air Traffic Management (ATM) procedures and technologies that will contribute to reducing delays and the negative impact of aircraft on the environment, as well as to increasing airspace and airport capacity. In connection with the effectiveness of the implemented assumptions, it was assumed that in 2020, among others, ATM costs will be reduced by 50%, the negative impact of aviation on nature will be reduced by 10% or capacity will be increased threefold while safety will be improved². It should be kept in mind that SESAR proposes the implementation of new navigation systems and aids such as GNSS as one of the main ways to optimise aircraft routes and increase airspace capacity.

2. ANALYSIS OF MAIN AIRPORTS AT FIR WARSZAWA IN TERMS OF AIRCRAFT DELAYS

Flight Information Region Warsaw (FIR Warszawa) is a defined area of airspace in which flight information service and emergency services are provided³. In Poland, air traffic management is the responsibility of the Polish Air Navigation Agency. FIR Warsaw includes the Polish airspace (over the land area, internal waters and territorial sea) and the ICAO-determined part of the Baltic Sea space, which is delineated by a line of defined geographical points. The Flight Information Region is classified as a controlled and uncontrolled area. In the controlled area of the aircraft, an ATC (Air Traffic Control) service is provided which regulates the flow of air traffic and prevents collisions of aircraft during air operations. This area includes the airways controlled by the ACC area control service, the TMA controlled area checked by the APP Approach Control Unit and the CTR controlled areas of airports where traffic control is exercised by the TWR Airport Control Tower. In the uncontrolled area, information is provided to the aircraft through the Flight Information Service (FIS).

There are five FIS sectors in the Republic of Poland:

- Warsaw (119,450 MHz).
- Olsztyn (118,775 MHz).
- Poznań (126,300 MHz).

² <http://ulc.gov.pl/pl/zegluga-powietrzna/ses-jednolita-europejska-przestrzen-powietrzna/3823-sesar>

³ Announcement of the Minister of Infrastructure and Development of 18 December 2013 on the announcement of a consolidated text of the Regulation of the Minister of Infrastructure on the structure of Polish airspace and the detailed conditions and manner of use of this space Journal of Laws of 2014, item 351

- Gdańsk (127,150 MHz).
- Kraków (119,275 MHz).

Operational Air Traffic Controllers (OATs) are responsible for the operation of military aircraft.

Figure 1 shows the CTR-controlled areas together with the operational information for EPKT airport. Figure 1 shows that the CTR-controlled areas of the following airports in Poland are included in the CTR-controlled areas:

- EPGD (Gdańsk-Rębiechowo).
- EPSC (Szczecin-Goleniów).
- EPSY(Olsztyn-Mazury).
- EPBY (Bydgoszcz-Szwederowo).
- EPPD (Poznań-Ławica).
- EPMO (Warsaw-Modlin).
- EPZG (Zielona Góra-Babimost).
- EPWR (Wrocław-Strachowice).
- EPWA (Chopina w Warszawie).
- EPLL (Łódź-Lublinek).
- EPRA (Radom-Sadków).
- EPKT (Katowice-Pyrzowice).
- EPKK (Krakow-Balice).
- EPRZ (Rzeszów-Jasionka)
- EPLB (Lublin).

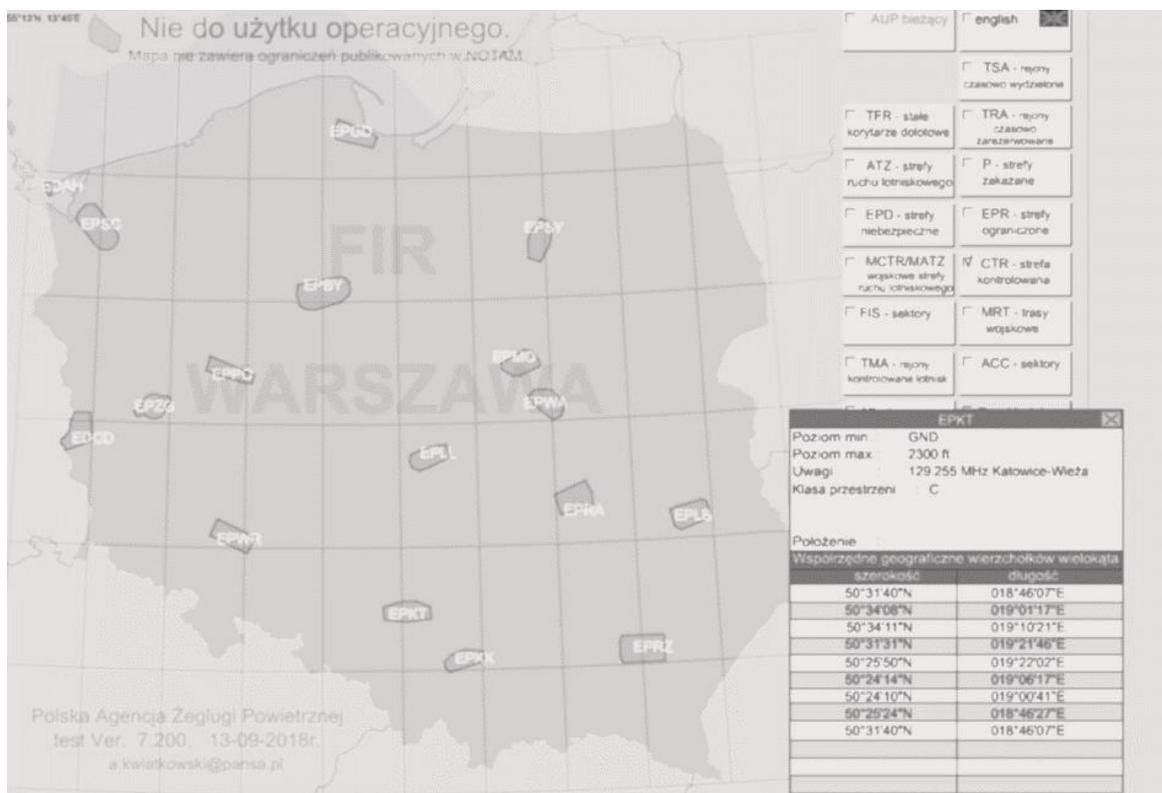


Fig. 1. Controlled areas of TMA airports
source: <http://www.amc.pansa.pl>

Figure 2 shows the FIS Air Information Service in the area of the FIR EPWW.

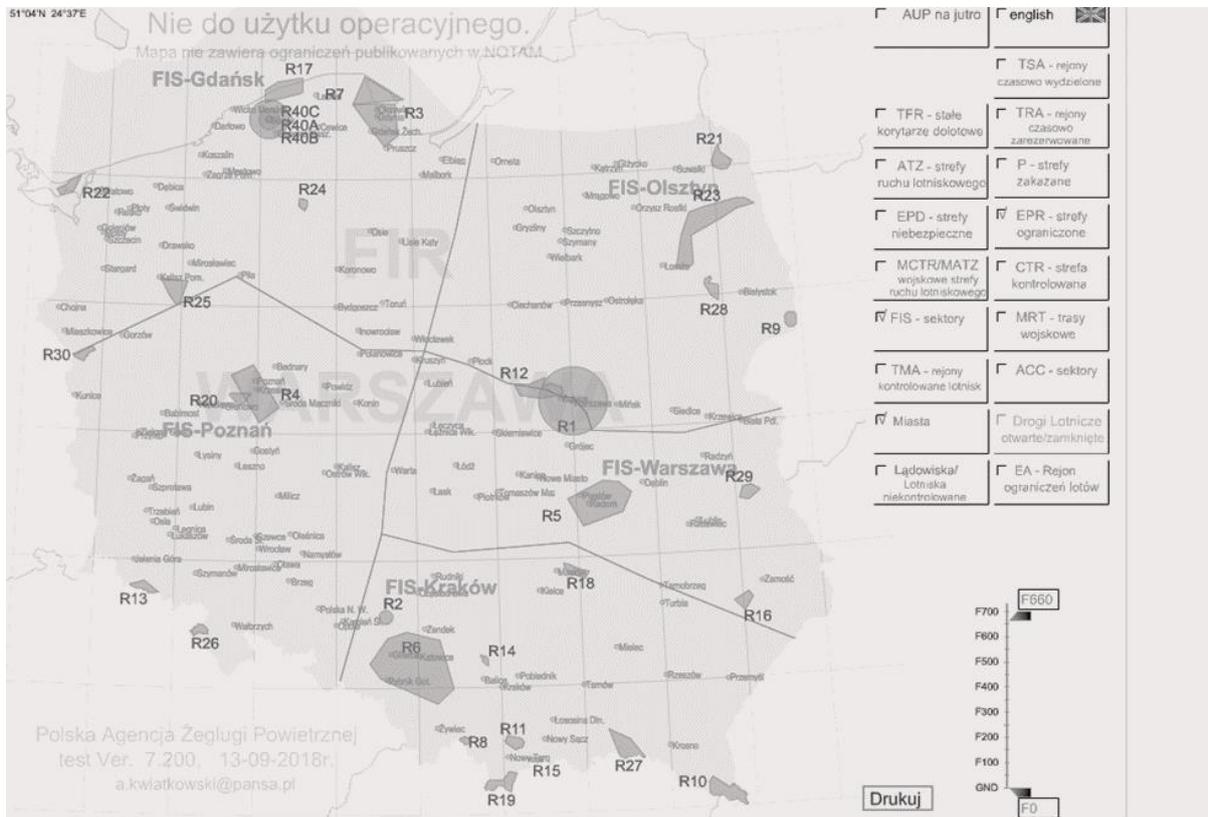


Fig. 2. Flight Information Services in the area of the FIR EPWW
source: <http://www.amc.pansa.pl>

In order to monitor the situation in the Polish sky, the Polish Air Navigation Agency issues an annual report on air traffic at FIR Warsaw. On the basis of this document, the analysis of delays at major airports in 2017 was made: Gdańsk Rębiechowo, Krakow Balice, Katowice Pyrzowice, Poznań Ławica, Rzeszów Jasionka, Szczecin Goleniów, Chopin in Warsaw, Wrocław Strachowice, Zielona Góra Babimost, Bydgoszcz Szwederowo, Łódź Lublinek, Warszawa Modlin, Lublin Świdnik, Radom Sadków and Olsztyn Mazury.

From the published data it shows that 457,913 operations were carried out at the airports listed above, an increase of 10.3% compared to 2016. The highest number of operations was recorded at Warsaw Chopin Airport (37.8%), Krakow Balice (11.7%) and Gdańsk Rębiechowo (9.5%). Figure 3 presents a detailed percentage share of individual airports in the air operations in 2017 [3].

The significant increase in the number of aircraft operations handled contributed to the aircraft delays already generated both on the ground and in the air.

According to the PAŻP report, the average delay per flight operation was 0.2 min per flight, of which enroute (on the route) was 0.1 min per flight.

Analysing the data from the report at the turn of 2002-2017, the biggest increase in delays was observed in 2007 and 2008. Compared to last year, when the average delay was 0.5 min per flight, the delay was reduced by 0.3 min per flight.

Figure 4 shows the relationship between traffic delays and traffic volumes from 2002 to 2017.

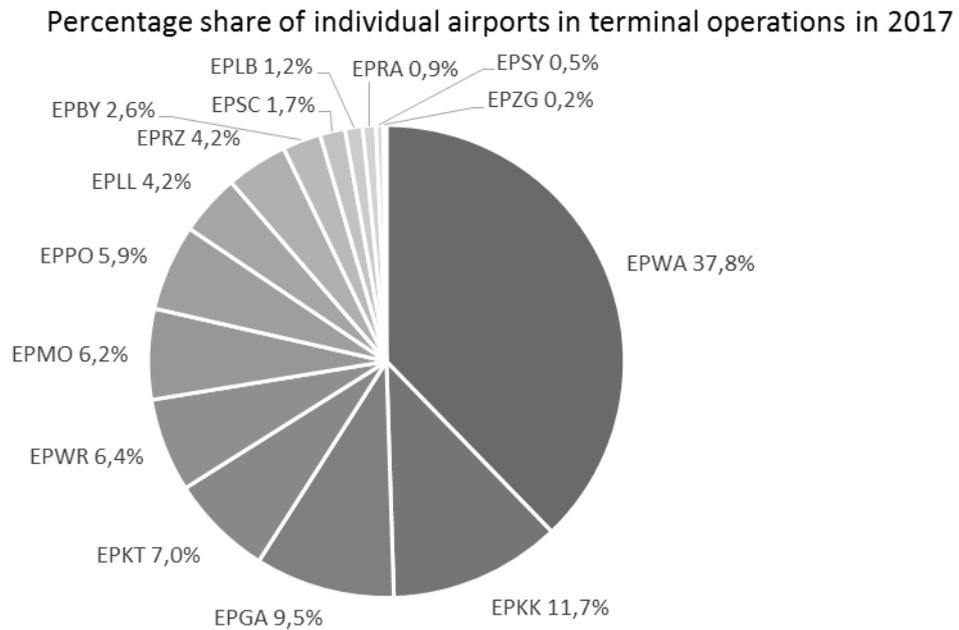


Fig. 3. Percentage share of individual airports in terminal operations in 2017
source: own elaboration

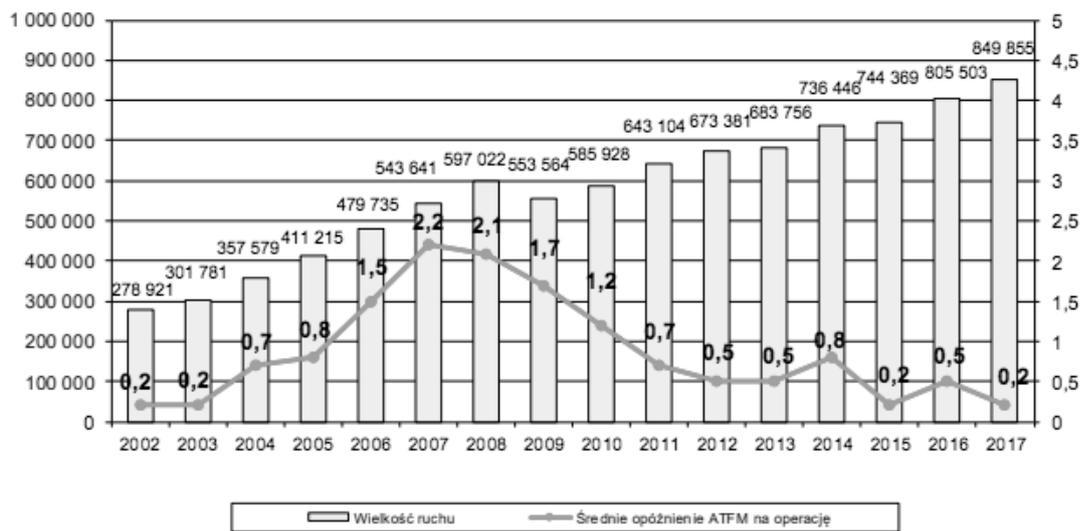


Fig. 4. Volume of traffic and delays in FIR Warsaw in 2002-2017
source: [3]

In continental terms, Poland was ranked fourteenth in terms of generating all the delays. France (24.5%), Germany (18.5%) and the United Kingdom (11.5%) were among the countries with the highest delays.

Aircraft delays can be caused by natural (for example, weather conditions) or artificial (for example, lack of manning) factors. The reasons for subsequent departures can also be classified according to the space concerned, that is, the airport and the route. The size of the delay rate generated at the airport is influenced by such elements as:

- lack of staffing.

- aerodrome capacity.
- airspace management.
- weather.
- equipment.
- ATC and aerodrome capacity.
- special events.
- other.

On the other hand, these contribute to delays on the aircraft route:

- weather conditions.
- equipment.
- ATC capacity.
- protest activities not related to ATC (industrial action non-ATC).
- lack of ATC staffing.
- other.

According to data published by the Polish Air Navigation Agency, in 2017 airports contributed to 28,570 min of delays. On the other hand, factors occurring on the route caused 87,644 min of delay. Figure 5 illustrates the percentage share of the different factors causing delays at airports. The presented data indicates that in over 50% unfavourable weather conditions such as fog, volcanic eruption, storms or turbulence affect 14,623 min of aircraft delay. Another factor determining irregularities in air operations is the capacity of the airport, which is responsible for 7,946 min of delay. Meanwhile, ATC equipment had the least effect on the later departure of the aircraft (85 min).

Figure 5 shows the percentage share of factors causing delays at the airport in 2017.

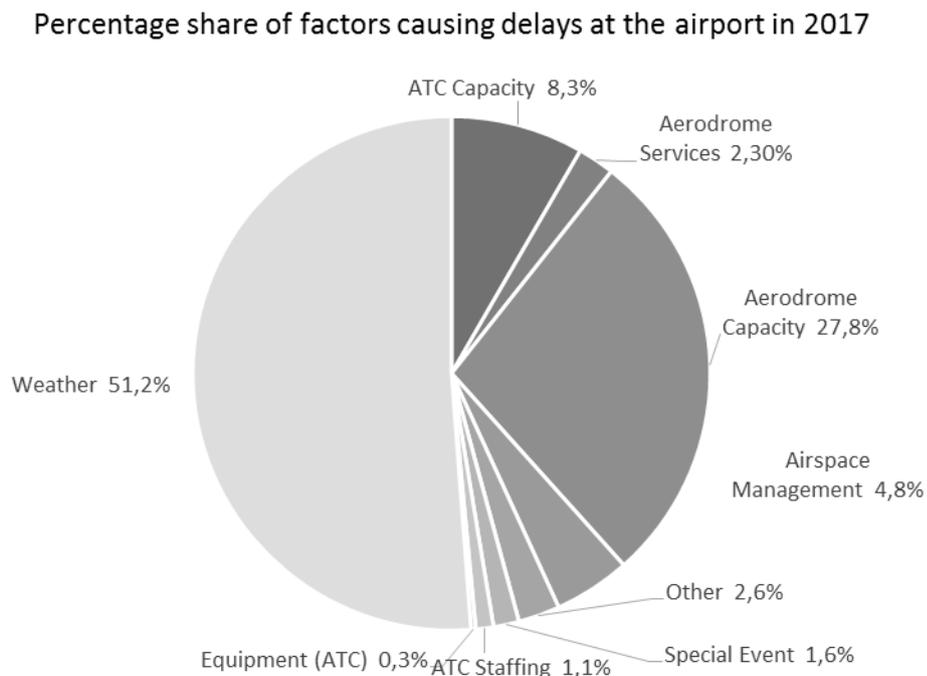


Fig. 5. Percentage share of factors causing delays at the airport in 2017
source: own elaboration

Figure 6 presents the same graph as Figure 5 illustrating the percentage share of elements causing aircraft delay on the route.

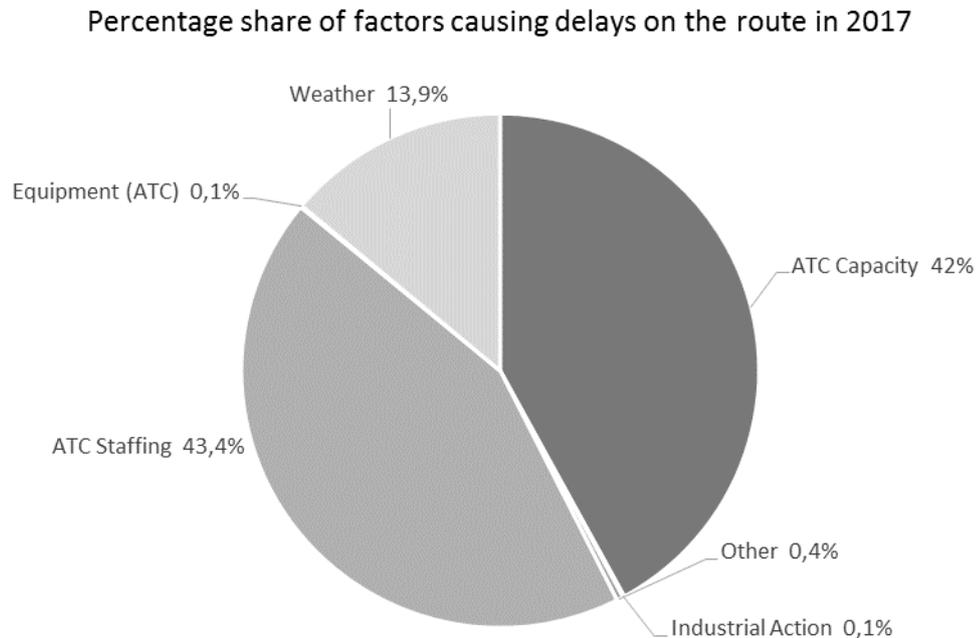


Fig. 6. Percentage share of factors causing delays on the route in 2017
source: own elaboration

On the basis of the above data, it can be concluded that in 2017 the main factor affecting the subsequent take off of aircraft was the lack of adequate level of human resources. It contributed to a delay of 38,055 min. A comparable effect (42%) had the capacity of ATC, which led to 36,853 min delay.

Comparative analysis of both charts (Figures 5 and 6) shows that the equipment had minimal impact on aviation operations. The capacity of both the ATC and airports proved to be problematic.

Factors belonging to other groups and special events must also be taken into account. Events such as the closure of the airspace during the NATO summit, the increase in air operations during the World Youth Day in Krakow or the political situation in Ukraine in 2016, contributed to the unpredictable growth in traffic and the generation of the high rate of delays.

3. SATELLITE SYSTEMS AND AIDS AS TOOLS TO REDUCE AIR TRAFFIC DELAYS

The number of implemented methods of delay reduction is increasing yearly. Airlines, operators, airport managers or aviation authorities such as PAŻP or ICAO strive to minimise delays in air operations. One such tool is the PBN (Performance-Based Navigation) concept. In 2008, ICAO issued the Doc 9613 "Performance-based Navigation Manual", which builds on the Required Navigation Performance (RNP) concept and obliges ICAO member countries to develop the plans for the above project. A PBN is an area navigation based on

characteristics that allow the position of an aircraft to be determined with precise accuracy for a particular phase of flight. This is possible because of a navigation system (for example, GNSS) that meets guidelines such as accuracy, functionality, integrity, availability and continuity. Through the use of PBN, it is allowed to fly on any designated route within the range of the ground navigation systems or the limits of the capability of autonomous devices or with the integration of both. The concept in question cooperates with many aviation entities: pilots, training centres, airport managers and air operators, aircraft manufacturers, as well as the authorities responsible for air traffic control and airspace management. The PBN comprises of two types of navigation specifications, which are a set of requirements necessary for the execution of flights within a defined airspace structure, namely RNAV (Area NAVigation) and RNP (Required Navigation Performance). In the RNAV specification, it is necessary to maintain the required navigation accuracy (for example, RNAV 2) and to meet the requirements for consistency, continuity as well as the functionality criterion (for example, installation of an on-board database). Aircraft equipped with a GNSS system, the RNP obtain through a Receiver Autonomous Integrity Monitoring (RAIM) receiver. In addition to the conditions for RNAV, the RNP also has a criterion for on-board monitoring of navigation accuracy and alarming. Navigation based on characteristics integrates elements such as navigation specifications, navigation applications and radio navigation infrastructure.

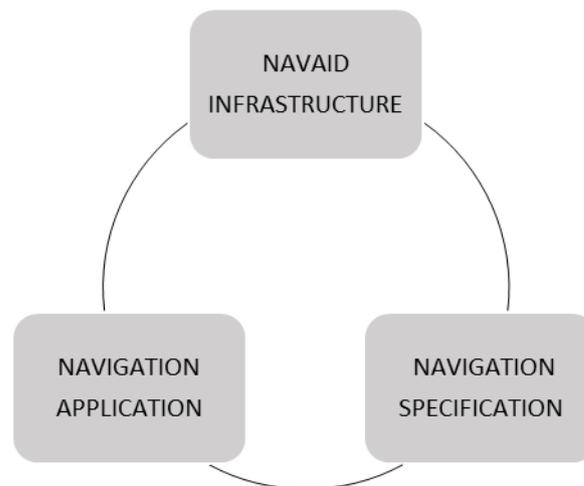


Fig. 7. Elements of the PBN concept
source: own elaboration

Radionavigation infrastructure includes terrestrial navigation aids (VOR, DME) and satellite navigation systems (GNSS: GPS, Glonass, Galileo).

The use of area navigation offers many benefits to air transport, including minimising delays in air operations. The most important ones are:

- reduction of separation for all phases of flight. Where airspace becomes more crowded, PBN allows the most efficient use of space through an appropriately managed reduction of separation and flight track along the route, during approach and landing.
- reduction of ATC and flight crew load (pilot-ATC communication will be reduced by up to 70%).
- rationalisation of the radionavigation infrastructure through optimisation of the terrestrial equipment of satellite systems (investment projects, costs).

- lower fuel consumption of aircraft. By minimising approach and landing routes, the aircraft's fuel demand is reduced.
- reduction of CO₂ emissions. By optimising fuel consumption, the amount of harmful substances emitted by the aircraft is reduced, which contributes to environmental protection.
- reducing the interdependence factor of terrestrial radionavigation infrastructure. The PBN concept is based primarily on GNSS. Such a solution makes it possible to reduce terrestrial navigation devices and thus their cost of maintenance and care.
- the introduction of so-called "global harmonisation". The PBN project is used all over the world by ICAO member states (192 countries). This means that the certification of operators and aircraft can be unified.
- reducing delays in air operations. Through more effective airspace management and more precise data such as aircraft position data, the punctuality rate of aircraft increases.

These advantages indicate that the RNAV GNSS system can be used not only as a tool to reduce aircraft delays but also on other planes, including environmental protection.

4. SUMMARY

The dynamic growth in air operations contributes to the continuous modification of existing procedures. In order to minimise the negative impact of congested airspace, new methods of efficient space management are being sought. One such tool is the implementation of the PBN concept, which creates many opportunities for aviation. As mentioned in the article, aircraft delays are serious problems for the air transport. The implementation of this system allows for an increase in air capacity, which in turn affects punctuality, and also reduces CO₂ emissions. The fact that RNP rules enable aircraft to be located more accurately is also a key element in improving safety. On the basis of the published data, it can be concluded that, despite the intensive growth of air operations, the aircraft delay rate in Poland is at an acceptable level on continental terms. Poland was only responsible for less than 1.0% of all delays. It should be remembered, however, that despite the development of aviation techniques, it is still the independent factors such as atmospheric conditions that affect more than 50% of all flight operations

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