



Volume 98

2018

p-ISSN: 0209-3324

e-ISSN: 2450-1549

DOI: <https://doi.org/10.20858/sjsutst.2018.98.6>

Journal homepage: <http://sjsutst.polsl.pl>



Silesian
University
of Technology

Article citation information:

Kozuba, J., Krawczyk, J., Korytek, Ł. The impact of air traffic increases on the safety of air operations in the Polish airspace. *Scientific Journal of Silesian University of Technology. Series Transport*. 2018, **98**, 53-63. ISSN: 0209-3324. DOI: <https://doi.org/10.20858/sjsutst.2018.98.6>.

Jarosław KOZUBA¹, Jacek KRAWCZYK², Łukasz KORYTEK³

THE IMPACT OF AIR TRAFFIC INCREASES ON THE SAFETY OF AIR OPERATIONS IN THE POLISH AIRSPACE

Summary. Polish airspace is available to all its users on an equal basis. The state is obliged to ensure the safety of aviation operations within its air borders and to safeguard the fluidity of air traffic through the appropriate operationalization of telecommunications, navigation, signal codes and proper airport infrastructure, as well as area navigation. Increasing air traffic requires constant amelioration of airspace structures and the management of airspace and air traffic flow, in accordance with international laws and country-specific circumstances. This article discusses the changes in air traffic throughput from 1997 to 2016 and analyses air traffic and its influence on airspace safety, based on statistics from the Polish Air Navigation Services Agency (PANSAs). The article also examines the increase in the number of aircraft, taking into account the delays generated in European and Polish airspace, while outlining the changes in air traffic management (ATM), as implemented by the PANSAs.

Keywords: Polish airspace, airspace security, increased effectiveness of airspace use, flight operations, vertical and horizontal airspace division

¹ Faculty of Transport, Silesian University of Technology, Krasińskiego 8 Street, 40-019 Katowice, Poland. E-mail: jaroslaw.kozuba@polsl.pl.

² University of Technology in Kosice, Faculty of Aeronautics, Rampová 7 Street, 041 21 Košice, Slovak Republic. E-mail: j.krawczyk@akademia.mil.pl.

³ War Studies University, Gen. A. Chruściela "Montera" 103 Street, 00-910 Warsaw, Poland. E-mail: l.korytek@o2.pl.

1. INTRODUCTION

The reasons for the increase in air traffic throughput stem from economic development and improved welfare in contemporary society. We are witnessing new airline connections at a Polish, European and worldwide level. New airports are built to provide passenger and cargo transport, equipped with appropriate airport infrastructure, while air, road, railway and water connections have been forged with other agglomerations, airports and other shipment sites. They also offer the possibility to service aircraft, as well as provide hangars, warehouses, shipment facilities and qualified personnel.

Road transport is associated with the necessity to provide road infrastructure. In recent years, we have observed various limitations imposed upon road vehicles as a result of environmental protection, cargo load mass or driver workload limitations. Heavy-duty vehicles or cars with traditional fuel combustion systems are increasingly and frequently being denied entry into agglomerations. This is accompanied by a shortage of appropriate and low-cost parking spaces within major cities, which is an additional challenge for shipment companies that use road transport. At present, electric cars are gaining popularity, yet due to their technological complexity and a limited number of charging stations, vehicle prices and legal solutions, they cannot be considered as a means of road transport for the transport of goods or people over long distances.

Railway transport is becoming more popular, owing to quick connections and improvements in the quality of railway infrastructure. We are also witnessing rapid technological progress in railway transportation. Trains are becoming faster, and the comfort of travelling is constantly increasing. Since railway transport is more advantageous and safer in comparison with road transport, new railway connections are planned for routes of 300 km or longer, which will be connected with various types of transport, and with airports in particular.

One drawback of the railway system is that it fails to reach a significant number of towns with over 10,000 inhabitants. In comparison with other European countries, such as the Czech Republic or Slovakia, Poland is in a disadvantageous position.

Heavy cargoes or large-capacity goods are transported via sea or inland water routes, as the transport of a significant quantity of heavy goods over long distances is cheaper than for other means of transport. An advantage of water transport is that it caters for the majority of cargo types, and is competitive in terms of transport costs per unit and attractive in terms of the worldwide scope of shipment routes.

At present, in Poland, sea and inland water transport is insufficiently developed, with Szczecin, Świnoujście, Gdańsk and Gdynia as the only cities that are significant for the national economy.

Despite being relatively inexpensive, sea transport faces constraints due to a limited number of and access to port facilities. Therefore, the majority of shipment companies provide mass cargo freight services on an international scale.

It is estimated that, in the near future, new ameliorations will be implemented in air freight, including an additional number of airports and new technological on-board solutions for aircraft and air traffic control (ATC) systems, which will contribute to a reduction in time loss and fuel consumption. This, in turn, will have a positive impact on environmental protection and the emission of greenhouse gases. Additionally, the use of low-emission fuels is envisaged. Eurocontrol is striving to improve security levels and increase the air traffic throughput.

An incentive to encourage air transportation will be changes in aircraft interiors through the customization of zones, the adjustment of the seat shape to passengers' body shape, and additional relaxation zones for passengers. Taking into account the fact that air transport allows for the freight of both small- and large-sized goods on short and long distances to destinations that are difficult to reach using road transport and often inaccessible to water or railway transport, it has become the most attractive solution. Additionally, it is the fastest and safest means of transport. That is why it has the most challenges to face. They can be responded to through the systematic development of ATM systems, airport infrastructure and means of air transport, and through the full integration of air transport with other types of transport, as well as transport and logistics infrastructure, both in major agglomerations and in small non-urbanized areas.

2. THE INCREASE IN AIR TRAFFIC THROUGHPUT AND ITS CONSEQUENCES

In recent years, we have observed a systematic and dynamic increase in air traffic throughput, both in European and Polish airspace. This means that it is necessary to continue the process of developing effective solutions in air traffic organization and management systems at a global, European and Polish airspace level, which will ensure the appropriate security standards of air transport, as well as the evenly distributed and timely throughput of air traffic.

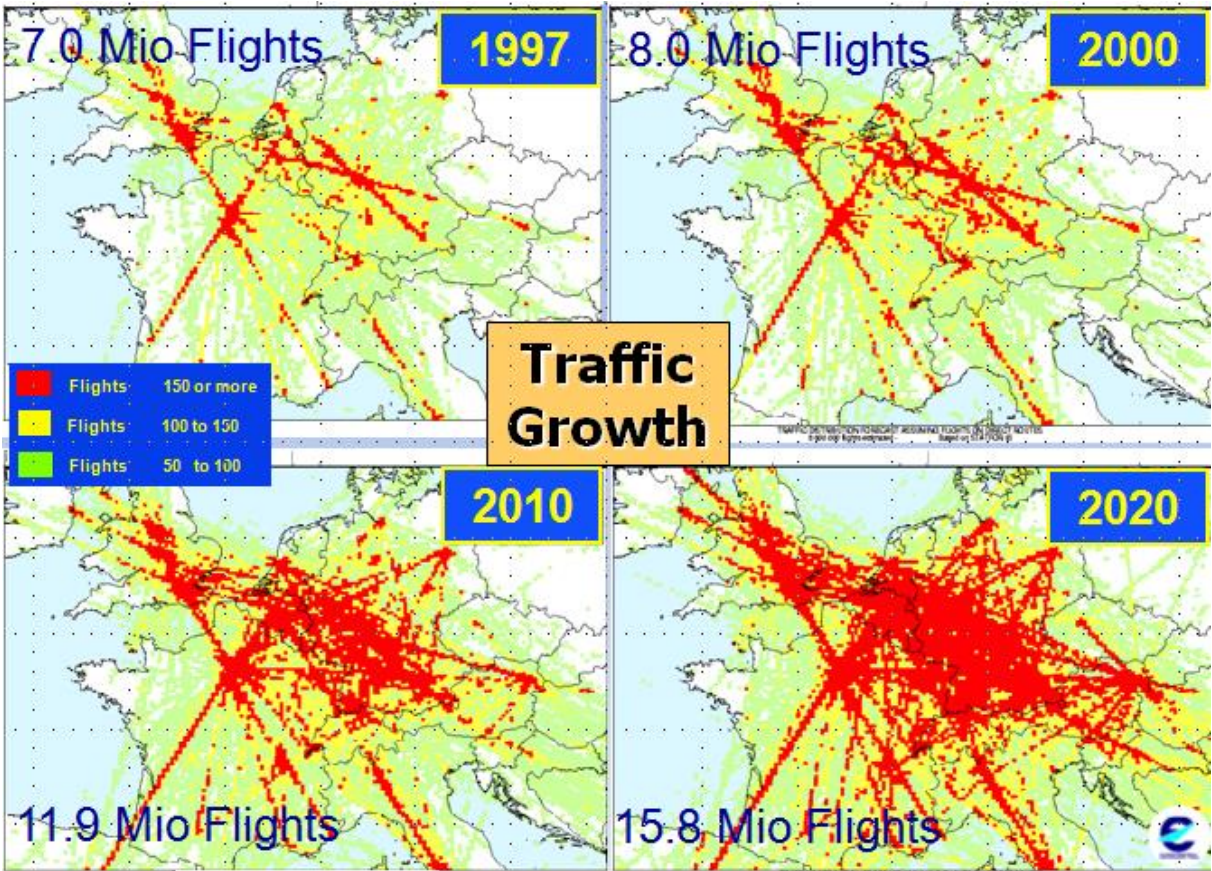


Fig. 1. Projected number of aviation operations
Source: Eurocontrol

In recent years, a systematic and dynamic increase in aviation operations in European airspace has been observed. In 1997, there were seven million flight operations. In 2000, there were approximately eight million flight operations, whereas, in 2010, there were approximately 11.9 million flight operations. It is envisaged that, in 2020, there will be approximately 16 million flight operations (Figure 1), which would appear to be a profound challenge for European regional and national ATM systems.

Flight operations are performed in airspaces that are optimal from the point of view of air carriers, whose aim is to fly along the shortest air route, with the best climb and descent procedure. The carriers' objectives should be optimally accomplished by air traffic services that help to prevent the so-called bottlenecks, which result in delays in air transport.

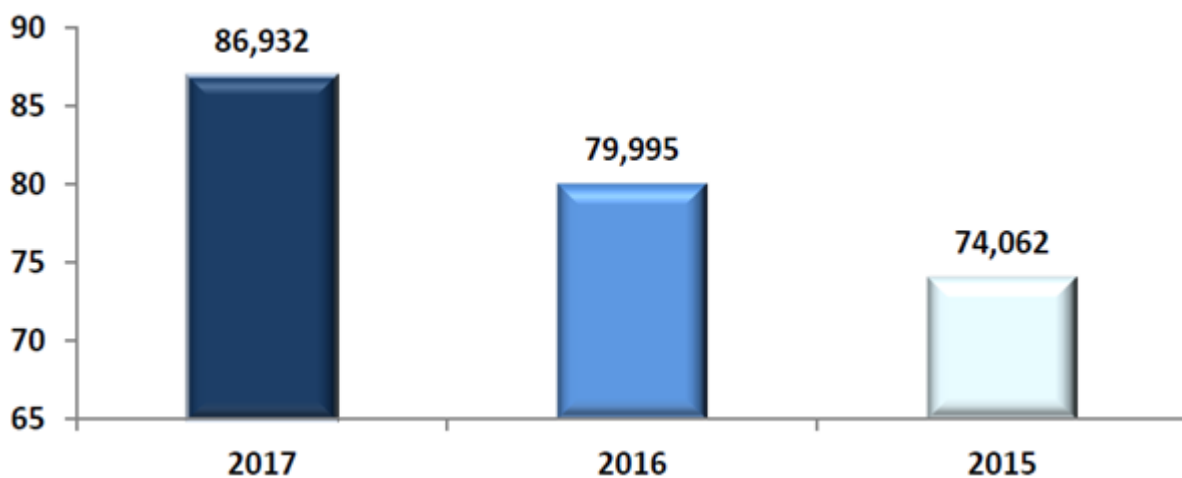


Fig. 2. Number of operations (in thousands) – second quarter

Source: ULC, “Civil Aviation Authority analysis of the air traffic market in the second quarter of 2017”

The above figures point to a gradual increase in air traffic throughput. It is anticipated that this increase will continue due to improving social welfare, the demand for these types of services, the competitiveness offered by air transport in comparison with other means of transport, as well as the capacity of air transport to meet needs on a regional, continental and worldwide scale. In turn, transport services are becoming cheaper and easily available. Unlike in the case of road transport, air transport carriers do not have to think about the rental of parking spaces and associated costs. Additionally, airport infrastructure is being developed, and ticket prices are considerably diversified, in accordance with seat availability, the booking date, the season, and the departure and arrival locations; nevertheless, prices are becoming cheaper.

The dynamics of air traffic development is increasing on a yearly basis. A case in point could be third quarter of 2016, when traffic was more than twofold in comparison with STATFOR's⁴ high forecast at 9.3%⁵. In the same period, an average delay was 0.95 min/flight.

⁴ STATFOR is a specialized Eurocontrol service preparing statistics, forecasts and analyses for Eurocontrol and the European Commission.

⁵ Announcement No. 29 of 27 October 2017 of the President of the Civil Aviation Authority on the Report Concerning the Activity of the Polish Air Navigation Services Agency in 2016.

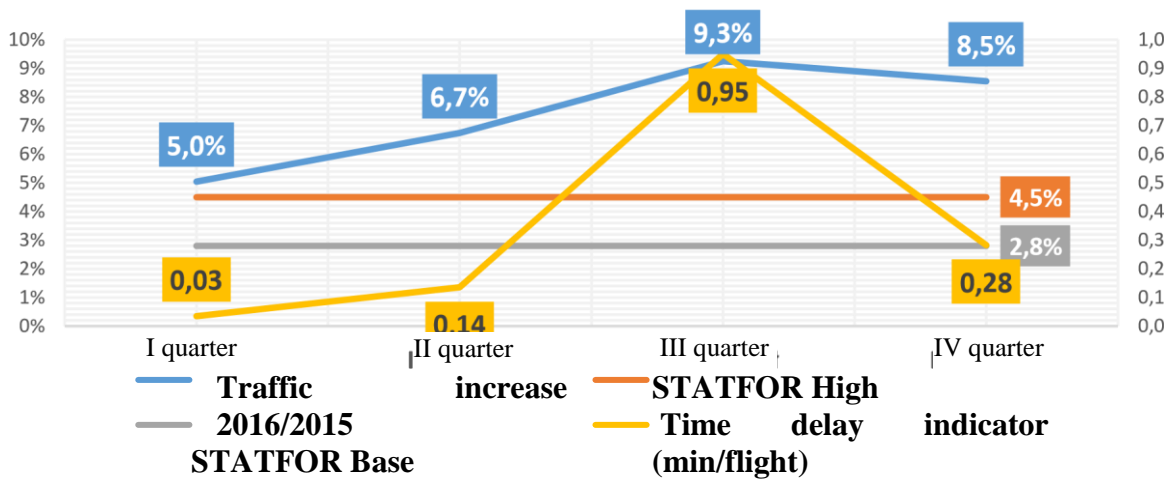


Fig. 3. The increase in air traffic and the number of delays en route on a quarterly basis in 2016

Source: PANSAs documentation on the basis of Eurocontrol/PRU data

The actual traffic increase led to exceeded throughput and considerable delays from July to October 2016.

In the case of high air traffic load, the provision of services, including adequate security standards, inevitably leads to an increased number of delays. This phenomenon occurred in 2016 throughout Europe, leading to an increase in delays in comparison with the assumed values. Irrespective of the above, flight security and fluidity were maintained.

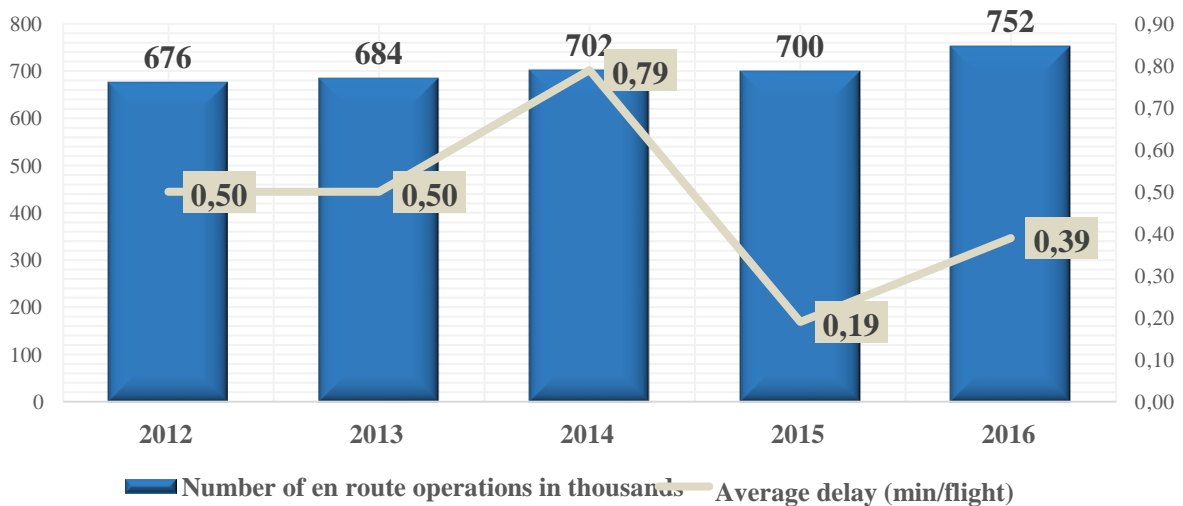


Fig. 4. The number of flight operations and the scope of delays en route in 2012-2016

Source: PANSAs documentation

Despite the undertaken organizational and operational actions, with the exception of 2015, it was not possible to reduce the value of the average delay below 35 s/flight. This resulted in differences between the planned and achieved value of the delay index.

The average delay in 2016 in Poland was 0.39 min/flight, with the expected value at the level of 0.23 min/flight. The delays were connected with the dynamics of the traffic increase in the Warszawa FIR, which, in 2016, was twofold with reference to the previously assumed value (+7.5%)⁶. In the same period, the average delay in European airspace was 0.86min/flight, with the air traffic increase at +2.4%.

The above data unambiguously indicate that the number of flight operations can be expected to increase in connection with the popularity of air transport and the development of airport and municipal infrastructure. Effective cooperation between land, water and air carriers and the appropriate agencies is essential in order to optimize transport, adjust services to meet current needs and ensure transport security.

The most significant challenge is faced by air transport, due to its dynamic development and huge possibilities. It is justifiable for other transport types to adapt to its requirements. This poses an enormous challenge for traffic management agencies, which must respond to the problems faced by air carriers and provide air traffic security for all airspace users.

3. CHANGES IN THE AIR TRAFFIC MANAGEMENT SYSTEM AS A CONSEQUENCE OF THE INCREASED NUMBER OF FLIGHT OPERATIONS

Each country is responsible for security within its own airspace⁷. In the times of peace, the responsibility for the provision of air traffic services, covering airspace management, air traffic throughput management, the provision of air traffic services, coordination of SAR operations, aviation information services, aviation training, meteorological information services, and air operations planning and organization, is vested in one institution: the PANSA.

The institution was established pursuant to the Law of 8 December 2006 on the Polish Air Navigation Services Agency (Official Journal of Laws of 2015, Item 1641). The institution was established in order to streamline ATM through the provision of air traffic services in Polish airspace. It was certified and assigned in accordance with the Act of 3 July 2002 on Aviation Law (Official Journal of Laws of 2017, Item 959 as Amended), and with EU law, by the competent minister for transport and the provision of air traffic services in the Warsaw flight information region (FIR).

Despite the economic crisis that took place in 2008-2009, since 2010, aviation has experienced a continuous increase in the number of passengers handled, flight operations performed, and the opening of new connections. Throughout the past 12 years, passenger traffic has increased fourfold, which is a considerable challenge for Polish airports, as well as PANSA, which is responsible for the provision of air traffic fluidity in the Warsaw FIR. ATM systems should be constantly developed and upgraded so that they can respond to challenges posed by the needs of air transport at present and over the next 10 years. The reason for determining requirements several years in advance is that the implementation of a new system in its operating mode, starting from the selection of the offer, through tests to the implementation of the operating mode, takes two to three years.

⁶ Announcement No. 29 of 27 October, 2017 of the President of the Civil Aviation Authority on the Report Concerning the Activity of the Polish Air Navigation Services Agency in 2016.

⁷ Commission Implementing Regulation (EU) No 1034/2011 of 17 October 2011 on Safety Oversight in Air Traffic Management and Air Navigation Services and Amending Regulation (EU) No 691/2010. Convention on International Civil Aviation, signed in Chicago on 7 December 1944 (Official Journal of Laws of 26 June 1956).

Tab. 1

Projected number of passengers served and the number of passenger operations in Poland to 2035⁸

Source: Civil Aviation Authority documentation

year	number of passengers (in thousands)	dynamic	number of passengers flights (in thousands)	dynamic	mobility rate
2015	30 392	12,3%	283	5,5%	0,79
2016	33 987	11,8%	310	9,4%	0,88
2017	39 300	15,6%	339	9,4%	1,02
2018	42 758	8,8%	363	7,1%	-
2019	46 271	8,2%	386	6,3%	-
2020	49 853	7,7%	408	5,9%	1,33
2021	53 439	7,2%	431	5,6%	-
2022	56 634	6,0%	452	4,8%	-
2023	59 466	5,0%	470	3,9%	-
2024	62 440	5,0%	488	3,9%	-
2025	65 312	4,6%	506	3,6%	1,75
2026	68 316	4,6%	525	3,6%	-
2027	71 185	4,2%	542	3,3%	-
2028	74 175	4,2%	560	3,3%	-
2029	76 994	3,8%	578	3,1%	-
2030	79 920	3,8%	596	3,1%	2,19
2031	82 637	3,4%	613	2,9%	-
2032	85 446	3,4%	631	2,9%	-
2033	88 352	3,4%	650	2,9%	-
2034	91 356	3,4%	669	2,9%	-
2035	94 462	3,4%	689	2,9%	2,62

Taking into account a gradual growth in flight operations in the Warsaw FIR, it has become clear that it is necessary to undertake actions that will result in increased throughput in the Warsaw FIR. Furthermore, according to Polskie Porty Lotnicze, beyond expectations, there were 12% more passengers⁹ handled in comparison with 2015.

In order to fulfil the airlines' expectations and, thus, the reduction in delays due to a lack of sector capacity resulting from a high traffic load, the PANSA, as the national provider of air navigation services, introduced a vertical division of airspace in March 2016, as a continuation of the P2010+ programme¹⁰, whose purpose is to meet capacity requirements, while, at the same time, preserving the highest security standards.

⁸ The air mobility index is defined as the ratio of a cumulative number of transported passengers to the total number of inhabitants. The index in the table has been established on the basis of the forecasted number of inhabitants in Poland in 2014-2050, published by GUS (Statistical Information Centre) in 2014 and the ULC (Civil Aviation Authority).

⁹ In 2016, three Polskie Porty Lotnicze handled approximately 34 million passengers.

¹⁰ Announcement No. 29 of 27 October 2017 of the President of the Civil Aviation Authority on the Report Concerning the Activity of the Polish Air Navigation Services Agency in 2016.

A significant change in the Warsaw FIR was the introduction of a vertical division of area control centre (ACC) zones (Figure 6). Until February 2016, in the Warsaw ACC, it was possible to open up to nine zones in different horizontal configurations, i.e., from FL 95 to FL660. Since March 2016, a change has been implemented, with the objective to increase the throughput of the Warsaw FIR and adjust ATC services to meet a gradually increasing air traffic load. Additionally, solutions aimed at the reduction of vertical and horizontal borders for respective terminal manoeuvring areas (TMAs) have been introduced, and the tracks of air routes have been altered.

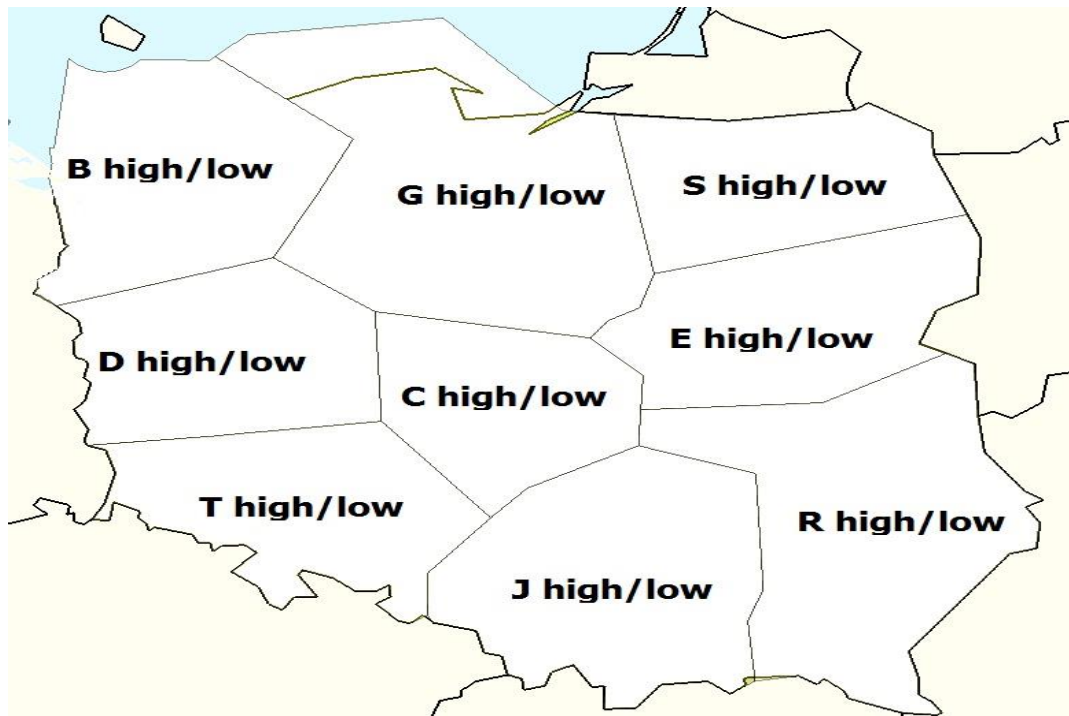


Fig. 5. A vertical division of air traffic zones in EPWW FIR
Source: PANSa, based on AIP Polska EP_ENR_2_2_1_en

The implementation of the vertical division allowed for a twofold increase in air traffic zones, which resulted in the necessity to introduce changes in their management and the volume index of those zones. Considering an additional number of zone listings, it has become necessary to define the aircraft capacity in zones, the number of controllers and various scenarios for the free opening and closing of zones. Horizontal borders for respective zones have undergone significant changes. Additionally, vertical and horizontal borders for respective TMAs have been reduced. As a result of these actions, the tracks of air routes have changed. Before the introduction of the above changes, they underwent simulations in order to ensure optimal traffic fluidity, thereby preserving air traffic safety, along with the optimization of air traffic controllers' work.

The assumption was not to reduce airspace capacity, provided that the envisaged traffic increase would be 2.8% at the base level and 4.5% at the high level (STATFOR forecast from February 2016)¹¹.

¹¹ Announcement No. 29 of 27 October 2017 of the President of the Civil Aviation Authority on the Report Concerning the Activity of the Polish Air Navigation Services Agency in 2016.

As a result of the dynamic growth in flight operations in 2016 (+7.5%), in the Warsaw FIR, a traffic throughput was higher than planned. During air traffic peak hours, there were situations in which physical needs exceeded 180 actions/hour, with the baseline values at the level of 150 flight operations. Traffic accumulation in the summer season oscillated between +8% and +15%¹²; changes were sharp due to the political situation in Ukraine. Additionally, limitations concerning airspace use were introduced due to the NATO summit, the World Youth Day, and planned as well as ad hoc military training.

Moreover, there were additional factors that resulted in changes concerning the traffic throughput in the Warsaw FIR after the outbreak of conflict in Ukraine, and in particular after the shooting down of a Malaysian Airlines aircraft. As a result of the latter event, aircraft avoided the dangerous area in Ukrainian territory and changed their routes, thus affecting traffic throughput in the zones of particular FIRs, including the Warsaw FIR.

4. THE IMPACT OF AIR TRAFFIC INCREASES ON RISK MANAGEMENT

The rising popularity of air transport is directly connected to the number of aircraft in airspace. Air traffic services are facing a challenge: on the one hand, they must ensure a proper level of air traffic safety, while, on the other, they must provide a fluid throughput of aircraft in the areas of responsibility of air traffic services.

In order to develop a comprehensive solution, it is necessary to implement an appropriate risk management system, which should be common to the whole of European airspace.

All countries should actively participate in research and development work conducted by European Aviation Safety Agency and on the Single European Sky ATM Research Programme, which should result in the implementation of common regulations and procedures aimed at ensuring a high level of airspace safety.

The increased number of flight operations must not negatively impact safety in airspace or those spaces where start and landing operations take place.

In order to ensure a high level of safety, risk consequences, and their outcomes and solutions have been identified to minimize threats to the ATM system, as presented below.

1. A small separation decrease due to:

- Excessive ATC load
- Insufficient concentration on the part of the aircraft crew
- Lowered efficiency of communications, navigation and surveillance* systems (supporting ATC work)

**Communications, navigation and surveillance are three technologies at the very heart of ATM.*

This is an unlikely event. If a such an event does occur, it should be analysed and any appropriate changes should be introduced to the ATM system.

2. Change of the flight track of one or several aircraft to such an extent that, in order to avoid collision with another aircraft or with the earth, the pilot must react or start the airborne collision avoidance system in response to:

- A considerable reduction in aircraft separation
- Insufficient control of the situation and no possibility to restore minimum separation on the part of the aircraft crew and the ATC

¹² Announcement No. 29 of 27 October 2017 of the President of the Civil Aviation Authority on the Report Concerning the Activity of the Polish Air Navigation Services Agency in 2016.

This is an unlikely event. If such an event does occur, it should be analysed and any appropriate significant changes should be introduced to the ATM system.

3. There is no possibility to avoid collision because:

- No ACT procedure can prevent it
- The crew cannot prevent the accident, as there is a total loss of steering control over the aircraft

There is a minimal likelihood that the above may occur. If that is the case, a new ATM system should be implemented.

It should be assumed that the increased number of aircraft will result in the heightened likelihood of adverse actions in airspace and at sites where flight operations take place. This is why it is necessary to analyse current and potential threats, introduce systematic preventative actions, as well as undertake the analysis and control of adopted solutions in the area of ATM.

It is necessary to use a common hazard coefficient, a common description of activities related to threats and a proper assessment of the results of adverse events, and thus introduce unified procedures in Europe and worldwide, respecting country-specific circumstances.

No potential threats resulting from systemic solutions can be tolerated, and corrective measures must be introduced as soon as possible with due diligence. Moreover, a 'lessons learned' process must be implemented to allow for reaching appropriate conclusions on the basis of experience, alongside proper corrective measures in the form of legal acts, principles or technical solutions in order to prevent adverse events in the future.

5. CONCLUSIONS

As a consequence of the increase in air traffic throughput in recent years, it has become necessary to implement new solutions concerning a new system of air traffic organization and management in airspace at a global, European and Polish level. These solutions should result in providing appropriate safety standards for air traffic and ensuring evenly distributed and timely air traffic throughput.

The reason for the increase of air traffic throughput is that the air transport can provide rapid cargo shipments and the transport of people over long and short distances. Air carriers cooperate with air traffic agencies and institutions providing logistics infrastructure, which guarantees that destinations are reached in a fast and comfortable way. Additionally, the number of air connections is increasing, while new connections are being established, reflecting the demands of an increasingly prosperous society, which considers flying as the most effective means of transport.

References

1. The 2016 Version (16th Edition) of Doc 4444 (Procedures for Navigation Services – Air Traffic Management).
2. FUA Concept (Flexible Use of Airspace).
3. Regulation (EC) No 2150/2005 of 23 December 2005 Laying Down Common Rules for the Flexible Use of Airspace. Available at:
<http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:342:0020:0025:EN:PDF>.

4. Convention on International Civil Aviation, signed in Chicago on 7 December 1944 (Official Journal of Laws of 26 June 1956 with Further Amendments).
5. *Annual Report on Polish Air Navigations Services Agency Activity in 2016*.
6. Regulation (EC) No 549/2004 of the European Parliament and of the Council Laying Down the Framework for the Creation of the Single European Sky (Framework Regulation) – Statement by the Member States on Military Issues Related to the Single European Sky.
7. Regulation (EC) No 550/2004 of the European Parliament and of the Council of 10 March 2004 on the Provision of Air Navigation Services in the Single European Sky (The Service Provision Regulation) (Text with EEA Relevance). Official Journal L 096, 31/03/2004 P. 0010-0019.
8. Regulation (EC) No 551/2004 of the European Parliament and of the Council of 10 March 2004 on the Organization and Use of Airspace in the Single European Sky (The Airspace Regulation). Official Journal L 096, 31/03/2004 P. 0020.
9. Regulation of the Minister of Infrastructure of 25 November 2008 r. on the Structure of Polish Airspace (Official Journal of Laws of 28 November 2008, Dz.U.2008.210.1324 with Amendments).
10. Act of 3 July 2002 on Aviation Law (Official Journal of Laws No. 130, Item 1112, with Amendments).
11. Act of 8 December 2006 on the Polish Air Navigation Services Agency (Official Journal of Laws of 2015, Item 1641, with Amendments).
12. Annex 11 to the Convention on International Civil Aviation (Air Traffic Services).
13. Annex 2 to the Convention on International Civil Aviation (Rules of the Air).
14. Polish Air Navigation Services Agency. Available at: <http://www.pansa.pl>; <http://ais.pansa.pl>.
15. Civil Aviation Authority. Available at: <http://ulc.pl/pl/>.
16. Petrus J. van V. Coetzee, Pieter A. Swanepoel. 2017. “Spatial relationships and movement patterns of the air cargo industry in airport regions”. *Journal of Transport and Supply Chain Management* 11(a 297).

Received 14.11.2017; accepted in revised form 15.02.2018

