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Svetlana Pavlova[1]
Alina Zadorozhnia[2]

ANALYSIS OF FREE ROUTE AIRSPACE AND PERFORMANCE BASED NAVIGATION IMPLEMENTATION IN THE EUROPEAN AIR NAVIGATION SYSTEM

[1,2]National Aviation University
Kosmonavta Komarova avenue 1, 03680, Kyiv, Ukraine
E-mails: [1]psv@nau.edu.ua; [2]alinazadorozhnia@gmail.com

Abstract. *European Air Traffic Management system requires continuous improvements as air traffic is increasing day by day. For this purpose it was developed by international organizations Free Route Airspace and Performance Based Navigation concepts that allow to offer a required level of safety, capacity, environmental performance along with cost-effectiveness. The aim of the article is to provide detailed analysis of Free Route Airspace and Performance Based Navigation implementation status within European region including Ukrainian air navigation system.*

Keywords: Air Traffic Management; capacity; cost-efficiency; environment; EUROCONTROL; Free Route Airspace; ICAO; Performance based navigation; RNAV; safety

1. Introduction

Volume of air traffic is growing steadily every year, which implies the need of continuous improvement of European Air Traffic Management (ATM).

Therefore it is vital goal to increase capacity and efficiency, with regards to environment and safety.

The main way to reduce the environmental impact is to decrease aircraft fuel consumption and to cut distance for flight performance that also causes the reduction of aircraft noise.

Achieving this goal as quickly and easily, begin at the flight routes.

Nowadays the subject of Air Traffic Control is an organization of aircraft movements in airspace, including the methods and practices in managing and securing traffic.

It has been created a lot of concepts and procedures for European air navigation system in order to enhance the flight operations ensuring a high level of flight safety meanwhile, such as Free Route Airspace and Performance Based Navigation (PBN) developed by EUROCONTROL and ICAO as appropriate.

Those concepts are aimed at the ensuring of the safe and efficient operation of air traffic, taking due account of the environmental impact as well as facilitating of the development of an airspace structure offering the required level of safety, capacity, flexibility, responsiveness, environmental performance and seamless provision of expeditious air navigation services, with due regard to security and defence needs.

In order to implement above mentioned concepts European States have done some initial steps.

2. Analysis of publications and investigations

Performance Based Navigation Implementation Handbook [6] that was developed by EUROCONTROL comprises the data of a potential Navigation Specifications and NAVAID infrastructure availability as well as anionic equipment for PBN implementation.

Meanwhile EUROCONTROL has raised the Free Route Airspace implementation principles in its European Route Network Improvement Plan [8] as well as in European Single Sky Implementation Plan [9].

Professor from the Czech Technical University in its article [10] tried to highlight the phased approach for the Free Route Airspace implementation in Europe.

All these researches provide a detailed description of the main principles and procedures of these concepts, expectations for its implementation; however there is a need to asses current status of PBN and Free Route Airspace concepts realization in European region by analysing statistical data.

The **aim** of the article is to provide detailed analysis of Free Route Airspace and Performance Based Navigation implementation within European region including Ukrainian air navigation system.

Such analysis gives an opportunity to identify those states that have not yet implemented proposed concepts and further to make recommendations regarding this.

3. Free Route Airspace Concept

The idea of Free Route Airspace was adopted as an Eight-States project in 1998 with the requirement to develop and implement a Free Route Airspace Concept within the airspace of Belgium,

Luxembourg, Germany, Denmark, Norway, Sweden, Finland, the Netherlands including Maastricht UAC.

Nowadays the implementation of Free Route Airspace Concept is prioritized within European airspace.

As evidence, Free Route Airspace implementation is one of the main objectives specified in ATM Master Plan, European Single Sky Implementation Plan and hence in Ukrainian Local Single Sky Implementation Plan (Fig. 1) [5].

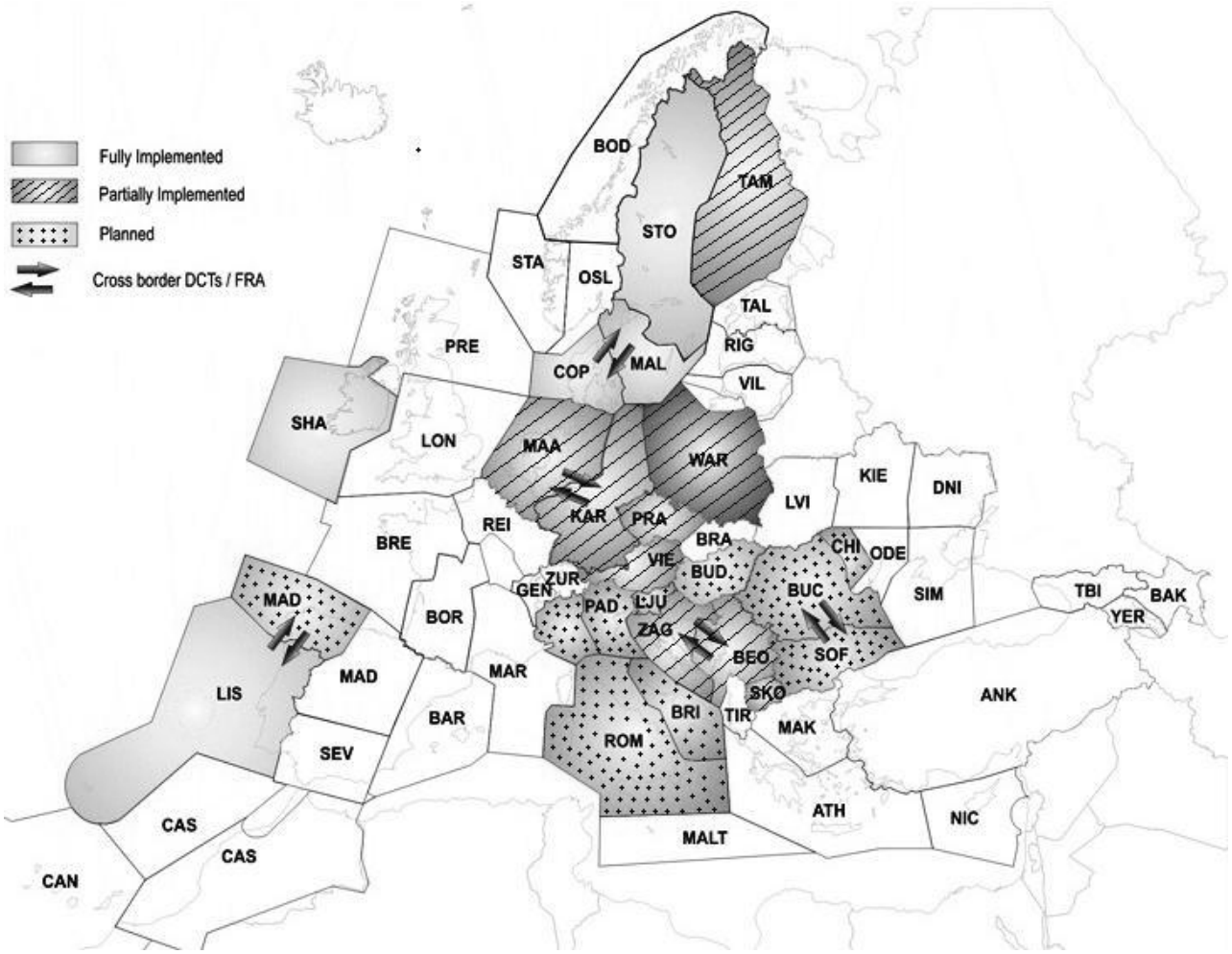

Fig. 1. European Free Route Airspace Deployment Plans

Free Route Airspace is defined as a specified airspace within which users may freely plan a route between a defined entry point and a defined exit point, with the possibility to route via intermediate (published or unpublished) way points, without reference to the Air Traffic Services (ATS) route network, subject to airspace availability.

Within this airspace, flights remain subject to air traffic control [9].

In other words Free Route Airspace allows to organize direct routings, but only between defined points as it is shown on Fig. 2.

Free Route Airspace implementation means that information about the availability of defined routes are replaced with information about the availability of airspace

Therefore there are problems that must be resolved before implementation.

First of all, the operator must adapt to a new style of designing flight routes.

For this purpose operator should always have an updated picture of airspace.

Secondly, Air Traffic Controller (ATC) should have Flight data processing systems capable free routes in order to process data in the correct sequence across sectors only with entry and exit point within Free Route Airspace.

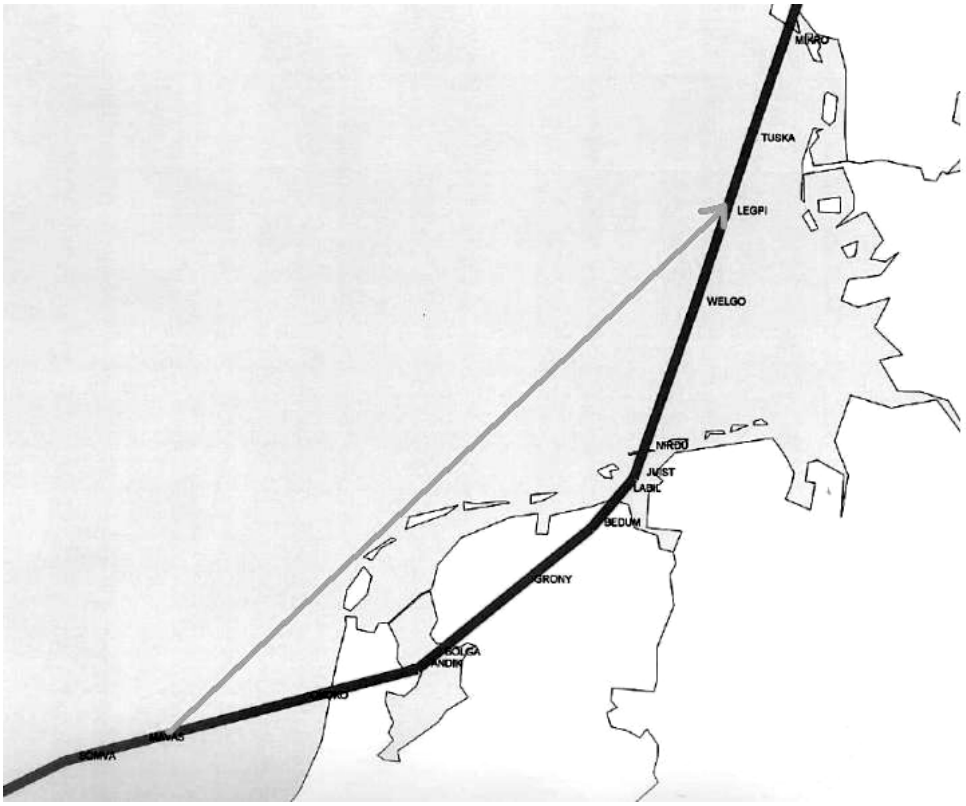

Fig. 2. ATS Routes Straightening within Free Route Airspace

Air Traffic Controller should have specific systems of dynamically updating the flight routes between sectors in case of the flight diversion from the planned track.

It is vital for ATC to posses the new operating procedures for the flight performance from the airspace with fixed ATS routes to the Free Route Airspace and vice versa (descending and climbing).

This can be achieved by provision of specific trainings and courses for aviation personnel.

For the Free Route Airspace implementation the Central Flow Management Unit (CFMU) that is located at EUROCONTROL must be able to process flight plans containing free routes and to distinguish between different times of day in case of Free Route Airspace implementation only for the part of the day.

Implementation of Free Route Airspace in Europe is not controlled by any mandate.

States, air navigation services providers, or functional airspace blocks (FABs) can establish Free Route Airspace according to its needs and demands.

Free Route Airspace cannot be implemented immediately however there are initiatives to introduce Free Route Airspace in phased approach, e.g. only during the night.

This practice shows no problems at the beginning of implementing free routes infrastructure, because at night there is less traffic, sectors can be unified and the overall air traffic controller workload is lower.

Free Route Airspace implementation brings a lot of benefits, which impacts all performance areas, such as:

– Environment: improvement of flight planning which results a possibility to uplift less fuel.

– This reduces the weight of the aircraft during flight and hence gives a benefit of reduced fuel burn and CO_2 emissions during the whole flight.

– After the implementation of Free Route Airspace over Europe it is expected to save around 8000 t of fuel that is equal to 27 000 t of CO_2 emissions.

– Safety enhancements by using new navigation and communication systems and complexes.

– Network Efficiency: reduction of complexity of the route structure and flight planning.

– There is also opportunity to rationalise some legacy inefficiencies in the network [1].

Cost-efficiency: it is expected to save around €6 million.

4. Analysis of Free Route Airspace implementation within Europe

By 2014, at least 16 ACCs of the 64 European ACCs will implement various steps of Free Route Operations.

They represent more than 25 % of the Nautical Miles (NM) area.

Savings from these projects would account to approximately 25 000 MNs per day.

As a result of these free route projects, flying distances would be reduced by approximately 7.5 million nautical miles, this representing the equivalent of 45000 tons of fuel saved, or reduced emissions of 150000 tons, or 37 million Euros [7].

Free Route Airspace implementation can take various operational formats.

The states where Free Route Airspace is implemented today are Portugal, Ireland, Denmark and Sweden, as well as the Upper Area Control Centres in Maastricht (MUAC) and Karlsruhe.

Portugal and Ireland implemented Free Route Airspace in 2009.

It is applicable above flight level 245, 24 h a day, and there is no fixed route network above FL245.

Direct flying is allowed between entry and exit points, via intermediate waypoints if necessary.

In Sweden, Free Route Airspace has been implemented for all flights with a planned cruising level above FL285.

In the Denmark/Sweden Functional Airspace Block Free Route Airspace implementation began in a phased approach in November 2011.

Maastricht and Karlsruhe was combined for geographical and time-based factors, with implementation phased over 2011 and 2012 by publishing allowed direct segments [10].

Since 2 May 2013, additional Free Route Operations are active at night in Croatia, Serbia, Poland and the Czech Republic**.**

Ukrainian authorities has approved Free Route Airspace in Ukraine (FRAU) Airspace Design Working Plan and adopted the Order of establishment expert working group for FRAU implementation.

Fig. 3 shows the detailed analysis of Free Route Airspace implementation within Europe, according to which 12,5 % of EUROCONTROL Member States have fully implemented free routes in upper airspace.

Meanwhile 17,5 % of EUROCONTROL Member States (Poland, Croatia, Serbia, Czech.

Republic, Austria, Germany and Finland) have partially implemented free routes.

Those States decided to apply phased approach for this process.

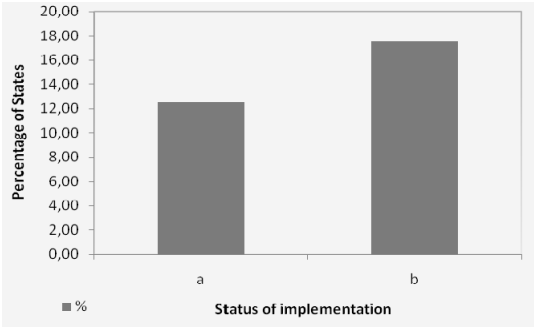

Fig. 3. Free Route implementation status within Europe:
a – implemented;
b – partially implemented

Preparation and validation for 24-hours Free Route Operations in Hungary and Spain, Night Free Route Operations in Italy**,** Slovenia and Moldova, joint Night Free Route Operations in Bulgaria and Romania as well as further expansion of Free Route Airspace Maastricht and Karlsruhe are ongoing for implementation**.**

5. Performance Based Navigation

Area navigation (RNAV) is a method of Instrument Flight Rules (IFR) navigation that allows an aircraft to choose any course within a network of navigation beacons, rather than navigating directly to and from the beacons.

This can conserve flight distance, reduce congestion, and allow flights into airports without beacons.

RNAV began as a means of navigation on a flight path from any point, or fix, to another.

These fixes could be defined by a latitude and longitude, and an airplane's position relative to them could be established using a variety of navaids.

RNAV facilitated a type of flight operation and navigation in which the flight path no longer had to be tied directly to overflight of ground navigation stations.

The use of Area Navigation systems is a basis for PBN Implementation Fig. 4.

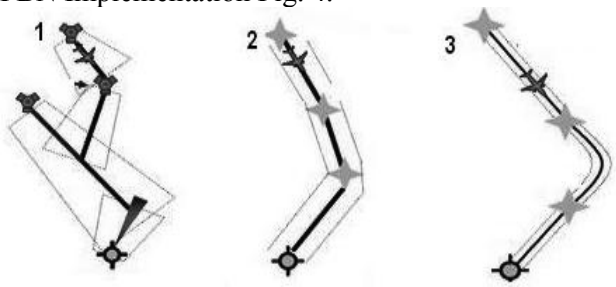

Fig. 4. Conventional routes compared to PBN-based routes:

1 – Conventional Routes (Limited Design Flexibility);
2 – RNAV (Increased Airspace Efficiency);
3 – RNP (Optimized Use of Airspace)

ICAO's PBN Concept was introduced through the ICAO publication in 2008.

Performance Based Navigation concept specifies that aircraft RNAV system performance requirements be defined in terms of accuracy, integrity, availability, continuity and functionality required for the proposed operations in the context of a particular airspace concept, when supported by the appropriate navigation infrastructure [6].

Performance Based Navigation concept identifies three components (Fig. 5):

– the NAVAID Infrastructure;
– the Navigation Specification;
– the Navigation Application.

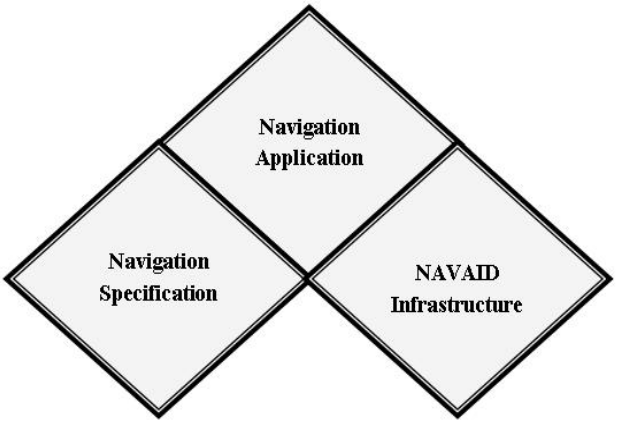

Fig. 5. Components of PBN Concept

The NAVAID Infrastructure refers to ground- and space-based navigation aids.

The Navigation Specification is a technical and operational specification that identifies the required functionality of the area navigation equipment and associated aircraft avionics. It also identifies the navigation sensors required to operate using the NAVAID Infrastructure to meet the operational needs identified in the Airspace Concept.

A navigation specification is either an RNP specification or an RNAV specification.

An RNP specification includes a requirement for on-board self-contained performance monitoring and alerting, while an RNAV specification does not.

Both RNAV and RNP specifications include requirements for certain navigation functionalities.

At the basic level, these functional requirements may include:

– continuous indication of aircraft position relative to track to be displayed to the pilot flying on a navigation display situated in his primary field of view;

– display of distance and bearing to the active waypoint;

– display of ground speed or time to the active waypoint;

– navigation data storage function;

– appropriate failure indication of the RNAV system, including the sensors.

The Navigation Application is the use of the NAVAID Infrastructure and Navigation Specification for the design of ATS Routes as well as Instrument Approach Procedures [6].

Because RNAV and RNP are part of PBN, lateral navigation standards for performance, functionality, and capability are intrinsic to it. PBN has the potential to provide operators with more efficient airspace and instrument procedures that can improve safety, access, capacity, and efficiency, while minimizing environmental impacts.

With PBN, all navigation aspects of operations – including terminal airspace – will be defined, developed, and implemented on the basis of operational requirements and the associated required performance.

The development and implementation of a PBN-based Airspace Concept makes significant contributions in terms of safety, environment, capacity and flight efficiency, such as:

– safety is enhanced by increased pilot situational awareness and by provision of precise lateral and vertical flight path that causes the reduction of Controlled Flight Into Terrain occurrences;

– Performance Based Navigation routes are more direct that reduces the track miles flown, which means lower fuel use and lower emissions;

– capacity and efficiency is improved by placing ATS routes in the most optimum location in lateral and vertical dimensions;

– enhanced reliability, repeatability, and predictability of operations lead to increased air traffic throughput and smoother traffic flow;

– Performance Based Navigation enables a decommissioning of typical navaids such as NDB and VOR.

This causes a cost reduction for the users due to eliminating costs for procurement and maintenance [7].

6. Analysis of Performance Based Navigation implementation status within Europe

ICAO specification RNAV 5 became mandatory as the primary mean of navigation in all ECAC en-

route airspace from FL95 and above. VOR/DME should remain available for reversionary navigation and for use on domestic ATS routes in the lower airspace, as appropriate.

Analysis of PBN implementation status in Europe is based on the ICAO statistics expressed in percentage of runways where PBN is implemented [11].

Fig. 6 shows that six States (Austria, Finland, Hungary, Lithuania, Germany, and Czech Republic) have implemented PBN for more that 50 % of runways however five States (Denmark, Iceland, Norway, France, and Switzerland) have implemented PBN up to 50 % of runways.

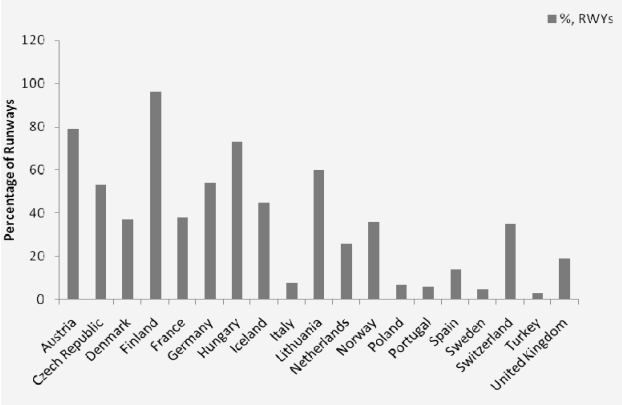

Fig. 6. Analysis of PBN implementetion status within Europe

7. Performance Based Navigation implementation in Ukraine

In 2010 the State Aviation Administration of Ukraine has approved a short-term PBN implementation strategy.

Aeronautical Information Service of Ukraine has issued Aeronautical Information Circular (AIC) concerning the PBN implementation in the terminal airspace.

According to the Strategy it is planned to implement RNAV 5 above FL 275 for en-route airspace.

It is also expected to establish RNAV 5 in whole airspace till 2016 along with the beginning of implementation of RNAV 1 specification. Long-term perspective for en-route airspace is A-RNP implementation.

The general strategy for implementation of PBN in Terminal Control Areas (TMA) and Aerodrome Flight Information Zones (AFIZ) is dependent on traffic density and of the specific function of the specific aerodrome in terms of:

– International air traffic (scheduled and unscheduled);

– Domestic air traffic (scheduled and unscheduled);

– Business/corporate operations;

– General aviation operations;

– Aerial works, aviation industrial production, sports aviation, etc. [2].

In Ukraine specification RNAV 1 is being introduced in the TMA's of following international aerodromes:

Boryspil`, Dnipropetrovs'k, Donets'k, Kharkiv (Osnova), Kyiv (Zhuliany), L'viv, Odesa.

It is also planned to implement A-RNP specification in Ukrainian TMA.

8. Comparison of Free Route Airspace and Performance Based Navigation implementation status

Fig. 7 shows the comparison of Free Route Airspace and PBN implementation status.

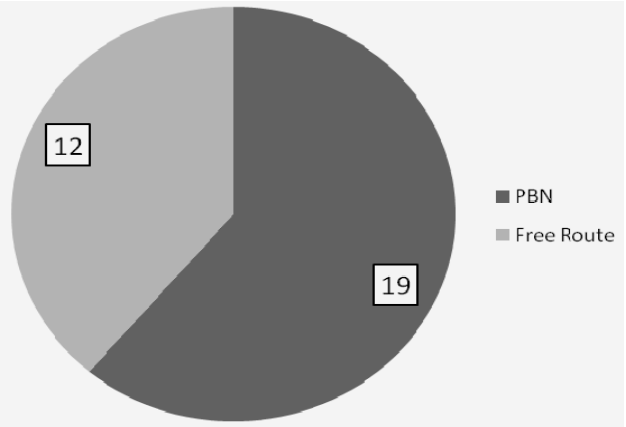

Fig. 7. Comparison of PBN and Free Route Aispace implementation status

The data used for this analysis were taken from the ICAO website.

As it is shown, 19 Member States have already implemented PBN in their runways however 12 Member States have completely or partially established Free Route principles in the upper airspace.

9. Conclusions

European aviation community is currently looking for the right steps in order to increase airspace capacity and airspace flexibility along with enhancement of operator's efficiency.

The environmental impact remains the vital problem for aviation industry.

The step ahead concerning all this issues is the development and implementation of Free Route Airspace and PBN in Europe, designed by EUROCONTROL and ICAO as appropriate.

Those concepts brings sufficient benefits, such as cost-efficiency, reduction of CO2 emissions in the atmosphere, safety enhancement by establishing additional procedures for the flight operations.

European States have supported the implementation of Free Route Airspace and PBN

within their national airspace and have already initiated some preliminary actions for this.

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С.В. Павлова[1], А.О. Задорожня[2]. Аналіз упровадження концепцій повітряного простору вільних маршрутів та навігації, заснованої на характеристиках, у європейській аеронавігаційній системі

[1,2]Національний авіаційний університет, просп. Космонавта Комарова, 1, Київ, Україна, 03680.

E-mails: [1]psv@nau.edu.ua; [2]alinazadorozhnia@gmail.com

Розглянуто питання забезпечення безпеки польотів, підвищення пропускної спроможності та економічної ефективності, зменшення впливу інтенсивності повітряного руху на навколишнє середовище. Проаналізовано розроблені міжнародними організаціями концепції повітряного простору вільних маршрутів та навігації, заснованої на характеристиках, у європейському регіоні та українській аеронавігаційній системі. Із результатів аналізу статистичних даних видно, що 12,5% країн-членів Євроконтролю впровадили концепцію повітряного простору вільних маршрутів у верхньому повітряному просторі повністю, 17,5 % країн-членів Євроконтролю (Польща, Хорватія, Сербія, Чехія, Австрія, Німеччина та Фінляндія) частково. За даними Міжнародної організації цивільної авіації показано, що шість країн упровадили процедури навігації, заснованої на характеристиках, для більш ніж 50 % злітно-посадкових смуг, п’ять країн упровадили ці процедури лише для деяких аеродромів.

Ключові слова: безпека польотів; економічність; Євроконтроль; зональна навігація; ІКАО; навігація, заснована на характеристиках; навколишнє середовище; повітряний простір вільних маршрутів; пропускна спроможність.

С. В. Павлова[1], А.А. Задорожняя[2]. Анализ внедрения концепций воздушного пространства свободных маршрутов и навигации, основанной на характеристиках, в европейской аэронавигационной системе

[1,2]Национальный авиационный университет, просп. Космонавта Комарова, 1, Киев, Украина, 03680.

E-mails: [1]psv@nau.edu.ua; [2]alinazadorozhnia@gmail.com

Рассмотрены вопросы обеспечения безопасности полетов, повышения пропускной способности и экономической эффективности, уменьшения воздействия интенсивности воздушного движения на окружающую среду. Проанализированы разработанные международными организациями концепции воздушного пространства свободных маршрутов и навигации, основанной на характеристиках, в европейском регионе и украинской аэронавигационной системе. Из результатов анализа статистических данных видно, что 12,5 % стран-членов Евроконтроля внедрили концепцию воздушного пространства свободных маршрутов в верхнем воздушном пространстве полностью, 17,5 % стран-членов Евроконтроля (Польша, Хорватия, Сербия,

Чехия, Австрия, Германия и Финляндия) частично. В соответствии с данными Международной организации гражданской авиации показано, что шесть государств установили процедуры, предусмотренные навигацией, основанной на характеристиках, для более чем 50 % взлетно-посадочных полос, пять государств внедрили эти процедуры только для некоторых аэродромов.

Ключевые слова: безопасность полетов; воздушное пространство свободных маршрутов; Евроконтроль; зональная навигация; ИКАО; навигация, основанная на характеристиках; окружающая среда; пропускная способность, экономичность.

Pavlova Svetlana (1966). Doctor of Engineering. Associate Professor.
Department of Air Navigation Systems, National Aviation University, Kyiv, Ukraine.
Education: Kyiv Construction Institute, Kyiv, Ukraine (1988).
Research area: analysis and synthesis of nonlinear ergatic systems, critical technologies, nonlinear dynamic.
Publications: 70.
E-mail: psv@nau.edu.ua

Zadorozhnia Alina (1989). Postgraduate student.
Department of Air Navigation Systems, National Aviation University, Kyiv, Ukraine.
Education: National Aviation University, Kyiv, Ukraine (2013).
Research area: analysis of air traffic management and flight safety trends, airspace use optimization.
Publications: 7.
E-mail: alinazadorozhnia@gmail.com