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Organisational Principles of Free Route Airspace in a Global Scale (multicriteria approach: safety and efficiency)

Principles of Free Route Airspace organisation on national and regional level in airspace under responsibility of Ukraine are considered. The main hazards in-fluence safety of flights (with use of multicriteria approach: safety and efficiency) are discussed.

Introduction

The development of Free Route Airspace (FRA) in European airspace was launched in mid-2008 by the European Organization for the Safety of Air Navigation (EUROCONTROL) and currently is carried out in practice by multiple national Air Navigation Service Providers (ANSPs) and Civil Aviation Authorities (CAA) of the EUROCONTROL-member states. The FRA concept is a frontline regional airspace design solution and challenging operational concept that covers the whole pan-European air traffic services (ATS) route network in upper airspace and, therefore, requires harmonised approach and seamless solutions for all involved states.

FRA is an airspace (national or regional) of defined vertical and horizontal dimensions, with scheduled operational hours (FRA-Night or FRA-H24), where aircraft operators are free to plan flights [1] between any entry and exit points, with no links to the existing fixed ATS routes network [2], but considering the airspace availability (TRAs/TSAs, military activity, etc.) [3,4]. All flights in FRA are subject to air traffic control [3,5] and, therefore, provided with separation and other ATS.

In contrast with flights via the ATS routes network, where air traffic flows are bound to the ATS routes segments (defined in the flight plan) [3,4], in case of FRA, aircraft fly direct routes (DCT) and, as a consequence, air traffic flows are distributed more evenly in ATS units sectors [2]. This feature requires higher situation awareness and consistency from air traffic controllers involved in air traffic control (ATC) operations in FRA and causes putting additional automated tools in human-machine interfaces (HMI) at workplaces. It becomes necessary in order to calculate/predict more complicated evolutions of existing and forthcoming traffic and assess potential conflict situations [5,6] between omnidirectional aircraft at same flight level (MTCD, Safety Nets (STCA, MSAW, APW), etc.).

The main benefits from FRA implementation are following:

- Possibility for the airspace users to plan flights via DCTs [1,3] to make available for planning routes, which were available only during the tactical airspace management (ASM);
- Increasing the flights cost-efficiency and reduction of negative impact to the environment.

The implementation of FRA on Pan-European level [3] gradually optimizes regional airspace structures, provides more flexible and efficient use of available airspace and increases its capacity, ensures higher predictability of air traffic flows. In addition, it simplifies operational procedures for ATS, air traffic management, airspace management and civil-military coordination.

For airline operators, FRA implementation increases the airspace attractiveness due to optimization of flight plan trajectories and, accordingly, gives additional opportunity to reduce fuel consumption, decrease flight time and minimise harmful emissions (CO_2 and NO_x) into the environment.

In the article, the authors provide insights into advantages of FRA implementation on particular example of the Free Route Airspace of Ukraine (FRAU) [5,7], as one of the regional leaders of FRA concept putting into the practice and further utilisation. At the moment, according to the European Route Network Improvement Plan (ERNIP) [8], FRAU Step 2, Scenario 2a [5,7] is under implementation through the sequence of phases, as follows (Fig. 1):

- Phase 1 – cross-border FRA-H24 within UKNESFRA, covering UTA Lviv, UTA Kyiv, UTA Dnipro-North and UTA Dnipro-South (only DVK Zone 1), successfully implemented 12 AUG 2021;
- Phase 2 – FRA-H24 within UKODSFRA, covering UTA Odesa-North and UTA Odesa-South, successfully implemented 02 DEC 2021;
- Phase 3 – cross-border FRA-H24 within the entire UIR Kyiv – UKBUFRA, covering UTA Lviv, UTA Kyiv, UTA Dnipro-North, UTA Dnipro-South, UTA Odesa-North and UTA Odesa-South, planned for the summer 2022.

Fig. 1. Current state of FRAU implementation

Harmonised FRA Implementation in the European Airspace

The Eurocontrol Network Manager (NM) coordinates the FRA implementation in the European airspace and publishes progress of all participated countries in the ERNIP [8]. The principles of FRA implementation are specified in ERNIP Part 2. European ATS Route Network - Version 2020 - 2024 [8], as follows:

- The airspace configuration is based on operational needs and regulatory requirements, overriding national or functional airspace borders, and is not limited only by upper and lower airspace volumes;

- Airspace design is a transparent process, that demonstrates the decisions made and their rationale, considering needs of all airspace users, while guided by safety and efficiency criteria, capacity, environmental aspects and requirements of military agencies; and

- Vertical and horizontal compatibility, terminal airspace connectivity, adjacent FRA areas interfaces and procedures harmonisation in order to enable aircraft flights as close as possible to the en-route cruising levels (ECL) and optimal flight profiles.

According to the ERNIP Part 2. European ATS Route Network - Version 2021 - 2030 [8], as of mid-2021, FRA-H24 has been successfully implemented in more than 30 area control centres (ACC) of Eurocontrol member states, for example, in Ukraine [5,7] – the FRA-Night in Lviv ACC (December 6, 2018), the cross-border FRA-H24 in Kyiv ACC and Dnipro ACC (May 23, 2019) and the FRA-H24 in Odesa ACC (UTA Odesa-North) (April 22, 2021). Furthermore, on August 12, 2021 Kyiv ACC, Lviv ACC and Dnipro ACC were merged into the cross-border FRA-H24 area, namely UKNESFRA, which is one of the biggest FRA areas in the European region.

One of the next Eurocontrol steps in a harmonized FRA implementation is the evolutionary integration of segregated FRA areas into wider, multi-regional cross-border FRA areas, which might unite airspace of many adjacent countries (Fig. 2) [8].

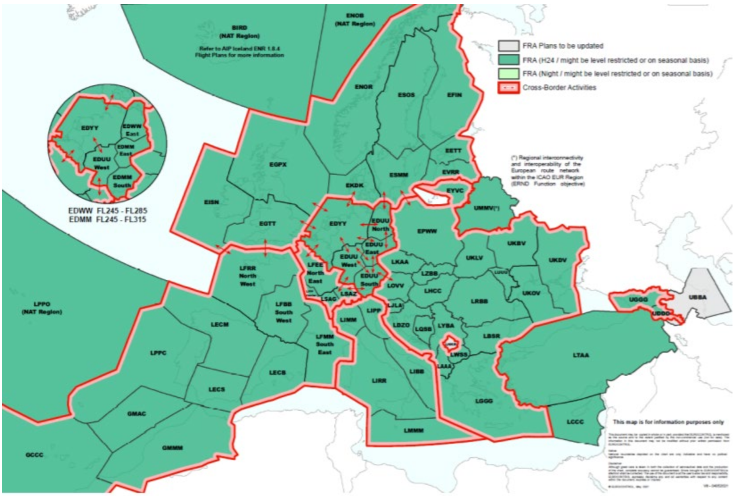

Fig. 2. FRA implementation plans in European airspace by the end of 2030

Conclusions

All abovementioned proves the high topicality and demand of further researches in the field of Free Route Airspace implementation and, if needed, transition of some scalable block solutions to other regions of the world focusing on following topics:

1. Safety aspects – analysis and list of hazards at FRA implementation [5,7], the brief description of problem is provided in the article [9].

The typical threats and hazards, connected with FRA implementation shall be listed and analysed in details, appropriate conclusions/solutions to be proposed. The short list of threats and hazards for analysis includes following: the coordination not performed or performed incorrectly, radar information monitor malfunction, delay (freezing) of radar information monitor readings, surveillance systems identification loss, on-board transponder failure, surveillance data misinterpretation regarding aircraft, loss of surveillance data for all aircraft, intrusion of aircraft into activated prohibition/restriction airspace (and vice versa, not cleared operational flights leaving the TRA/TSA). The typical threats and hazards and possible ANSPs mitigation countermeasures shall be also analysed with use of adaptive neural networks.

2. Efficiency aspects – the universal and unified algorithm of acceptability assignment and further correct generation of DCT restrictions in a horizontal and vertical planes, the partial solution of problem for the selected issues (relevant for Ukrainian airspace) is provided in the article [10].

Some inconsistency and inaccuracy in a process of creation of DCT restrictions shall be analysed, common algorithm to be proposed for issues in horizontal and vertical planes. The list of specific issues selected for analysis includes following: issue with checking the proximity of DCTs close to the FRA area border, issue with FRA area border "clipping", issue with transition "laterally" via FRA intermediate point and issue with transition "vertically" below FRA significant point. The common algorithm might help more correctly generate DCT restrictions and more efficiently use FRA, enabling possibility of automated procedures for, at the moment, manual technology processes. Comparison and analysis of existing and proposed DCT restrictions shall also include Pearson's chi-squared test (χ^2).

3. Combined safety and efficiency aspects – common algorithm of calculation of positions of FRA horizontal entry/exit points based on information about main traffic flows (retrospective and forecast data) including simulations in the Eurocontrol NEST tool, considering restricted airspace (TRAs/TSAs) vertical/horizontal dimensions (including activation times).

The Eurocontrol NEST tool provides functionality for air traffic flows researches under different functional restrictions, search of optimal flight trajectory and flight cost efficiency optimisation. The NEST will help to check theoretically calculated positions of FRA horizontal entry/exit points and provide visualisation of new air traffic flows. Some parameters of initial and simulated air traffic flows shall be analysed with use of Pearson's chi-squared test (χ^2) and Pareto principle/distributions.

4. Combined safety and efficiency aspects – common algorithm of generation of DCT restrictions based on activated restricted airspace (TRAs/TSAs) of defined dimensions and involved FRA horizontal entry/exit points.

The ad-hoc activation of TRAs/TSAs requires immediate closure of appropriate ATS routes segments (routine task) and associated FRA DCTs (more complicated task in case of wide FRA area, for example, UKNESFRA). Common algorithm for automatic generation of DCT restrictions shall be proposed. Comparison of manually plotted and automatically generated DCT restrictions shall include also Pearson's chi-squared test (χ^2).

References

1. (2018). NM Flight Planning Requirements – Guidelines. Brussels, EUROCONTROL.
2. (2017). Free Route Airspace (FRA) Application in NMOC – Guidelines. Brussels, EUROCONTROL.
3. (2020). European Route Network Improvement Plan. Part 1 – European Airspace Design Methodology – Guidelines. Brussels, EUROCONTROL.
4. (2019). Free Route Airspace Design Guidelines. Brussels, EUROCONTROL.
5. (2018). Free Route Airspace Ukraine (FRAU) Operational Concept, Step 1 - Scenario 1b. UkSATSE.
6. (2021). Safety Assessment in ATM system of UkSATSE on implementation of Free Route Airspace (Step 2, Scenario 2a). UkSATSE.
7. (2018). FRA UKRAINE (FRAU) Airspace Design, Working Plan. UkSATSE.
8. (2019). European Route Network Improvement Plan – Part 2. European ATS Route Network. Brussels, EUROCONTROL.
9. Chynchenko Yu., Kharchenko V. (2021). The Free Route Airspace Ukraine implementation cornerstones. Proceedings of the National Aviation University, vol. 1, 6-12.
10. Chynchenko Yu., Kharchenko V. (2021). Integrated algorithm for compiling and assessment of direct routes restrictions in Free Route Airspace of Ukraine. Proceedings of the National Aviation University, vol. 3, 15-22.