The Effects of the Introduction of Free Route (HUFRA, Hungarian Free Route Airspace) in the Hungarian Airspace

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***Abstract*—This paper presents the evolution of the Hungarian air route system, and outlines the steps taken to introduce HUFRA- the Hungarian Free Route Airspace- successfully. According to the present figures, the introduction of HUFRA reduced the costs of aircraft operation, fuel consumption, the emission of pollutants, and flight time considerably. However, its influence on the capacity of an airspace depends a great deal on the level of homogeneity of traffic in a given airspace. On account of the above, HungaroControl also participated and ran validation exercises in order to assess what changes a cross-border FAB CE Free Route Airspace would imply on the traffic flows and human performance. Focusing on the Hungarian sectors, the last section presents the results of the study with a strong emphasis on human performance and conflict points.**

Keywords-HUFRA, Free Route Airspace, Air Traffic Control, Air Traffic Management, Human Factors

I. Introduction

Free Route was introduced in Hungary on 5 February 2015, which enabled aircraft to fly over the country on the shortest possible route, with no deviations, in a straight line between entry and exit points. This has resulted in advantageous effects for aircraft operators, passengers and the environment, while the workload of air traffic controllers has not increased significantly.

Traditionally, the first successful flight of the Wright brothers on 17 December 1903 is considered to mark the birth of powered flight. It took another two decades for air traffic to reach the level of development where the designation of air routes for long haul flights became necessary.

In Hungary the first written trace of the air route network is a map published in the Hungarian Directory of Regulations (Magyar Rendeletek Tára) in 1933 (see Figure 1). These decades brought about the evolution of navigation reliant on the ground-based radio direction finding services, thus, there were no, or hardly any routes designated with the use of radio navigation equipment supporting independent on-board navigation. Because of this, the first radio direction finding equipment mounted on board of aircraft used the signals from radio broadcasting stations to determine the position of the aircraft.

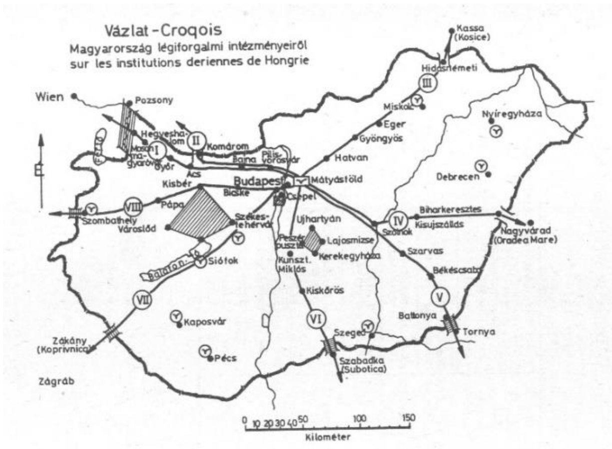


Figure 1. The Hungarian air route system in 1933 [1]

The situation changed profoundly by the second half of the 20th century, when the use of cockpit mounted radio navigation equipment became widespread as a result of the technical development in World War Two. The first generation of this equipment, the NDB/ADF system, was capable of using the signals from radio broadcasting stations if necessary, but this was also the time when the installation of non-directional beacons, NDB's began to mark the junctions and the waypoints of air routes.

In order to correct the shortcomings of the radio direction finding system, the VHF/UHF band based VOR/DME system was developed, which demanded the establishment of special transmitter stations on the ground at the intersections and waypoints of air routes. This was also an essential requirement for the newly formed air navigation services, since the separation minima between aircraft in procedure air traffic control defined in ICAO DOC 4444 could only be ensured with the use of this equipment. After some time, however, the ground fixed system became an obstacle to development, since air routes could not be modified without relocating the ground based navigation equipment, which would have incurred considerable costs and time. As a result, the air route network in Hungary became fixed for decades, and the situation was further complicated by the air corridor system used due to military considerations. (see Figure 2)

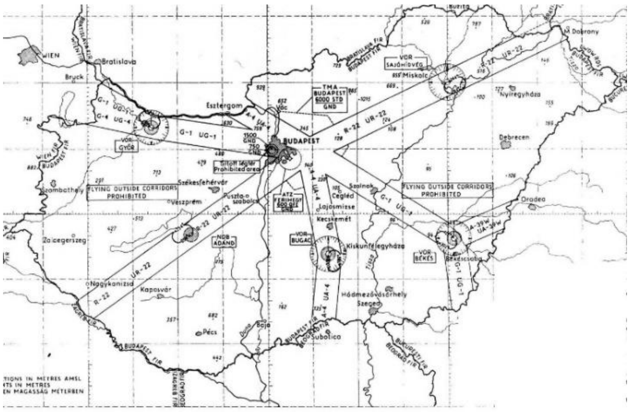


Figure 2. The air navigation map of Hungary from the 1970’s [2]

In line with the general spread out of civilian radars, procedure air traffic control in Hungary was replaced by radar control in 1991, and in 1992 the air corridors were terminated. The introduction of new on-board equipment (e.g. FMS and INS/GPS) and radar control opened the way for R-NAV capable aircraft to deviate from the former, strict air route network, as these devices were able to place “ghost VOR’s” anywhere relying on the ground based VOR/DME transmitters. This means that they could display and measure the current location of the aircraft in relation to them. With the widespread use of FMS, after the turn of the millennium modern aircraft became capable of flying any route independently.

The shifting of air traffic trends had a considerable influence on the composition of traffic flying through the Hungarian airspace starting from the beginning of the 1990’s: a main traffic flow evolved with a north-west, south-east direction, used by flights connecting the north-west of Europe with the Middle and Far East (see Figure 3).

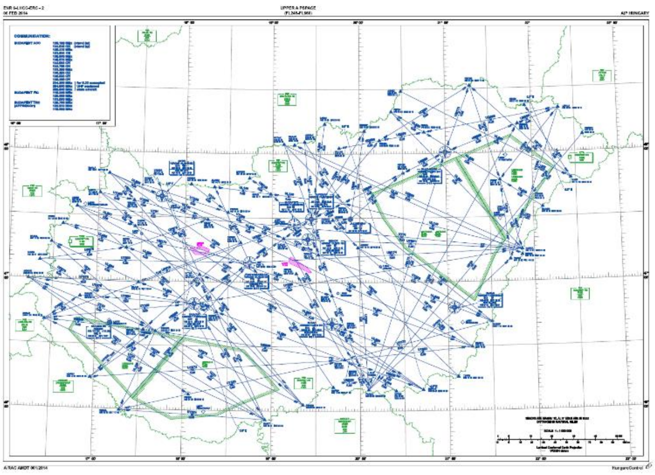


Figure 3. Hungary’s air navigation map from 2014, FL245-FL660

II. The Termination of the Route System

The Single European Sky and SESAR program, both running under the wings of EUROCONTROL, aim to increase the efficiency of European air traffic, and reduce the costs and delays. A prominent element of these programmes is to make it possible for aircraft to fly between their departure and destination airport on the shortest (or optimised) route, free from unnecessary turns. The results (e.g. reduced flying time, reduced fuel consumption and reduced emission of pollutants) are of common European interest. The Commission Implementing Regulation (EU) No 716/2014 was adopted in line with the above objectives, prescribing that by 01 January 2022 fixed flight routes above 9000 metres shall be terminated, and the possibility for flights to determine their own flight route shall be ensured.

The Hungarian Air Navigation Service Provider, HungaroControl - Hungarian Air Navigation Services Pte. Ltd. Co. introduced Free Route, or HUFRA (Hungarian Free Route Airspace) on 05 February 2015, after a long period of preparation, and thus was the first in Europe to provide completely restriction-free (both in space and time) airspace use. As a result, aircraft are able to travel through the Hungarian airspace in a straight line between the entry and exit points on the borders.

The introduction of the system, now in its third year of successful operation, was made possible by the following factors:

- the relatively homogenous nature of the former fixed route system, having a north-west and south-east main traffic flow;
- minimal crossing traffic load (mainly on the R-22 route from Ukraine to Northern Italy);
- the fact that the departing and arriving traffic at the country’s only large traffic airport, Budapest Liszt Ferenc Airport, fitted in well with the main traffic flow;
- the high technical standard and flexibility of the air traffic control system, MATIAS, applied by HungaroControl;
- the high level of technical knowledge and skills of the air traffic controllers;
- thorough preparation work (e.g validations, trainings).

One of the most important considerations when introducing Free Route is how it will affect the workload of the air traffic controllers (ATCOs). From a mathematical perspective, Free Route causes the former flow of traffic, which could be considered as arranged, to become disarranged (see Figure 4). This in turn has an impact on air traffic controllers workload and the capacity of the airspace in two contradicting ways:

- because of the disarranged traffic flow, the same volume of traffic is distributed more evenly in the same airspace, leading to an increased average distance between aircraft, which reduces the workload of air traffic controllers and increases the capacity of the airspace;

- the handling of the traffic flow in the former route network containing routes and route junctions required air traffic controllers to conduct linear conflict detection and conflict solving, and the search for conflicts between aircraft using the routes or approaching the crossing point of routes could be focused on well-defined areas. However, in the course of Free Route usage, due to the non-linear interaction between elements the entire airspace has to be monitored continuously, which translates into increased workload (for illustration see Figure 4, and for real-life experiences supporting both arguments see [20]).

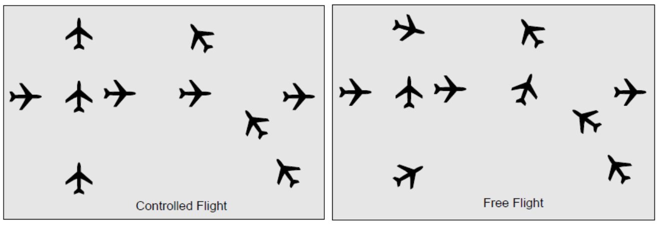


Figure 4. Flow of traffic in controlled flight vs free flight [3] [4]

In order to estimate the impact of free route airspace on ATCO workload, it is essential to determine which factors play a significant role in general. In the light of the above mentioned, it has been shown that sector load is not the only predictor of subjective cognitive workload [5]. Several studies demonstrated that workload is significantly impacted by other complexity indicators (e.g. number of flights with changing vertical profile, horizontal and vertical proximity between two aircraft), weather, sector structure or frequency congestion [5] [6] [7]. Consequently, workload is often estimated by integrating the complexity of the given airspace into a mathematical model.

Such a model can then be applied in Fast-Time or Real-Time Simulations to estimate how a new concept impacts the workload. Fast-Time Simulation (FTS) provides a cost effective way to examine the impact of new aspects on operations and help stakeholders to make informed decisions. The simulation is executed at accelerated speed, which provides opportunity to test various scenarios. In contrast, Real-Time Simulation (RTS) is used to validate new operational concepts with the contribution of air traffic controllers who are proficient in the measured airspace. In order to ensure realistic and high-fidelity environment the human-machine interface can be reproduced to match to the ATCO's own system [8]

One model that has been applied for such inference is the Messerschmitt Bölkow Blohm (MBB) method. In a EUROCONTROL study [9], the MBB was calculated every two minutes during RTS and compared with a subjective questionnaire (Instantaneous Self Assessment, ISA [10]), using the following formula:

$$MBB = Tot + 0.2 * Mil + 0.24 * Evol + 0.26 * FIR + 0.30 * TMA + 0.38 * RV + 1.4 * Nconf + 0.6 * Nhold$$

where:

To = Nbr. of aircraft (a/c) entering the sector

Mil = Nbr. of military aircraft entering the sector

Evol = Nbr. of a/c changing flight level

FIR = Nbr. of a/c transitting between FIR and UIR

TMA = Nbr. of a/c transferring from/to the Approach

RV = Nbr. of radar vectoring orders given

Nconf = Nbr. of inputs to resolve conflicts

Nhold = Nbr. of a/c placed in holding pattern

Considering this MBB method, it is transparent that the RV and Nconf are the factors subject to change in the transition from fixed-route network to free route airspace. Albeit the attached weights, the positional relation between aircraft pairs cannot be extracted in a straightforward way from this model. This is considered rather essential as it has been shown that such relationship has different impact on perceived workload [11]. Interestingly, Kageyama et al. [12] addressed this weakness and measured workload based on a modified MBB method. Specifically, they used the AirTOp software for fast-time simulation, which has a built-in controller workload estimation [13]. The main aspect to highlight is the inclusion of the lateral and vertical conflict type. They differentiate between the vertical relationship types (e.g. both cruising; one in vertical; both in vertical movement) and horizontal relationship based on flight angle (following with heading difference between aircraft is smaller than 45 degrees; opposite with heading difference between aircraft is bigger than 135 degrees; crossing in all other cases). The software then assigns time for each event, but applies a weighing to each lateral/vertical conflict type based on subject matter evaluation [12] [13]. According to the figures, conflict detection and resolution takes more time in case of a crossing type conflict, regardless of the lateral position of the aircraft pair. However, a situation with following aircraft pairs, in particularly in cruising phase, takes the least time to detect and resolve.

This logic implies that within the cruising phase the airspace complexity hence workload is higher if crossing type of conflicts are present. The result of this calculation is supported by the fact that the introduction of Free Route (complete or partial, with restrictions) has so far been possible in countries where the nature of the traffic flow is relatively homogeneous, and follows a distinguished direction (Hungary, Sweden, Denmark, Ireland, Portugal). On the other hand, the procedure has not yet been introduced in airspaces with a high level of complexity, with a complicated traffic load.

III. Effects of the Introduction

As a result of the introduction of the HUFRA system, the length of the routes flown by the flights using the airspace of Hungary has shortened by 1.5 million kilometres, leading to a

15 000 ton per year reduction in CO_2 emission, and also saving 3 million US Dollars annually for airlines in fuel costs. On top of these benefits, there are three main aspects worth noting about the effects of HUFRA.

A. *Safety*

Since the introduction of HUFRA it has been shown that the risk of an accident has not increased. According to the latest report, HungaroControl's safety performance has not only been maintained, but even improved, despite the continuous traffic growth (see Figure 5).

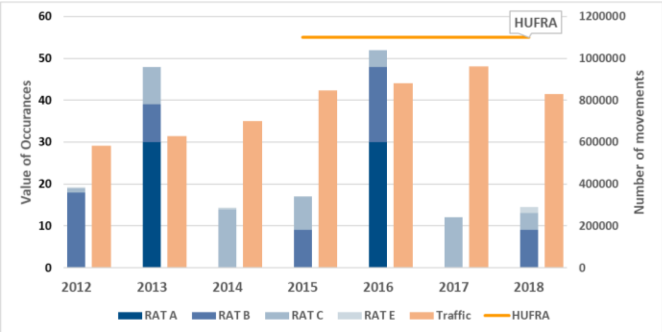
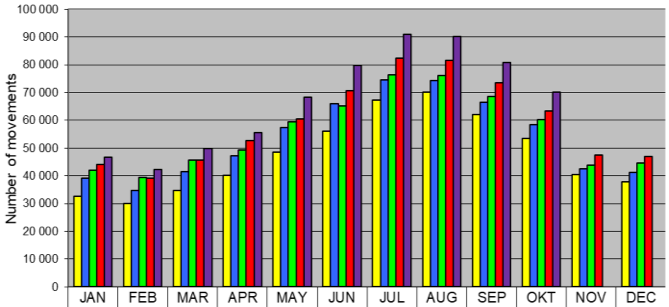


Figure 5. Classified safety occurrences within ATCC Budapest between 2012 and 2018 based on the Risk Analysis Tool (RAT).

B. *Traffic growth*

One of the key benefits of FRA is to offer multiple options for the airlines to plan routes. Consequently, since 2015 fundamentally new traffic patterns have emerged. A good example is the Vienna-Malta city pair's route (Austrian Airlines), which was inconceivable prior to HUFRA given the lack of route in the ATS fixed route system from Austria to Malta via Croatia in the past. There are other new flights brought by FRA (e.g. via LONLA-KARIL points in the eastern sector) which only spend a few minutes in the sector. Thus, it is fair to say that HUFRA plays an integral part in the continuous traffic growth (see Figure 6).



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OKT	NOV	DEC
2014	32 559	30 018	34 608	40 270	48 633	55 957	67 268	70 122	62 163	53 403	40 322	37 808
2015	39 200	34 784	41 395	47 108	57 279	65 839	74 548	74 211	66 566	58 535	42 519	41 261
2016	42 110	39 414	45 574	49 414	59 347	65 221	76 412	76 237	68 590	60 241	43 954	44 540
2017	43 974	39 051	45 744	52 754	60 525	70 572	82 388	81 610	73 515	63 477	47 467	47 043
2018	46 784	42 188	49 936	55 528	68 302	79 768	91 048	90 198	80 933	70 049		

Figure 6. Number of movements of ATCC Budapest between 2014 and 2018.

However, it is essential to emphasize that whilst the traffic has soared in the previous years, HUFRA alone does not account for the increase in complexity of the Budapest ACC (LHCC). There are other contributing factors such as new city-pair connections (i.e. flights with new departure airport such as Temesvár (LRTR), Nagyvárad (LROD)).

Although the air traffic controllers have effectively handled the significant increase, this efficiency could not be maintained this year (2018), as major delays have been witnessed. It is important to stress that the delays were not due to capacity constraints caused by the concept. According to the internal analysis, the delays were attributable to (i) the major difference between the predictions of the Network Operations Plan (NOP) and the actual flight demand, (ii) extremely bad weather conditions in the summer period (Cumulonimbus-activity).

C. *Human Factors*

Compared to the fixed route network, HUFRA brought various changes in cognitive processing. As the location of hotspots became more distributed and unpredictable, ATCOs need to scan the entire airspace and traffic continuously. They apply different information acquisition techniques and are required to process significantly more information. Furthermore, more risks and scenarios need to be taken into consideration during traffic planning or conflict resolution. In order to maintain situational awareness, sustained attention is required.

In order to establish a skill-based behaviour (i.e. execute highly practised actions smoothly), the introduction of HUFRA also had a considerable impact on the length and content of the ATCO training. Whilst the duration of the simulator module has been increased, so did the average days of the On the Job Training (OJT) days; from 300 to 400 hours. A huge help is attributed to the MATIAS-BEST simulator, which is also the contingency platform with the same softwares as in the OPS room. Interestingly, instructors noted that the previous expertise in vector calculus (e.g. from high school, university studies) became of great use for the ATCO trainees.

In a bid to manage the workload, HungaroControl is assessing the technological and operational feasibility of smaller geographical sectors. At the moment, HungaroControl operates large geographical sectors in comparison to any neighbouring ANSPs. This airspace reorganisation is expected to support ATCOs and optimise their performance without significantly enhancing the coordination task load.

IV. Simulation Use Case

A. *Scope of the validation*

Free Route Airspace is not only being introduced within separate FIRs, but there is also an increasing trend of cross-border FRA implementation. The reason for it is manifold. In line with EC Regulation No. 716/2014, it will be mandatory for air navigation organizations to introduce Free Route Airspace (FRA), above 9000 meters across the whole of Europe by 1 January 2022. Since Functional Airspace Block Central Europe (FAB CE, see Figure 7) is in the heart of the European airspace, the introduction of FRA is of special importance.

Figure 7. FAB CE airspace [19]

In a study conducted in 2016, the main objective was to assess the feasibility of implementation of the above mentioned strategic objectives through the development and validation of the Free Route Airspace Concept of Operations (CONOPS) of the intra-FAB cross-border free route operations.

Based on the maturity level of the concept, simulation exercises have been applied with the following objectives:

- **Objective 1**: Safety assumptions and requirements documented in Functional Hazard Assessment (FHA) and Preliminary System Safety Assessment (PSSA) will be addressed by the Validation.
- **Objective 2**: Airspace Design accommodates the FAB CE FRA concept and also supports connectivity to national FRNs and Terminal areas while supports more efficient 4D flight profiles.
- **Objective 3**: CONOPS will be accepted by the FAB CE ATCO community.

The aim of the validation was to simulate the FAB CE airspace and investigate what changes the FAB CE FRA would imply on the current fixed route network and the FRA within individual FAB CE Member State borders. In addition, it has examined the location of hotspots, the sustainability of aviation safety, the effect it would have on the workload of ATCOs and what savings it would represent for airlines. In addition, it was deemed important to test specific working procedures and technics for conflict detection and resolution in FRA with special attention to conflicts close to the boundaries between sectors and ATC units. This section only covers the study's impact on the Hungarian airspace and controllers.

B. Methodology

HungaroControl has used its standard validation methodology in line with the European Operational Concept Validation Methodology (E-OCVM, [14]). Validation exercises were divided into Fast-Time Simulation (FTS) and Real-Time Simulation (RTS) to assess the objectives and the derived hypotheses of the study. RTS was mainly applied to test the effect of the new concept on human performance with the inclusion of air traffic controllers and pseudo pilots. Note that the FTS and its results are beyond the scope of this paper.

1) Airspace and traffic sample

The simulated airspace has been split vertically which enabled each ANSP to operate simultanously. On the whole, the sector configuration included 31 sectors with division levels varying between FL345 and FL365, but only 17 sectors were simulated simultaneously. Based on the traffic sample, HungaroControl decided to simulate two sectors in the TOP airspace (i.e. LHWT for the west sector and LHET for the east sector) and two sectors in the lower airspace. Note that the paper will not cover the lower airspace in the followings.

The three samples covered each selected date (Friday, Saturday and Sunday) and each period from the summer of 2015 (morning, midday, afternoon) in order to account for the main traffic flows. The duration of the traffic samples was 90 minutes. The trajectories of the traffic samples were based on the shortest route assignment, however, were modified later to suit the requirements of the project team. It was considered vital to establish a reasonably balanced sector load, thus additional flights were included on certain flows, which in turn affected the whole airspace. The following three figures (Figure 8; Figure 9 Figure 10) illustrate the difference in occupancy between the TOP airspace traffic samples.

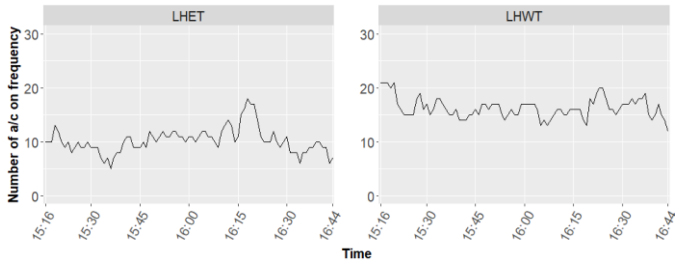


Figure 8. Occupancy in the TOP airspace for LHCC sectors in the afternoon traffic samples

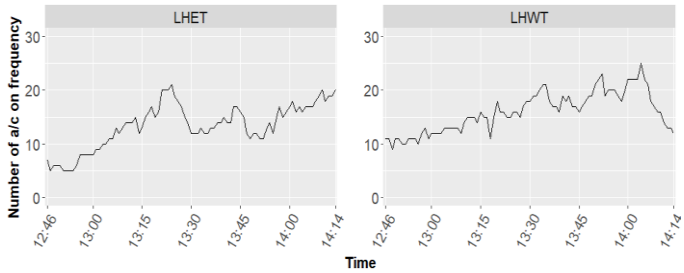


Figure 9. Occupancy in the TOP airspace for LHCC sectors in midday traffic samples

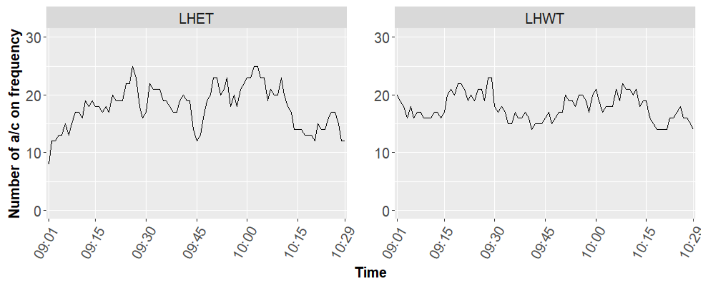


Figure 10. Occupancy in the TOP airspace for LHCC sectors in morning traffic samples

This implementation project received funding from the European Union's Connecting Europe Facility (CEF) „2014 CEF Transport Call" program.

2) ATM Systems

The RTS was run on HungaroControl's radar simulator (see Figure 11). In the RTS a simplified but feature-rich environment was modelled where the platform behaved as a single ATM System, with full SYSCO between the sectors. A "Generic HMI" was used with the same set of ATC Tools for each ANSP, which supported the aim of the study in general and the assessment of the specific hypothesis. The radar simulator encompasses 34 controller and 27 pseudo pilot working positions, from which all the positions were filled.

Figure 11. Real-Time Simulator facility at HungaroControl's Simulation HUB

3) FRA- Specific OPS Procedures

In the FRA concept the removal of published routes leads to a change in the number and location of conflict points. One of the critical issues is the change in the Silent Transfer of Radar Control. While in a fixed ATS route network environment traffic from one ATC unit to another is transferred over predefined Change Over Point (COP) and Silent Transfer of Radar Control conditions are specified with reference to these points (e.g. 10NM separation for successive flights), in a cross-border FRA environment such as FABCE x-Border FRA traffic would be transferred in most cases over the common sector border irrespectively of COPs.

In order to reduce the risks associated with the transfer of control from one ATC unit to another, new procedure shall be applied for Silent Transfer of Radar Control in the Letter of Agreements (LoAs). The implementation of such new procedures would not change the responsibility for ATS provision, especially provision of separation. Each ATC unit would remain responsible for provision of separation within its own Area of Responsibility (AoR). During the preparation phase, the core group members have agreed on two solutions to be tested in the RTS, which are presented in the followings.

a) Distance-based Area of Common Interest (AoCI)

The AoCI is a portion of the airspace located in the close vicinity of the internal common AoR boundaries and characterized by enhanced coordination, intensive exchange of information and by extended automated system support (MTCD) if possible. Based on simulation and night operation results the proposed dimension of the AoCI was 20 NM (see Figure 12).

Control sector of the transferring ATC unit shall monitor the evaluation of separation within the AoCI and shall propose such sector exit conditions, which ensure that traffic exiting the same control sector remains separated within the downstream control sector at least within the AoCI. If the predicted separation would be less than the agreed minima (e.g. 10 NM), the transferring sector initiates coordination and it is up to the receiving control sector to accept these conditions or counter-propose new conditions based on the traffic situation within its own AoR. If the two flights originate from different sectors, the receiving control sector shall initiate coordination for safe sector entry conditions.

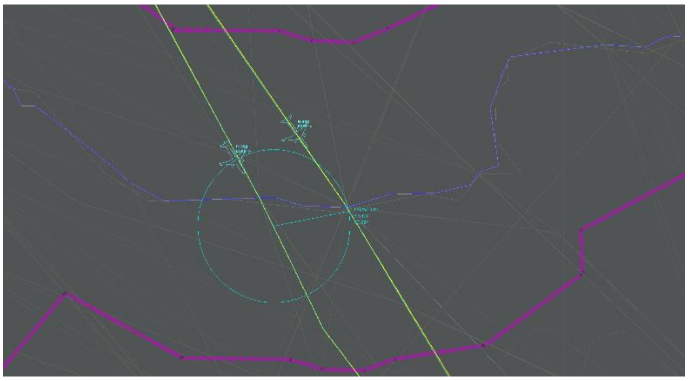


Figure 12. Distance-based AoCI. The blue line depicts AoR, whilst the purple dashed lines show the AoCI (20-20 NM from the AoR). The two selected flights are within the AoCI, and the separation between them would be less than 10 NM after entering the next sector. Note that this figure is only for illustration purposes; the purple lines do not correspond to 20 NM for each section in this map and was created with AirTOp [13].

b) Time-based Area of Common Interest (AoCI)

In the case of "time based AoCI" the transferring ATC unit shall ensure, that within agreed minutes of flying time beyond the sector border the separation between exiting aircraft would not be less than agreed minima (e.g. 10NM). Based on the existing practices the proposed value is 5 minutes flying time after passing the common sector border. As the 5 minutes flying time varies depending on the type of aircraft it cannot be made available on the radar screens of the ATC units involved (for illustration purposes, see Figure 13). The responsibilities of the transferring and accepting ATC units were the same as described in the distance-based AoCI.

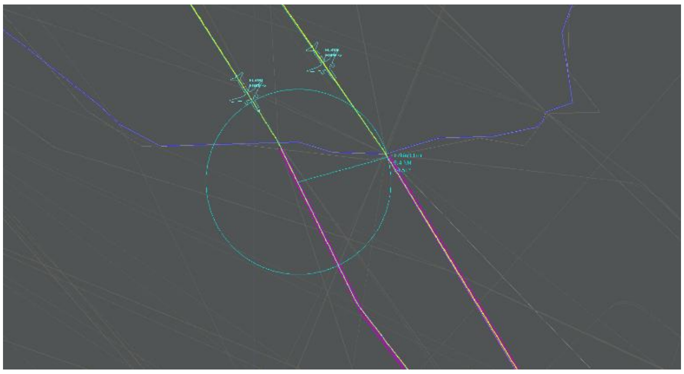


Figure 13. Time-based AoCI. Similarly to the previous figure, the blue line illustrates the AoR. However, instead of having a well-described portion of AoCI airspace, this procedure is more dynamic as the 5 minutes flying time after entering the receiving sector varies depending on the type of aircraft (the trajectories for the next 5 minutes are shown in purple dashed lines. The lines were not visualized in the RTS, but a speed vector could be applied).

4) Experimental design

The exact description of the validation design is out of the scope of this paper, however, it is worth noting that the main tested variable was the Area of Common Interest. Two weeks were allocated to the RTS at the end of 2016, during which all the objectives outlined in the Scope of the validation sub-section have been addressed (e.g. adequacy of the OPS procedures, ATM tools and sectorisation).

Several metrics have been registered in order to provide evidence for each hypothesis. Among the subjective measurements, the ISA [10], the NASA-TLX [15], the Bedford Workload Scale [16] and the SASHA-Q [17] have been filled out in order to assess workload and situational awareness during and after each run, respectively. Furthermore, simulation specific questionnaires have been developed by the project team to understand the impact of the variables and the tested ATM tools on human performance. With regards to the objective measurements, the usage of the SKIP function has been investigated. The SKIP function is used in case of sector clippings, which refer to the occasion when an aircraft is passing through a sector within a very short period of time that results in extensive coordination. Therefore, the SKIP function enables to skip the "short" sector and avoid unnecessary frequency changes. Subject matter experts have made observations and debriefings have been held in order to discuss the impressions on the concept and derive conclusions.

C. Results

In this section only a high-level description of the results is provided, with a strong focus on workload and conflict points experienced during the RTS in the TOP airspace. The data has been analyzed with the R statistical software [18].

1) Workload

According to the results, the workload remained at acceptable level during the whole simulation. Figure 14 shows the workload values assessed with the Bedford Workload Scale. Values below 60% can be interpreted as acceptable. Similar results have been obtained through the NASA-TLX and ISA metrics. Interestingly, there was no significant difference between the Executive-Planner controller (EC) workload (see Figure 15). In fact, it was suggested that the Planner Controller's (PC) workload has been increased compared to today's operation due to the extensive monitoring and coordination activities (Figure 16). Of note, the situation awareness values were in line with the workload ratings.

2) Conflict points

According to the results, the conflict points have not increased significantly in the LHCC sectors, however, one hotspot has been identified in the north-western corner, between the Vienna airport and Bratislava airport. Due to the sector clippings at that area, the SKIP function was used extensively.

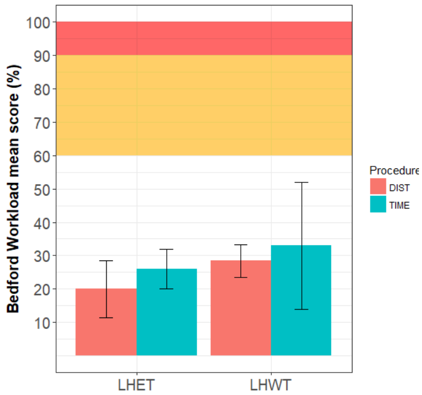


Figure 14. The results of the Bedford Workload Scale in the TOP airspace scenarios, separated for the two Area of Common Interest value (i.e. Distance vs Time-based) in the LHCC sectors (LHET and LHWT). The error bars represent standard deviation.

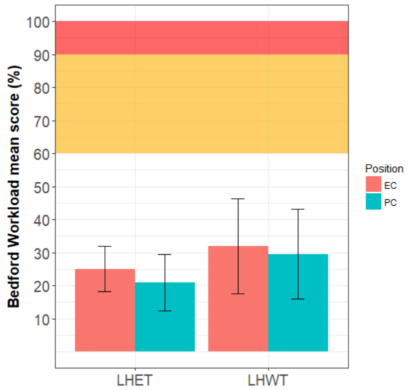


Figure 15. The results of the Bedford Workload Scale in the TOP airspace scenarios, separated for the two ATCO roles (i.e. Executive vs Planner) in the LHCC sectors (LHET and LHWT). The error bars represent standard deviation.

Figure 16. PC (left)-EC (right) teamwork in the East sector during the RTS at HungaroControl

D. Simulation discussion

The aim of the validation was to simulate the FAB CE airspace and investigate what changes the FAB CE FRA would imply on the current route network of the respective FAB CE Member States and on human performance in general. Two versions of the Area of Common Interest solutions were applied and whilst the two concept could not be differentiated from the quantitative analysis, the qualitative feedback suggested that the acceptance of either of the concept was dependent on the local practises and familiarity with the procedure. For instance, HungaroControl participants were most comfortable with the distance-based AoCI as it was already put in place with Romania and Slovakia in the LoA, and also due to the possibility to display the physical area on the map.

Another interesting finding was the enhanced usage of the SKIP function, especially cross-unit wise in the Hungarian West Top sector. The reason for this was (i) the high number of sector clipping aircraft in north-western corner and (ii) due to the fact that the simulator behaved as a single ATM System with full SYSCO. The SKIP was deemed useful as it replaced the currently used telephone coordination with the transferring unit and manual labelling of the aircraft, reducing the workload for the controllers.

On a more general level, it has been concluded that the introduction of FAB CE wide cross-border FRA would require a step-wise implementation strategy, with mitigation strategies developed to channel certain traffic flows and with the introduction of advanced ATM Tools to support conflict-detection.

V. Conclusions

The introduction of the Hungarian Free Route Airspace-HUFRA has contributed to the increase in safety, traffic growth and required a fundamental shift in cognitive processing from the air traffic controllers. The latter change has been already accounted for in the training plans, and further steps in airspace reorganisation have been taken to support controller's performance.

However, Free Route Airspace is not only being introduced within separate FIRs, but there is also an increasing trend of cross-border FRA implementation (e.g. SEAFRA; SAXFRA; SECSI FRA; SEEN FRA, NEFRA, see [20]). As an essential step, the FAB CE FRA has been simulated and its potential effects assessed. Whilst the results were informative and pointed to already existing practises within individual FRA operations (e.g. need for SKIP usage, AoCI experience), it is evident that all the listed cross-border FRA initiatives have been established in line with the major traffic flows, with SEEN FRA bridging the airspace between two Functional Airspace Blocks (i.e. DANUBE FAB and FAB CE). There are still technological and procedural differences between the two major cross-border FRA initiatives (i.e. SECSI FRA and SEEN FRA regarding flight plan management), an exciting step could be a combined, inter-FAB cooperation to achieve a common European FRA for 2022.

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