DOI: 10.18372/2306-1472.67.10428

Oleksandr Luppo[1]
Gennadiy Argunov[2]
Andrii Mohyla[3]

CONCEPT OF ADVANCED FLEXIBLE USE OF AIRSPACE

National Aviation University, Kyiv, Ukraine
E-mails: [1]luppo-ae@mail.ru; [2]argunovg@mail.ru; [3]mogila.an11@gmail.com.

Abstract

Purpose: *Concept of Flexible Use of Airspace (FUA) allows to eliminate many problems on the basis of civil-military coordination, but there are still a lot of areas for improvement. These improvements will be implemented in the Advanced Flexible Use of Airspace (AFUA) concept.* ***Methods:*** *We examine the airspace structure in the frames of AFUA concept, which includes variable profile areas, temporary reserved and temporary segregated areas, danger or restricted areas. Mission Trajectory in AFUA which allows designing ad-hoc structures delineation at short notice is also examined. Regarding the performance enhancements of AFUA we compare these with FUA concept. Examination of AFUA structure gives us better view of the functions and opportunities of this concept.* ***Result:*** *AFUA concept provides many advantages for the civil aviation stakeholders and includes many other positive sides. Variable Profile Areas provide more flexibility, particularly in a high density traffic area and any combination of basic volume possible. Collaborative decision-making will increase the situational awareness of both parties and help to decrease the transit between airbases and training areas, allows military to use larger airspaces for missions on an absolute time-limited basis. As a result of mission trajectory implementation in AFUA concept general air traffic crossing are possible in all type of airspace structures, after coordination or under specific permanent agreements. The use of Centralized AFUA Services will allow the central collection, integration and provision of ASM data in support of continuous collaborative network processes, in such a way improving operational performance during the planning and execution phases (predictability, flexibility, better use of capacity, enhanced flight efficiency, real time sharing of information, better management of available airspace).* ***Discussion:*** *Given the important contribution that AFUA brings into air traffic management system, its main architectural components and performance enhancements, collaborative decision making process and concept's implementation phases.*

Keywords: advanced flexible use of airspace; allocation; cooperation; efficiency.

1. Introduction

Nowadays with a rapid growth of air traffic many airspace management problems arises. Organizing and managing airspace in the future using Advanced Flexible Use of Airspace concepts (AFUA) will play a vital role in improving civil-military cooperation and in increasing capacity for all airspace users.

In the original Flexible Use of Airspace (FUA) concept, the Collaborative Decision Making (CDM) process clearly shows areas for improvement. In particular for the integration of Airspace management (ASM), Air Traffic Flow and Capacity Management (ATFCM) and Air Traffic Service (ATS) and availability of real time data; the utilization of civil/military airspace structures; adequate supporting systems (to be extensively deployed); performance evaluation (to be complete and systematic); the harmonization of the ASM processes (Table 1).

2. Analysis of the latest research

The objectives and business models of airspace requirements are different for the civil and military airspace users. Whereas the civil aviation develops a trajectory with the most cost efficient routing, the military have a mission objective including the most mission effective routing and usage of the airspace [1]. Therefore, many programs, concepts and proposals to increase the flight efficiency, capacity and civil/military coordination level had to be analyzed. Efficiency of flight performance and flying shorter routes was always one of the top priorities of

ASM in both in Europe and in the USA [2, 3]. With continuous growth of air traffic the efficiency of flight directly influences the safety [4, 5].

In the future the mitigation of traffic complexity application may be applied [8]. With current level of technologies FUA and its future version AFUA are best suited for the safe and efficient performance of flights, increasing the capacity of airspace. The FUA is defined by the European Commission (EC) Regulation N°2150/2005 of 23.12.2005 [9]. The implementation of the flexible airspace structure has given a big growth in the general level of flight performance, including efficiency, capacity, reduction in distance and time [10, 11]. The concept of AFUA is described in SESAR Concept of Operations Step 1 from 09.05.2012 and based on dynamic airspace management in all phases of the flight, from the initial planning to the execution phase [12].

3. Airspace structure

The AFUA regards airspace as a single entity that is available to all users. The aim will be to replace fixed airspace structures with volumes of airspace to be made available in a dynamic manner, including cross-border and multi-State arrangements, on the basis of the close cooperation between civil and military authorities. Embodied within the Network Management function will be an airspace reservation process to facilitate this, but such reservations should be temporary, created only when required and be tailored to meet the needs of specific missions. A modular design of airspace reservation/ restriction, Variable Profile Areas (VPA) for new airspace requirements is introduced to enable sub-divisions, new areas or revised airspace requirements closer to air bases (<100 nm radius) and define different airspace scenarios to address local, sub-regional and network impact.

Table 1 Comparative table of FUA and AFUA

FUA	**AFUA**
Levels 1,2 & 3 fixed in time	Levels 1,2 & 3 interactive
Independent national ASM	Consolidated Network management
Fixed ATS Route System	Dynamic User Preferred Routings
Fixed Scenarios	Active Airspace Configurations
Time constrained snapshots	Rolling process
AMC & FMP separated	Integrated ASM/ATFCM/ATS Activity
Fixed sectors	Proactive sector management
Static TRA/TSAs	Variable Areas
CDRs	Conditional Structures (CDS)
Europe-CBO (Cross border operation) only between neighbors	Wide CBO sharing
Airspace Use Plan (AUP), Updated Airspace Use Plan (UUP), eAMI (ATM Management Interface)	AFUA SERVICE & Network Operations Plan (NOP)

A VPA can be any type of airspace reservation or restriction consisting of either individual or a combination of volumes / modules.

The basic unit volume of a VPA will be defined by High Level Airspace Policy Body (HLAPB) according to the following principles:

- the construction of the VPA shall allow the maximum of flexibility and offer several combinations that can fit the airspace users' needs;
- smaller basic unit volume provide more flexibility, particularly interesting in a high density traffic area e.g. 10x10 nm;
- vertical limits shall be adaptable depending on the mission type, mission objectives, aircraft capabilities, etc.;
- any combination of basic volume is possible;
- the status (Temporary reserved area (TRA), Temporary segregated area (TSA), Danger area (D) or Restricted area (R)) shall be adapted to the mission, the route network associated with the VPA has been taken into account in the area design to enable capacity optimization and different airspace allocation and rerouting scenarios [12].

For specific missions and under certain circumstances, fixed airspace structures will remain, including ATS Route, CDR and Airspace reservation (ARES) due to safety, security, environmental or legal constraints.

Airspace reservations are fully embedded in the trajectory and negotiated through collaborative decision making process, limited to the individual

operational need by the implantation of modular areas. The penetration into a TSA-type or Prohibited-type of Airspace, shall be intended to cover urgent situations and not as a common authorization. The continuous sharing of airspace planning and status between all ATM actors should limit the number of unnecessary constraints.

4. Collaborative decision making

Collaborative decision-making (CDM) is the process whereby all ATM decisions, except tactical Air Traffic Control (ATC) decisions, are based on sharing all information relevant to air traffic operations among all civil and military partners. The principles of CDM should be adopted by States and service providers, with the participation of military planners, as a tool to support ASM (Fig 1).

Integrated CDM & rolling process:

- all ASM data updated and available in real time NM;
- common reference database;
- common situation awareness;
- interoperable supporting systems;
- ASM data complemented by ATFCM data;
- harmonized CDM procedures;
- proactive CDM;
- data stored available for analysis;

5. AFUA embedded in the Mission Trajectory

The possibility to design ad-hoc structure delineation at short notice is offered to respond to short-term airspace users' requirements not covered by pre-defined structures and/or scenarios. Changes in the airspace status are uplinked to the pilot and shared with all other concerned airspace users by the system. General air traffic (GAT) crossing are possible in all type of airspace structures, after coordination or under specific permanent agreements, depending on the nature of the airspace. Automated processes are in place at ground and airborne levels (Wing Ops, ATC Systems, Airspace management Cell (AMC), Air defense Centers, Aircraft Equipage, etc.) in order to make the Mission Trajectory execution consistent with airspace allocation process (ARES activation/deactivation displayed in real time on Controller Working Position (CWP) displays.

The main assumptions upon which the above is based are as follows:

- full application of agreed FUA concepts will be in place in all States by 2020 providing the basis for the next step of AFUA;
- equal consideration will be given to meeting the needs of civil Airspace Users and military requirements;
- protection of secure and sensitive military data will be assured;
- agreed rules for certain priority procedures to enable military operations (e.g. national obligations and international commitments) to be fulfilled will be applied;
- states' sovereignty and responsibility for airspace will remain[17].

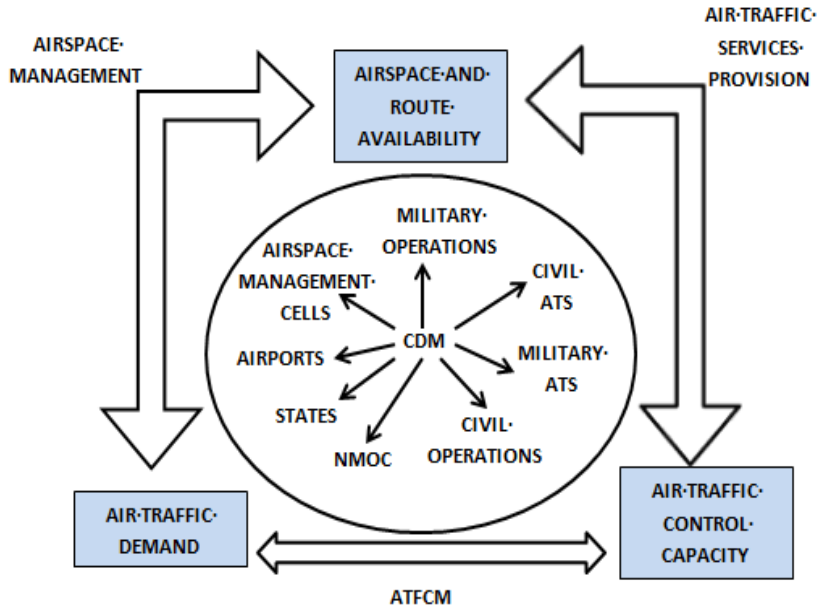

Fig. 1 NM CDM Process with European Airspace Stakeholders

The concept of Advanced FUA embedded in the Mission Trajectory is expected to provide more flexibility based on dynamic airspace management in all phases of the flight, from the initial planning to the execution phase.

6. AFUA performance enhancement

A pre-defined and coordinated organization of routes and their associated airspace structures, temporary airspace reservations and ATC sectorisation. The development, implementation and deployment at Network level of a centralized advanced civil/military flexible use of airspace service (AFUAS) will optimize the use of available airspace both locally and at network level, across border, delivering increased flight efficiency, this resulting in more performing flights (Table 2) [18].
So, the main concept enhancements are:

- area Modularity in airspace design;
- direct routing and Free Route Airspace;
- CDM with NM based on enriched information sharing;
- airspace configurations for tailored flexibility to the different environments;
- impact assessments and the use of performance indicators;
- increase the impact awareness by participation;
- sharing real time airspace status;
- maximum use of automated interfaced local ASM support system.
- increase common situational awareness
- makes better use of available airspace
- Provision of better data for performance measurement

Table 2 Performance enhancement of Airspace Management with AFUA

FUA	**AFUA**
A key enabler: Civil-military ASM coordination	A key enabler: Civil-military ASM cooperation
National and European Network	National, FAB and European Network
Strategic, Pre-tactical and Tactical (execution) phase	Strategic, Pre-tactical and Tactical (execution) and Measurement phase
Implementation is depending on National initiatives	alImplementation is depending on all initiatives (Single European Sky ATM Research (SESAR), National Functional Airspace Blocks (FAB),EUROCONTROL, ANSPs, Industry,…)
Airspace is one continuum (no CIV or MIL airspace)	Area Modularity in airspace design
Conditional routes & temporary reserved areas	Direct routing and Free Route Airspace
Direct coordination between civil and military	Enriched data sharing between civil and military
Strategic decisions of performance measurements	Cooperative Decision Making involving all actors
	Use of Performance measurement in pre-tactical phase

7. Architecture of AFUA

Principles:
- Service oriented architecture
- Interoperability
- Harmonization of models, interfaces and the use of standards

System support:
- Local and FAB (Functional airspace block) support systems
- Secure Communication Infrastructure
- Centralized AFUA services
- Network Management systems [18].

8. Centralized AFUA Services

The AFUAS concept is based on the introduction of a centralized database for network wide ASM and consists in the establishment of a service allowing the central collection, integration and provision of

ASM data in support of continuous collaborative network processes related to airspace needs, constraints, booking and actual use in Europe. Centralized service (CS) will be a central collection of the latest information of the civil and military airspace planning of all connected States (Fig. 2).

Strategic level	***Pre-tactical level***	***Tactical level***	***Post-ops level***
Several years to D-7 Information related to airspace reservations/ military exercises known long time in advance: -New/temporary airspace reservations - Ad-hoc airspace reservations adaptations - Introduction of new ASM concepts	• D-7 to day of operations • Information related to the planning of airspace for the following day/days, comprising: - national or FAB AUPs - national or FAB UUPs - EAUP and EUUP - All related updates supporting the rolling process when fully operational - Expected availability of CDRs/airspace reservations on the day of operations-Ad-hoc airspace reservations adaptations - Introduction of new ASM concepts	• On the day of operations • Information related to the short term planning and actual utilization of airspace in real time: - airspace status (available, booked, used, released) - actual shape and location of considered portions of airspace - real time availability of CDRs/airspace reservations	• After the day of operations • Information related to the booking and actual utilization of airspace achieved : - airspace really booked, available, used, released - availability of the information related to the actual status and utilization of airspace.

Fig. 2 ATS data on ASM levels

This strategic, pre-tactical and tactical information will be accessible for all Airspace Management actors at local, sub-regional and network manager level.

The AFUAS Service Provider will be responsible for H24/7 service provision, real-time quality control of exchanged data; responding to user trouble investigation and reports, Quality of Service, system development, evaluative maintenance, technical support; the service will include adequate ATM knowledge.

The AFUAS Service Provider will exchange data with the actors of ASM :

- States/FABs Airspace management cells (AMC)
- Military airspace users
- Military controlling units
- Civil aircraft operators and flight plan service providers
- ANSPs/Area Control Centers/Flow Management Position (ACC/FMP)
- Network manager

Opportunities:

- o enhancing capabilities and services;
- o civil-Military transparency;
- o reduction of costs;
- o common basis for future developments (e.g. SESAR).

The service would:

- o support the different operational stakeholders in exercising their roles related to the application of Flexible Use of Airspace;
- o improve operational performance during the planning and execution phases (predictability, flexibility, better use of capacity, enhanced flight efficiency, real time sharing of information, better management of available airspace);
- o improve impact assessment capabilities at local, sub-regional and network levels;
- o support regulatory bodies to assess the performance of the FUA process;
- o provide a common source for Airspace structure definitions (with user tailoring);
- o enable an automated collection and sharing of Long Term/Event planning (strategic planning);
- o enhance AUP/UUP exchange to include Free Route Airspace (FRA) requirements;
- o enable a continuous on line sharing of Airspace reservation planning with EUROCONTROL/NM and other local ASM;
- o enable CDM process by exchange of CDM messages;
- o enable a continuous on line sharing of Airspace status with other local ASM systems (Cross Border Area (CBA)/ Cross Border Operation (CBO) coordination) and EUROCONTROL /Network manager (NM);
- o archive and transfer of ASM data for post ops processing in EUROCONTROL/NM;

- allows military to use larger airspaces for missions on an absolute time-limited basis;
- allows civil traffic to fly shorter routes;

9. AFUA phases

- The first phase (up to 2015) is focused on the consolidation of recent improvements and the finalization of objectives under discussion.
- The second phase (up to 2017) will be focused on the introduction of improvements aiming at supporting an effective airspace management in a free route environment, including the initial management of real time airspace data and dynamic airspace configuration.
- The third phase (up to 2020) will be dedicated to the exploitation of a full rolling ASM/ ATFCM/ATC process (no more snapshots), supported by an automatic share of information among the different stakeholders, for the management of suitable dynamic airspace configurations offering the best ATM performance to satisfy airspace users requests.

10. Conclusions

A result of research we propose the implementation of AFUA concept in Ukraine's air navigation system using the planning stages described below.

On the strategic planning stage the available strategic planning information is collected and included in the central database, and considered for the Network Strategic Plan (NSP), the Network Operations Plan (NOP) and the European Route Network Improvement Plan (ERNIP). Management of strategic military planning is done with the AFUA ASM functionalities or other Ukrainian ASM systems connected to the centralized database for network wide ASM, and made available to the relevant stakeholders in a continuously updated way and to NM.

On the pre-tactical planning stage the centralized database for network wide ASM and local ASM systems continuously exchange information of level 2 and allowing the required network impact assessments and CDM. On the tactical planning and execution phase the tactical changes after AUP publication are supported by centralized database for network wide ASM and real-time information is continuously exchanged with local systems and Ukrainian ATC and military systems. AFUA implementation on the territory of Ukraine will make better use of available airspace and allow militaries to use larger airspace volumes for missions on an absolute time-limited basis. It will give possibility for civil traffic to fly shorter routes, increase common situational awareness, better provision of data for performance measurement, enhanced ASM data visibility and ASM performance feedback. The AFUA will foster innovative technologies in cooperation with the militaries and enable the Single European Sky (SES) implementation. It would also provide:

- Enhancement of civil-military ATM coordination and network performance.
- Optimization of local/sub-regional and network ASM procedures.
- Enabling civil-military CDM.
- Provision of better data for performance measurement.
- Decreasing the transit between airbases and training areas, help to save fuel and allow more flexibility.
- Improving ATM, capacity, flight efficiency, interoperability, safety, security.

In the nearest future the implementation of advanced civil/military flexible use of airspace service in Ukraine will optimize the use of available airspace both locally and at network level, across border, delivering increased flight efficiency, thus resulting in more performing flights.

References

[1] EUROCONTROL Civil/Military Interface Standing Committee, Determining Future Military Airspace Requirements in Europe, Brussels, Belgium, 2003.

[2] *Kettunen T., Hustache J.-C., Fuller I., Howell D., Bonn J., Knorr D.:* Flight efficiency studies in Europe and the United States. USA/Europe Air Traffic Management R&D Seminar, 2005.

[3] *Mihetec T.; Odić D.; Steiner S.* Evaluation of Night Route Network on Flight Efficiency in Europe. International Journal for Traffic and Transport Engineering. Volume 1(2011), 3; p. 132-141.

[4] *Luppo A., Hlushko O., Dolmatova D.* Analysis of air traffic and forecast of its growth in European region. Proceedings of the National Aviation University. 2013, N 1 (54), p. 37–43.

[5] *Skorupski J.*: Measuring of controlled air traffic safety. Archives of Transport, 2007, Vol. 19, p. 177-191.

[6] *Versteegt H.H., Visser H.G.* Traffic complexity based conflict resolution. Air Traffic Control Quarterly, 2003, no. 11(2), p.103-122.

[7] *Durand N., Alliot J.-M.* Ant Colony Optimization for Air Traffic Conflict Resolution. Eighth USA/Europe Air Traffic Management Research and Development Seminar (ATM 2009).

[8] *Idris H. Delahaye D.* Distributed Trajectory Flexibility Preservation for Traffic Complexity

Mitigation, Eighth USA/Europe Air Traffic Management Research and Development Seminar

[9] COMMISSION REGULATION (EC) No 2150/2005 of 23 December 2005

[10] *Mihetec T., Steiner S., Odić D.* Utilization of Flexible Airspace Structure in Flight Efficiency Optimization Traffic&Transportation. 2013, Vol. 25, No. 2, p. 109-118

[11] International conference of scientific paper AFASES 2011 Brasov, 26-28 May 2011 The concept of Flexible use of airspace. Constantin BUJOR p. 1071-1074

[12] EUROCONTROL – SESAR Concept of Operations Step 1. Edition: 01.00.00. Date: 09.05.2012.

[13] EUROCONTROL - The Centralised Services – Information Session. CS#4 – ADVANCED FLEXIBLE USE OF AIRSPACE. Date: 26 June 2013.

[14] EUROCONTROL - CENTRALISED SERVICE 4 ADVANCED FLEXIBLE USE of AIRSPACE. Olivier Mrowicki. Date: 5th September 2013

[15] EUROCONTROL - Advance Flexible Use of Airspace.P.DELMOUZEE. Date: 05th March 2014

[16] EUROCONTROL - The Network Manager tasks and the ASM improvement initiative. AFUAS Workshop. Date: 24th June 2015

[17] EUROCONTROL –The ATM target concept DLM-0612-001-02-00a - September 2007.

[18] EUROCONTROL - Advance Flexible Use of Airspace Service (AFUAS) – CS4. Date: 11 March 2015, World ATM Congress.

Received 03 March 2016.

О.Є. Луппо[1], Г.Ф. Аргунов[2], А.О. Могила[3] . Концепція AFUA

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

E-mails: [1]luppo-ae@mail.ru; [2]argunovg@mail.ru; [3]mogila.an11@gmail.com

Проведено аналіз концепції AFUA. Розглянуто організаційну структуру розширеного гнучкого використання повітряного простору та залучення до процесу спільного прийняття рішень. Визначено шляхи використання цієї концепції у виконані військових місій; порівняно підвищення продуктивності з концепцією гнучкого використання повітряного простору. Підсумовано основні переваги розширеного гнучкого використання повітряного простору.

Ключові слова: взаємодія; ефективність; розподіл; AFUA.

А.Е. Луппо[1], Г.Ф. Аргунов[2], А.О. Могила [3] Концепция AFUA

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

E-mails: [1]luppo-ae@mail.ru; [2]argunovg@mail.ru; [3]mogila.an11@gmail.com

Проведен анализ концепции AFUA. Рассмотрена организационная структура расширенного гибкого использования воздушного пространства. Определены пути использования этой концепции в исполнении военных миссий; произведено сравнение повышения продуктивности с концепцией гибкого использования воздушного пространства. Подсуммированы основные преимущества расширенного гибкого использования воздушного пространства.

Ключевые слова: взаимодействие; распределение; эффективность; AFUA.

Luppo Oleksandr (1958). Candidate of Pedagogic Sciences. Associate Professor.
National Aviation University, Kyiv, Ukraine.
Education: Academy of Civil Aviation, Leningrad, USSR (1982).
Research area: air traffic management enhancement, human factor investigation, methods for ATCOs' professional skills improvement.
Publications: 68.
E-mail: luppo-ae@mail.ru

Argunov Gennadiy (1973). Associate Professor.
National Aviation University, Kyiv, Ukraine.
Education: State Flight Academy of Ukraine, Kirovograd, Ukraine (1994).
Research area: prediction and elimination of potential conflict situations in the process of air traffic control.
Publications: 68.
E-mail: argunovg@mail.ru

Mohyla Andrii O (1996). Student.
National Aviation University, Kyiv, Ukraine.
Research area: air traffic management enhancement.
E-mail: mogila.an11@gmail.com