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Master's degree in aeronautics

Option: Air Operation.

THEME

Optimization of Algerian airspace through the adoption of direct routes for west-east traffic flow

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Choose an item.

Thanks

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Dr.

Dedications

To my extraordinary family, whose unwavering support and boundless love have shaped the very essence of my being. My heartfelt gratitude goes to **my mother BOUCHETATA Samia**, *whose nurturing embrace and enduring strength have been my guiding light. To* **my father KEMCHE Hocine**, *whose wisdom and encouragement have instilled in me the values that paved the way for this academic journey.*

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With immense gratitude and love,

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Et àmoi-même.

Yousra

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EXTRA HEADINGS

AIRAC: Aeronautical Information Regulation and Control.

AIS: Aeronautical Information Service.

AMAN: Arrival Management.

AMC: Acceptable Means of Compliance.

ANSP: Air navigation service provider

ASBU: aviation system block upgrades

ASM: Air Traffic Management

ATC: Air Traffic Control Service

ATFM: Air Traffic Flow Management

ATM: Air Traffic Management

ATS: Air Traffic Services

AUP: Airspace Use Plan

CCO: Continuous climb operations

CCR: Area Control Centre

CDO: Continuous descent operations

CEAC: Committee for European Airspace Coordination

CNS/ATM : Communication – Navigation – Surveillance / Air Traffic Management

CSO: Center for Special Operations

DMCA: Directorate of Civil and Meteorological Aviation

DCA: Air Traffic Department

DCT: Route Direct

DMAN: Departure Manager

DRA: Direct Route Airspace

DRFC: Financial Resources and Accounting Directorate

DRO: Direct Route Operations

ENNA: National Air Navigation Establishment

ESAF: Eastern and Southern African Office

FANS: Future Air Navigation Systems

FIR: Flight Information Region

FRA: Direct Route Airspace

FRTO: Free Route Operations

FUA: Flexible Use of Airspace

GANN: Global Air Navigation Plan

GASP: The Global Aviation Safety Plan

GAT: The Global Aviation Safety Plan

GATMOC: Global Air Traffic Management Operational Concept

GPI: Glide Path Indicator

GSA: General Services Administration

HLAPB: High-Level Airspace Policy Body

ICAO: International Civil Aviation Organization

OAT: Operational Air Traffic

OLDI: On-Line Data Interchange

PANS: Procedures for Air Navigation Services

PBN: Performance-based navigation

PIRG: Planning and Implementation Regional Groups

POC: point of contact

RNP: Required navigation performance.

SARP: Standards and Recommended Practices

SDG: Strategic Development Group

SMS: Safety Management System

SMM: Safety Management Manual.

SUA: Special Use of Airspace

TDF: Training and Development Facility

TRA: Temporary Reserved Area

UAC: Upper Area Control

UIR: upper information region

UUP: Updated AUP

ملخص

المجال أن تبين الجزائرية، الطيران معلومات منطقة في الأخيرة السنوات في الجوية الحركة توقعات و لتحليل وفقًا الجوي المجال تحسين على البحث هذا يركز مذهلاً توسعًا شهد أن بعد متزايد بشكل مشبعًا أصبح الجزائري الجوي الحركة إدارة في الحالية الاتجاهات استكشاف خلال من لاسيما الجزائري، الجوي المجال في دقة أكثر بشكل الموجود حركة لتدفق شامل حليل الجوي. للمجال المرن الاستخدام **FUA**الحر الجوي المجال **FRA** ذلك في بما الجوية المدني – العسكري التنسيق ذلك في بما مختلفة، تحديات انقطاع دون واجه الشرقي، الغربي المسار و الموجهة المرور أمران الطرق شبكة تحسين و الحيز تحسين أن وثبت**.**الدولي أو الوطني الصعيد القائمة 7،على القطاعات مستوى على الحيز. هذا في أكبر مرونة و الطائرات سلامة من عال مستوى لضمان ضروريان

ABSTRACT

According to the analysis and forecasts of air traffic in recent years in FIR Algeria, it was found that the Algerian airspace is becoming increasingly saturated having experienced a spectacular expansion.

This research focuses on the optimization of the airspace existing more precisely in Algerian airspace, particularly by exploring current trends in air traffic management including "FRA (free route airspace) and FUA (flexible use of airspace)" and a thorough analysis for the flow of oriented traffic and the west-east course, uninterrupted met with various challenges, including the civilian-military coordination at the level of the 7 existing sectors, at the national or international level.

The optimization of the space and the improvement of the route network proved necessary in order to ensure a high level of aircraft safety and greater flexibility of this space.

RESUME

D'après les analyses et les prévisions du trafic aérien de ces dernières années en FIR Algérie, on a constaté que l'espace aérien Algérien devient de plus en plus saturé ayant connu une expansion spectaculaire.

Cette recherche se penche sur l'optimisation de l'espace aérien existant plus précisément l'espace aérien algérien , particulièrement en explorant les tendances actuelles de gestion du trafic aérien le notamment « FRA (free route airspace) et FUA (flexible use of airspace)» et a l'aide d'une analyse approfondie pour le flux du trafic orienté et du cap ouest-est , ininterrompue s'est heurtée à divers défis, dont la coordination civil-militaire au niveau des 7 secteur qui existe, à l'échelle national ou international .

L'optimisation de l'espace et l'amélioration du réseau de route s'est avérée nécessaire dans le but d'assurer un niveau élevé de sécurité des aéronefs et une meilleure flexibilité de cet espace.

KEY WORDS : optimization, GANP, ASBU, FIR , ATFM, FRA FUA, traffic , civilian-military , coordination , airspace, flow, DCT,zones.

General introduction:

Air traffic, a key sector of global connectivity, has grown steadily for decades. With air traffic growth doubling every 10 years, with the exception of the COVID-19 pandemic, forecasts point to even greater growth in the coming years. Air traffic management is a complex discipline requiring precise coordination to ensure safety, the efficiency and regularity of the flights and the growth of the traffic implies an increased demand for the air routes and a more efficient use of the airspace available take steps to address this growth. This included the recruitment of additional personnel, the restructuring of airspace, the adoption of innovative technologies and new methods to better use and optimize Arian space.

These efforts have helped to absorb increasing traffic while maintaining a high level of safety and security. Advances such as the use of radar, the automation of coordination between control centers, the introduction of increasingly sophisticated human-machine interfaces, the division of space into smaller sectors, new concepts are emerging, Notably, the concept of "free route Airspace (FRA) and flexible use airspace (FUA) is a notable illustration and gives airlines greater flexibility in choosing their routes. The FRA allows aircraft to fly directly, optimizing flight times, reducing distances and reducing fuel consumption. This revolutionary approach has significant advantages in terms of environmental sustainability, operational efficiency and cost reduction for the aviation industry.

Talking about Algeria, Algeria occupies a strategic geographical position as a crossing point between Europe and Africa, as well as relation to the important air traffic routes connecting the Middle East to the American continent. However, this advantageous position leads to a gradual saturation of Algerian airspace as air traffic continues to grow significantly. However, the current air routes, often determined by historical and geographical constraints, including restricted areas, are not always optimal. Indirect routes, resulting in additional flight distances, extended flight times and increased fuel consumption, are a major challenge.

Algeria has implemented all the necessary means to offer a better quality of service to users, notably by improving radar control, implementing ADS/C surveillance, and seeking to optimize the use of airspace. This includes the addition of additional higher flight levels through the application of RVSM, as well as the adoption of new navigation concepts such as RNP (Required Navigation Performance) and RNAV (Area Navigation).

The optimization of Algerian air traffic is crucial to solve the challenge of indirect routes. Three major factors come into play: flight time, flight distance and fuel consumption.

Reducing these elements offers significant potential to improve airline operational efficiency, reduce costs and minimize environmental impact.

Having presented the problem of this brief, we will now present the work plan which is subdivided and focused on five major chapters:

- **The first chapter:**Presentation of the Global Plan Air Navigation System (GANP)and Block Upgrade (ASBU).
- **The second chapter:** presenting the airspace managements end its derivative (ATFM, FUA, Airspace….)
- **The third chapter:** describes the proposed new advice ‘free routing and direct routing’ with a total presentation that affects everything related to FRA, free routes and its operations that relies on civilian military coordination.
- **The fourth chapter:**stands on existing routes, a predictive analysis was conducted to apply the proposed solution, the work presented in this research is centered on this last chapter.

Finally, we finish all this study with a conclusion that is include perspectives to improve the application of the concept of free route to the FIR Algiers.

Chapter 1 : Global aviation navigation plan (GANP)

1.1 Introduction:

The International Civil Aviation Organization's (ICAO) Global Air Navigation Plan (GANP) outlines a framework for harmonizing aircraft capabilities and required ground-based Air Traffic Management (ATM) infrastructure and automation. This framework is the Aviation System Block Upgrades (ASBU). This CANSO ASBU booklet is intended for Air Navigation Service Providers (ANSPs), airports, operators, military aviation, and the industry as a whole to comprehend the requisites for enhancing aviation systems and services through ASBU implementation.

To aid ICAO regions, sub-regions, and individual States in the formulation of their regional and national aviation strategies, the International Civil Aviation Organization (ICAO) established the Global Aviation Navigation Plan (GANP). This initiative was designed to oversee the worldwide advancement of air navigation systems, addressing the growing demand for air travel while concurrently enhancing safety, efficiency, and environmental sustainability.

To aid ICAO regions, sub-regions, and individual States in the formulation of their regional and national aviation strategies, the International Civil Aviation Organization (ICAO) established the Global Aviation Navigation Plan (GANP). This initiative was designed to oversee the worldwide advancement of air navigation systems, addressing the growing demand for air travel while concurrently enhancing safety, efficiency, and environmental sustainability.

1.2 What is GANP?

The GANP is a forward-looking, 15-year strategic framework that capitalizes on existing technologies and anticipates forthcoming advancements, aligning with operational objectives agreed upon by governmental bodies and the aviation industry. It employs a staged implementation approach spanning six-year intervals, spanning from 2013 to 2031 and beyond. This structured progression enables the adoption of prudent investment plans while fostering the engagement of governments, manufacturers, operators, and service providers. Together with other prominent ICAO initiatives, the GANP serves as a route map to guide ICAO regions, subregions, and individual states in setting their air navigation priorities for the forthcoming 15 years. The GANP outlines ten fundamental principles of ICAO's civil aviation policies that shape global, regional, and national air traffic planning.**[1]**

The primary objective of the GANP is to enhance the capacity and efficiency of the global civil aviation network, all the while elevating safety standards or, at the very least, maintaining the current safety levels. Furthermore, the GANP encompasses strategies aimed at fulfilling the broader strategic objectives set by ICAO. This comprehensive plan includes the Aviation System Block Upgrades (ASBU), their respective modules, and the accompanying technological route maps, which encompass communication, surveillance, navigation, information management, and air traffic management (CNS/ATM). The global plan also offers a comprehensive view of the immediate implementation considerations related to performance-based navigation (PBN) and the initial Block 0 modules. It also outlines the role of regional Planning and Implementation Regional Groups (PIRG), which will be responsible for overseeing regional projects.**[1]**

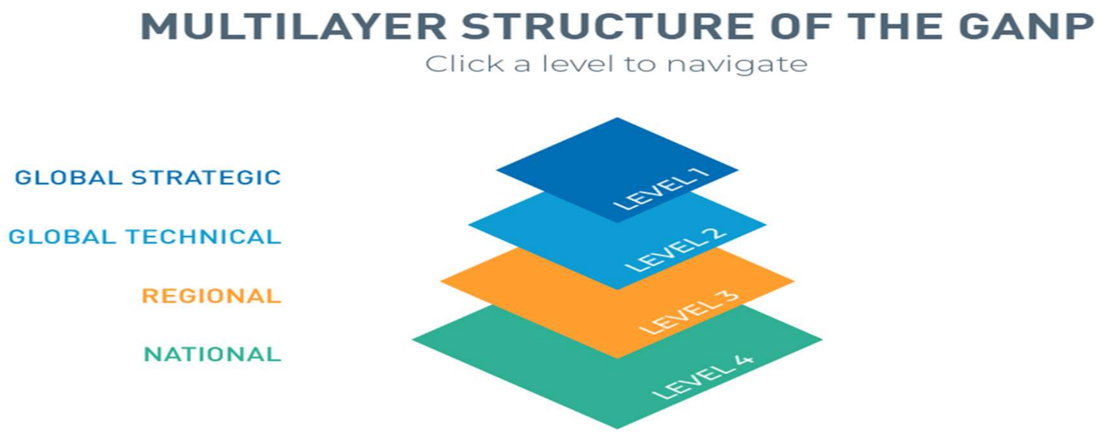


Figure 1-1 :Multilayer Structure of GANP.

1.3 Ancestral Aspects of ICAO Navigation Policy:

- Commitment to ICAO's Goals ICAO's regional air navigation planning and state-level planning align with its strategic objectives and 11 key performance areas.
- Aviation Safety Priority ICAO regions and states consider safety priorities from the Global Aviation Safety Plan when developing their navigation plans.

- Gradated Planning Approach the Global Aviation Safety Plan and ICAO Global Air Navigation Plan guide regional and state navigation plans. Regional plans by the Regional Planning and Implementation Groups (RIRPs) also influence individual state plans, addressing regional and inter-regional concerns.
- Global ATM Operational Concept (GATMOC) ICAO-endorsed documents, including Doc 9854, provide a foundational framework for evolving global air navigation and traffic management systems.
- Prioritizing Global Air Navigation ICAO should develop regulations, materials, and online training to support global air navigation priorities.
- Regional and State Navigation Priorities ICAO regions, sub-regions, and states, through PIRGs, establish their navigation priorities aligned with global goals.
- Periodic Review and Evaluation ICAO conducts a transparent review every three years of the Global Air Navigation Plan (GANP) and relevant air navigation planning documents.**[1]**

1.4 ICAO Navigation Policy Implementation Aspects:

ICAO focuses on implementing key navigation strategies, including Performance-Based Navigation (PBN), Continuous Descent Operations (CDO), Continuous Climb Operations (CCO), and Runway Sequencing Capabilities (AMAN/DMAN). It underscores the need for characterizing critical blocks to ensure aviation safety and compliance with standards. Coordination at the global or regional level may be necessary. Any implementation of Aviation System Block Upgrades (ASBUs) requiring mandatory capabilities must gain regional approval.**[1]**

A) Increased Functionality: ICAO is enhancing PBN to improve airport access and routing efficiency, addressing aviation challenges and aiming for advanced terminal operations as part of ATM modernization.

B) Strategic Development: ICAO is developing a long-term strategy to streamline PBN specifications while promoting standardized terminology for global PBN understanding and safety.

C) Implementation Assistance: ICAO facilitates effective PBN implementation through guidance, workshops, and training, supporting standards and regional harmonization.

D) Environmental Benefits: PBN procedures like CDO and CCO are reducing noise and emissions at major airports, offering fuel savings and environmental benefits.

E) Air Traffic Flow Management (ATFM): ICAO supports ATFM adoption to enhance safety, sustainability, and efficiency, providing international references and regional collaboration for effective resource allocation.

F) Module Prioritization: ICAO establishes guidelines for prioritizing upgrade modules to address international aviation community needs, emphasizing the importance of synchronized global implementation for interoperability and security.

1.5 Training, Recruitment, and Human Performance in GANP:

In the context of GANP implementation, aviation professionals are crucial, and GANP changes may affect their roles and skills. Ensuring a qualified workforce is essential for safety, and ICAO's NGAP program prepares the next generation. Human performance considerations must be integrated into planning, training, and cultural change management, requiring coordination among stakeholders for operational safety and successful standard/system implementation.**[1]**

1.6 Evolution from GANP to Regional Planning:

GANP offers a global perspective but recognizes that not all ASBU modules need universal implementation. Coordinated implementation at national, regional, and international levels is preferred. National and regional planning processes should harmonize module selection based on operational needs, involving diverse stakeholders. The goal is a globally interoperable and efficient air navigation system.**[1]**

1.7 Evolution and Management of the Global Air Navigation Plan:

GANP evolved from the "FANS concept" in 1993 to address growing air travel demands. It led to the publication of the Global Air Navigation Plan for CNS/ATM Systems in 1998, and the creation of route maps for MTA implementation in 2004. The fourth edition introduced the ASBU methodology for future developments.**[1]**

1.8 Scalability of GANP Implementation:

GANP has an 18-year planning horizon to modernize the aviation system, harmonizing ATM improvements. ASBU guides equipment planning for ANSPs and airspace users, offering flexibility in module selection. Regular evaluations and obstacle resolution are crucial for achieving GANP's performance objectives.**[1]**

1.9 The Global Air Navigation Plan (GANP) and Block Upgrade (ASBU):

GANP includes ASBU, with modules and technology route maps covering communication, surveillance, navigation, and avionics. ASBUs are designed for regions, sub-regions, and states to achieve harmonization and interoperability across regions and the world.**[1]**

1.9.1 Aviation System Block Upgrade (ASBU):

- **The ASBU:**

The ASBU framework represents an ICAO approach to system engineering designed to achieve worldwide ATM interoperability and standardization. The grouping of levels is the outcome of extensive and enduring cooperation among ICAO, ANSP, member nations, and global industry stakeholders. ASBU empowers air navigation service providers to devise their distinct deployment and investment strategy by opting for and implementing the modules that align best with their particular operational requirements. To ascertain the cost-effectiveness ratio of a module, a profitability analysis needs to be conducted. This document delves deeper into the subject of profitability analysis.**[2]**

The performance improvement domains have been organized into four blocks (Blocks 0, 1, 2, and 3) based on the calendrers of diversity that they represent, as shown in the graphic below.**[2]**

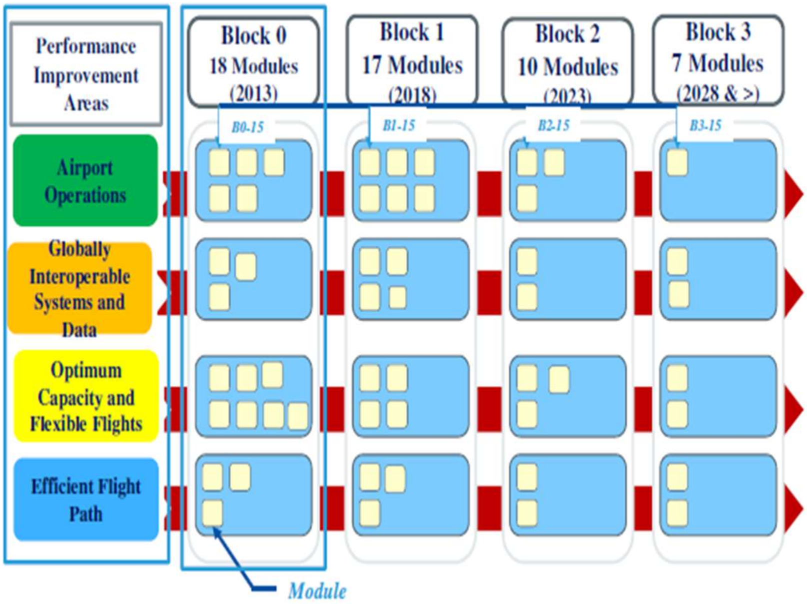


Figure 1-2 :Block availability stages 0-3, performance enhancement domains, and technology/process/capacity modules.

Each Bloc consists of multiple modules, as depicted in the images above and below. These modules are activated exclusively when they fulfil an operational requirement of a specific state. Once activated, they are supported by procedures, technologies, regulations, or standards, along with an accompanying analysis dossier.**[2]**

Every block is associated with a designated target date for its availability. For each module within the blocks to become operational, they must undergo a readiness review. This review encompasses the availability of standards, encompassing performance standards, approvals, guidelines, indicator elements, and more. It also covers aviation aspects, infrastructure, system automation, and other facilitating capabilities. To present a cohesive overview, each module should have undergone testing in two separate regions and obtained approvals and operational procedures. This approach enables states considering the adoption of these blocs to draw from the experiences of those who have already utilized these capabilities.**[2]**

Block 0 comprises modules featuring technologies and capabilities that are already established and operational in various regions worldwide. As a result, it displays a medium-term availability timeline, specifically an initial operational capacity (IOC) set for 2013, in accordance with regional and national operational requirements. On the other hand, blocks 1 to 3 are characterized by solutions that are either currently in existence or are planned within the performance domains. These solutions are expected to become available in successive stages, with starting dates of 2018, 2023, and 2028, respectively.**[2]**

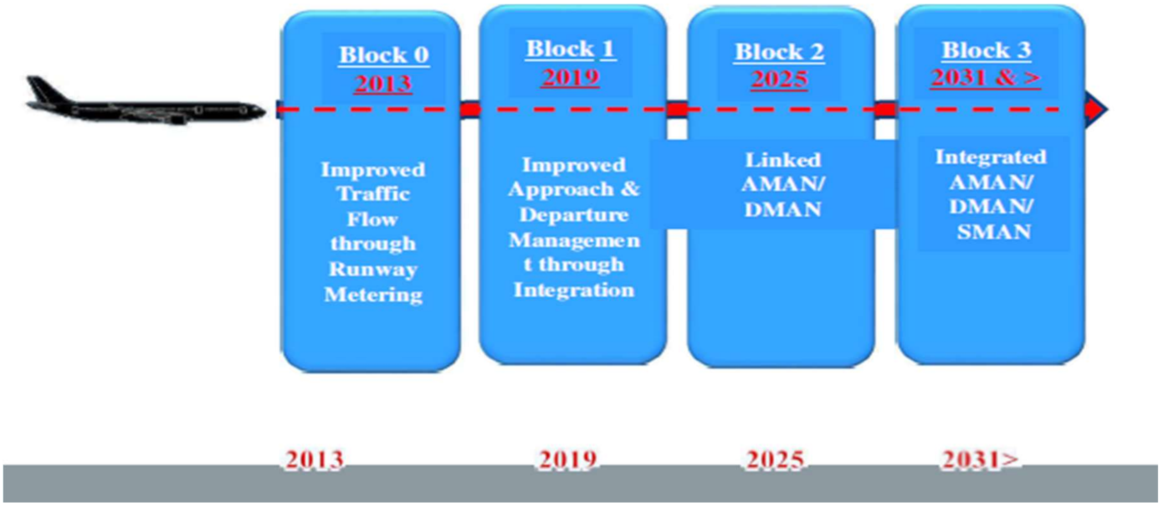


Figure 1-3:Block availability stages 0-3, performance enhancement domains.

Numerous aviation enhancement initiatives, such as SES, NextGen, CARATS, SIRIUS, among others in Canada, China, India, and Russia, should be carried out within the framework of ASBU. The projected schedules for implementing operational enhancement modules are depicted through the sequential progression of these blocs.**[2]**

The stipulations at the bloc level incorporate a forward-looking perspective in alignment with the three documents accompanying ICAO's aviation navigation planning. Their role involves harmonizing clear operational objectives for ground-based flight operations with the requisite aircraft, data transfers, and ATM systems. The global strategy aims to bring transparency across the industry and ensure the assurance of vital investments for operators, equipment manufacturers, and ANSPs.**[2]**

The foundational concept is intertwined with four distinct yet interconnected domains of aviation performance enhancement, namely:

a) airline operations.

b) worldwide data interoperability systems.

c) optimized capacity and adaptable flight paths.

d) efficient flight trajectories.

- **Evolution of ASBUs, Modules, and Route maps:**

ASBUs, modules, and route maps, integral to the GANP, are continually evolving as their content is refined and updated. This evolution includes the development of related provisions, supporting documents, and training materials.**[2]**

- **Application of ASBU Blocks and Modules:**

While GANP maintains a global perspective, it doesn't require the universal application of all ASBU modules. Regions, subregions, and states adopting ASBU blocks and modules must adhere to specific ASBU requirements to ensure global interoperability. Certain ASBU modules may become globally essential and subject to ICAO-mandated implementation dates.**[2]**

- **Economic Considerations and Financial Aspects:**

The implementation of air navigation measures, including those in ASBUs, may require substantial investments. Regions, subregions, and states should conduct cost-benefit analyses when considering the adoption of blocks and modules to assess cost-effectiveness. ICAO is developing guidance to assist states in this process.**[2]**

- **ICAO Tools for ASBU Module Implementation:**

1) **ICAO Documentation for ASBUs:**

Each ASBU module provides a comprehensive list of the standards, procedures, guidelines, and approval documents necessary for fully realizing operational improvements. ICAO has synchronized its work program with this list and will regularly update the documents as part of a six-month amendment cycle.**[2]**

2) **Standardization Route map:**

ICAO is developing a standardization route map in line with recommendations from the Twelfth Air Navigation Conference and the 38th Session of the ICAO Assembly. This route map extends beyond following ICAO's work plan and serves as a basis for collaboration with other standardization bodies. The objective is to leverage the work of recognized standardization bodies in the development of ICAO Standards and Recommended Practices (SARPs), Procedures for Air Navigation Services (PANS), and Technical Guidance, subject to appropriate verification and validation processes.**[2]**

- **ASBU and Enhanced Airspace Capacity:**

Modern aircraft capabilities support the shift from static to flexible flight routes to meet changing operational demands. Daily flexible itineraries and Free Route Airspace (FRA) are introduced to optimize fuel efficiency and reduce carbon emissions. Airlines' advanced planning systems and improved ATS ground systems are instrumental in achieving this transition to flexible routes.**[2]**

Chapter 2 : Air space management (ASM)

2.1 Definition:

A planning function that primarily aims to optimize airspace utilization by dynamically sharing time and, in certain instances, segregating airspace among various categories of airspace users based on short-term requirements. This process involves selecting and implementing airspace options to meet the needs of the ATM community. It is the component of Air Traffic Management (ATM) that ensures compatibility among various aerial activities.**[3]**

2.2 Exploring Airspace Management (ASM):

ASM (Airspace Management) aims to optimize airspace usage, minimize permanent airspace segregation, and enhance network performance. Despite complex challenges due to competing interests, ASM strives to minimize operational disruptions when separating different types of traffic, such as military exercises. It operates within a hierarchical framework comprising three levels **[3]**:

1. Strategic (Tier 1): Focuses on long-term national and international airspace policy.
2. Pre-Tactical (Level 2): Deals with daily airspace allocation in preparation for real-time utilization.
3. Tactical (Level 3): Manages airspace in real-time to ensure efficient use based on current operational requirements, following the Flexible Use of Airspace (FUA) concept.

2.3 Airspace Management (ASM) Principles:

Airspace management (ASM) aims to fairly address the diverse needs of all airspace users while optimizing airspace utilization based on actual requirements and avoiding permanent segregation when possible.**[3]**

In the context of civil-military cooperation, the following guiding principles and strategies should be followed:

- Airspace is a shared resource allocated through coordination.
- All available airspace must be managed flexibly, without being restricted by national borders or facilities.

- Consideration of dynamic flight paths and provision of optimal operational solutions.
- When necessary, airspace divisions separating different traffic types should be designed to minimize operational disruptions.
- Coordination and monitoring of airspace usage are crucial to balance user demands and minimize operational constraints.
- Advance planning of airspace reservations and dynamic adjustments when needed.
- Meeting unplanned short-term needs, recognizing operational complexities may limit flexibility to some extent.**[3]**

2.4 State Requirements Identification:

To realize the benefits of civil-military cooperation, States must establish formal structures and processes. This begins with identifying the needs and objectives of various stakeholders, both civilian and military. Factors to consider include airspace complexity, efficiency, air navigation system performance, types of aviation activities, military training areas, capacity constraints, weather conditions, access availability, and more. This analysis is integral to civil-military cooperation and airspace management.**[3]**

2.5 Enhancing Civil-Military Tactical Coordination:

Improving tactical coordination, involving ATS and military units, is essential for aviation safety and effectiveness. This requires identifying stakeholders, setting up communication channels, and establishing coordination procedures. Key stakeholders involved include civilian ATS units, military units, the Airspace Management Cell, regional ATFM centres,**[3]**

2.6 Air Traffic Flow Management (ATFM):

2.6.1 Definition:

ATFM is a supplementary service to ATS, established to assist the AIC in ensuring the optimal flow of air traffic to and from specific regions during periods when demand surpasses or is forecasted to exceed the available capacity of the ATC system.**[5]**

A service for managing air traffic flows (ATFM) will be implemented in airspace where traffic demand occasionally exceeds the defined ATC capacity. ATFM should be implemented based on a regional air navigation agreement or, where appropriate, through a multilateral agreement.**[5]**

The ATFM service within a region or other designated area should be developed and executed as a centralized ATFM entity, supported by traffic flow management units established at each ACC within the region or applicable area.**[5]**

Certain flights may be exempted from ATFM measures or given priority over other flights. Detailed procedures governing the provision of measures and the ATFM service within a region or area should be specified in a regional ATFM manual or another appropriate document.**[5]**

2.6.2 Air Traffic Flow Management Procedures:

ATFM should encompass three implementation phases**[6]**:

a) Strategic Planning: When measures are decided more than one day before their effective date. Strategic planning is typically carried out well in advance, usually two to six months ahead.
b) Pre-Tactical Planning: When measures are decided the day before they will take effect.
c) Tactical Operations: When measures are decided on the day, they will take effect.

a) Strategic Planning

Strategic planning should involve collaboration with ATC and aircraft operators. It should entail assessing the demand for the upcoming season, evaluating where and when demand is likely to exceed available ATC capacity, and working to address the imbalance by:

- Arranging with the ATC authority to provide sufficient capacity at the desired location and time.
- Rerouting certain traffic flows (traffic orientation).
- Establishing or revising flight schedules as necessary.
- Determining the need for tactical ATFM measures. In areas where Traffic Orientation Schemes (TOS) are planned to be introduced, routes should, whenever possible, minimize time and distance penalties for the concerned flights while allowing a degree of flexibility in route selection, especially for long-haul flights. When a TOS is agreed upon, the details should be published by all relevant states in a standardized format.**[6]**

b) Pre-Tactical Planning

Pre-tactical planning should refine the strategic plan based on updated demand data. During this phase:

- Certain traffic flows may be rerouted.
- Contingency routes may be coordinated.
- Tactical measures will be decided upon.
- Clarifications for the next day's ATFM plan should be published and made available to all stakeholders.**[6]**

c) Tactical Operations

Tactical ATFM operations should include:

- Implementing agreed-upon tactical measures to mitigate and regulate traffic flow in areas where demand would otherwise exceed capacity.
- Monitoring the progression of air traffic conditions to ensure the intended impact of applied ATFM measures and taking corrective actions in case significant delays are reported. These actions might include traffic rerouting or altitude assignments to make the most of available ATC capacity.

If the demand for traffic exceeds, or is forecasted to exceed, the capacity of a specific sector or airport, the responsible ATC entity will notify the corresponding ATFM entity and any other relevant ATC organizations. Aircraft flight crews scheduled to fly through the affected region, as well as operators, should be informed as early as possible about anticipated delays or forthcoming restrictions.**[6]**

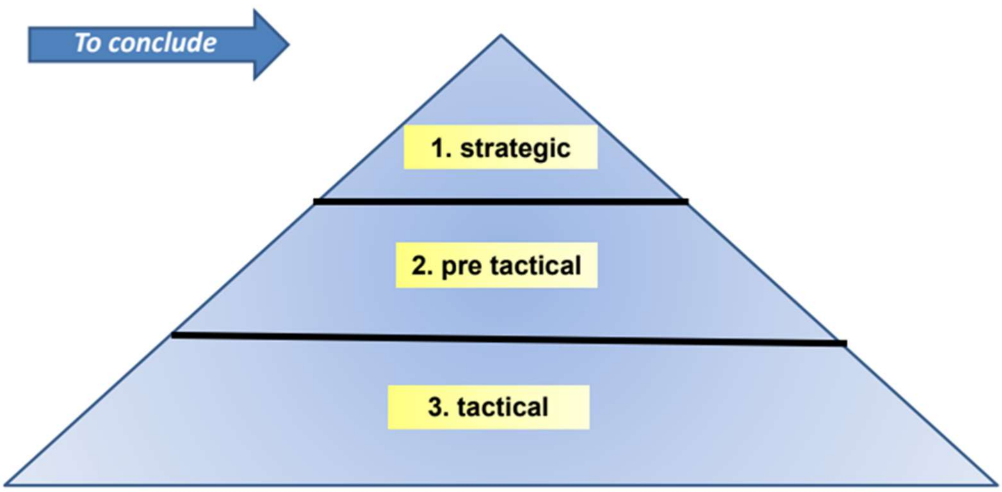


Figure 2-1 : ASM levels.

2.7 Flexible Use of Airspace (FUA):

2.7.1 The concept of flexible use of air space:

The concept of Flexible Use of Airspace (FUA) is based on the principle that airspace should not be designated purely as civil or purely military, but rather as a continuum in which the needs of all users are addressed to the greatest extent possible.**[4]**

The FUA concept encompasses effective communication, cooperation, and coordination to ensure safe, efficient, and predictable use of airspace. The establishment of joint civil-military coordination entities for the organization and management of airspace is essential for achieving current and future CNS/ATM initiatives. Meeting the future needs of air traffic in terms of safety, security, capacity, efficiency, environmental sustainability, and increased sovereignty depends on effective coordination between civil and military stakeholders.**[4]**

2.7.2 Principles of FUA:

A FUA concept should embody the following principles **[4]**:

a) Coordination between civil and military authorities should occur at strategic, pre-tactical, and tactical levels (see Figure 1) to enhance airspace safety and capacity and improve the efficiency of air operations.
b) Consistency between Airspace Management (ASM), Air Traffic Flow Management (ATFM), and Air Traffic Services (ATS) should be established and maintained across all three levels of ASM.
c) Airspace reservations should be temporary in nature, applied only for limited periods, and based on actual airspace usage.
d) The FUA concept should, when feasible, be applied across national borders and/or Flight Information Region (FIR) boundaries.

2.7.3 Strategic Airspace Management:

At the strategic ASM level, the following tasks need to be accomplished to ensure the general application of the FUA concept**[4]**:

a) Establish airspace structures.
b) Develop coordination procedures and airspace management procedures.

c) Define cross-border coordination standards and separation between civil and military flights.

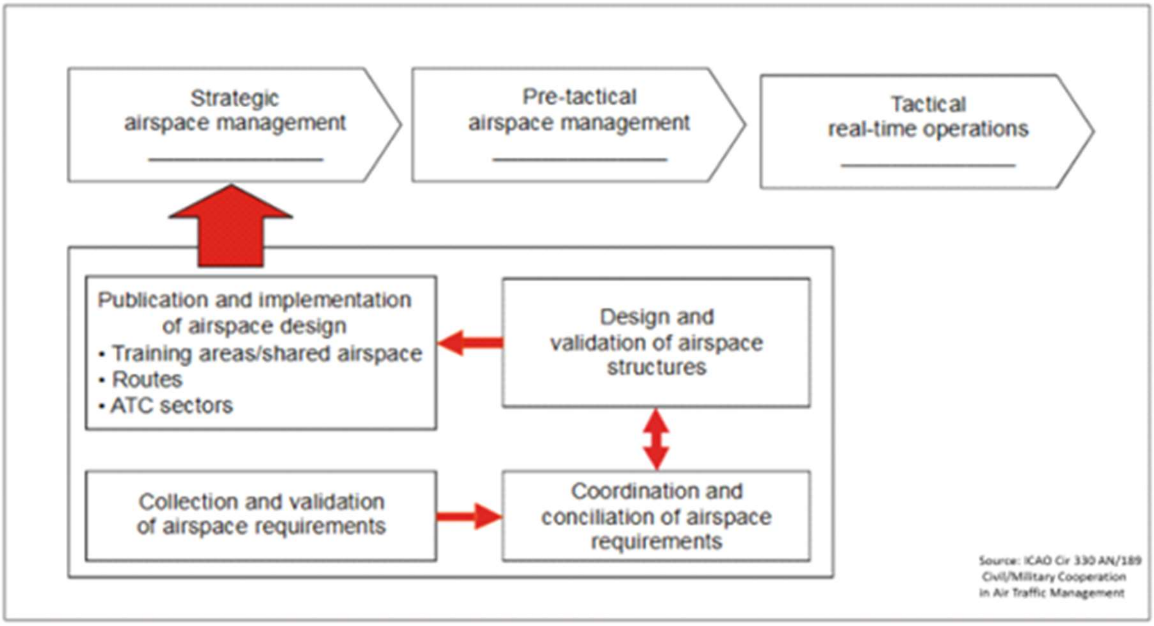


Figure 2-2 : Coordination between civil and military authorities at the strategic, pre-tactical and tactical levels.

2.7.4 Airspace structures, flexible procedures and adaptable:

A concept of FUA can be founded on the potential provided by flexible and adaptable airspace structures, along with specially tailored procedures for temporary allocation and utilization. These include conditional routes, temporarily reserved areas (TRA), temporary segregation areas (TSA), and cross-border areas (CBA).**[4]**

a) **Conditional Route:** A conditional route denotes a non-permanent ATS route or segment that can be planned and used under specified conditions. Depending on its anticipated availability, flight planning possibilities, and expected activity level of associated TSAs, the following categories of conditional routes are distinguished:

- Category one: permanently plannable.
- Category two: non-permanently plannable.
- Category three: not plannable.

b) **Temporarily Reserved Area (TRA**). A TRA **(Figure1.10)** is an airspace designated for specific user utilization during a predetermined period, allowing other aircraft to transit through it with air traffic control authorization.

c) **Temporary Segregation Area (TSA).** A TSA **(Figure2.3)** is an airspace set aside exclusively for the use of specific users during a defined period, with no other traffic permitted to transit through it.

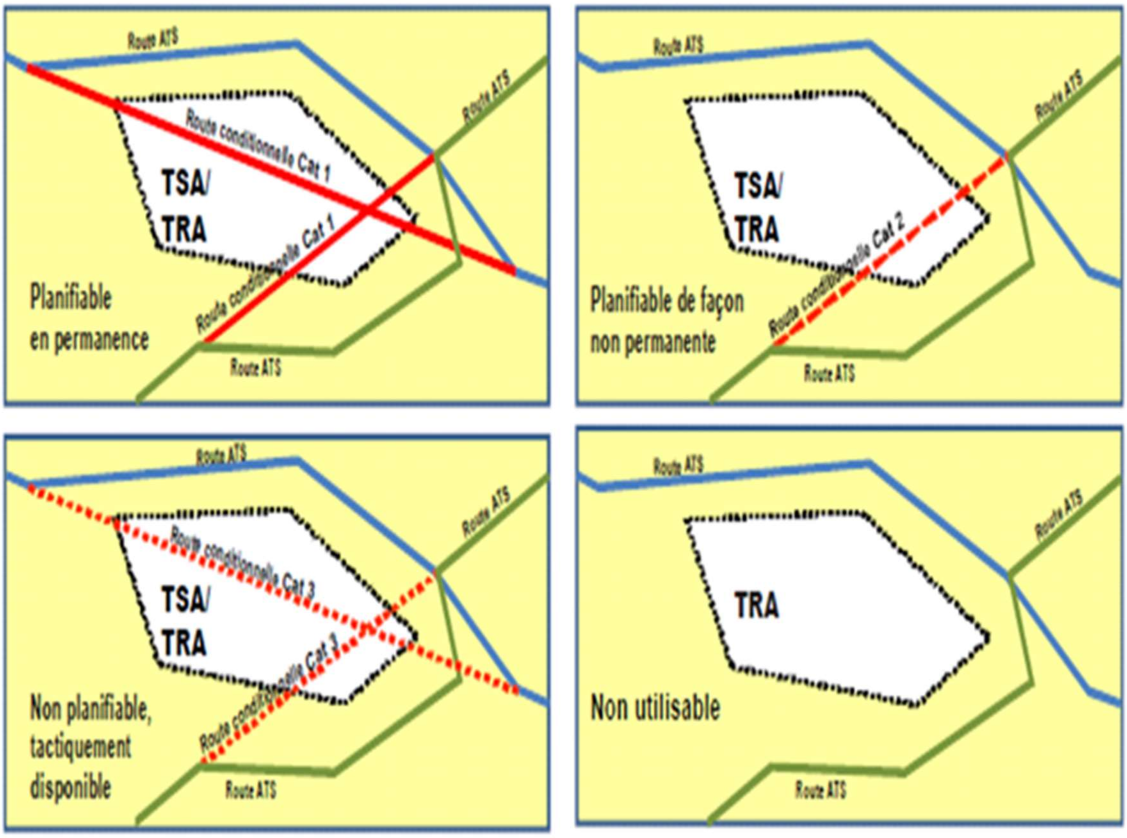


Figure 2-3 :Conditional route.

d) **Cross-Border Areas (CBA).** A CBA **(Figure2.4)** is a reservation/segregation of airspace established for specific operational requirements. CBAs are created to facilitate training flights across international borders and other military operational flights on both sides of a border. Unconstrained by national boundaries, CBAs can be strategically positioned to benefit both civilian and military aviation. When combined with possible usage of conditional routes crossing them, CBAs enhance the airspace structure in border regions and contribute to the improvement of the ATS route network. Official agreements encompassing political, legal, technical, and operational aspects between concerned states are essential prior to establishing CBAs. These formal agreements for CBA establishment and usage should address matters of sovereignty, defence, legality, operations, environment, and search and rescue.

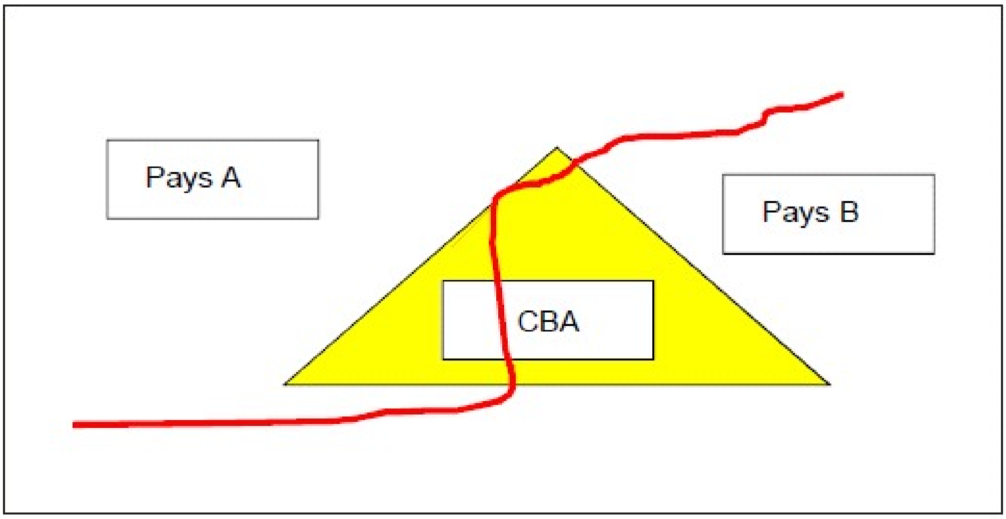


Figure 2-4 : Cross-border area (CBA).

2.8 Airspace:

2.8.1 Definition:

Airspace is the portion of the atmosphere controlled by a country above its territory, including its territorial waters or, more generally, any specific three-dimensional region above the Earth's surface that is designated for the flight of aircraft. It is not the same as aerospace, which is the general term for Earth's atmosphere and the outer space in its vicinity.**[5]**

2.8.2 Aerial Space Organization:

The types of flights:**[8]**

- VFR flights (Visual Flight Rules) or visual flight rules: This is a flight plan that is subject to favourable weather conditions. In general, VFR flying necessitates good visibility and sufficiently high numeric ceilings.
- IFR (Instrument Flight Rules) flights or instrument flight rules: The pilot navigates using radio navigation equipment and hence does not require visual references.

2.8.3 Aerial Space Division:

The delimitation of parts of airspace within which services of air circulation are provided is done based on the nature of the network of routes and the requirements of service effectiveness rather than national borders. The sky is divided into two sections:**[8]**

1. **ControlledAirspace:**

Controlled airspace is an area where the provided services include control, flight information, and alert services, this space includes:**[8]**

- **CTA: (CONTROLAREA): They** are defined in such a way that they encompass sufficient airspace to accommodate the flight paths or portions of flight paths of IFR aircraft to which air traffic control services are intended to be provided, taking into account the capabilities of navigation aids normally used in these regions.
- **Terminal Control Regions (TMA):** Terminal control regions are typically established at the intersection of ATS routes around one or several significant aerodromes. Their inner limit is generally at 3000 feet MSL, and the upper limit does not exceed FL195.
- **Airways (AWY):** These are controlled regions or segments of controlled regions forming radio beacon-guided corridors with a width of 10 NM.
- **Control Zones (CTR):** They encompass initial and final flight paths with the runway, typically forming a 5.6 NM circular area centred on the airfield, with a ceiling of 3000 feet MSL or 1000 feet AGL.
- **Upper Control Areas (UTA):** These are controlled upper spaces, where the lower limit is defined by the CTA, and the upper limit is set at Flight Level FL660.

2. **Uncontrolled Airspace:**

Uncontrolled airspace is an area where services are limited to flight information and alert services. There are two types:**[8]**

- **Flight Information Regions (F.I.R)**: A flight information region is defined to cover the entire network of air routes it serves, providing flight information and alert services from the surface up to FL195.
- **Upper Flight Information Regions (U.I.R):** These were established to reduce the number of Flight Information Regions (FIRs) that high-altitude aircraft would need to traverse. These regions encompass the airspace within the lateral boundaries of a specific number of FIRs.

Aerial space can also be imagined as verticallyin the upper and lower space.

Vertical Division of Airspace:

Based on what we have covered so far, the airspace is divided into two distinct levels:**[8]**

- **LowerAirspace:**

It extends from 450 meters above the surface of the Earth or water up to FL295.

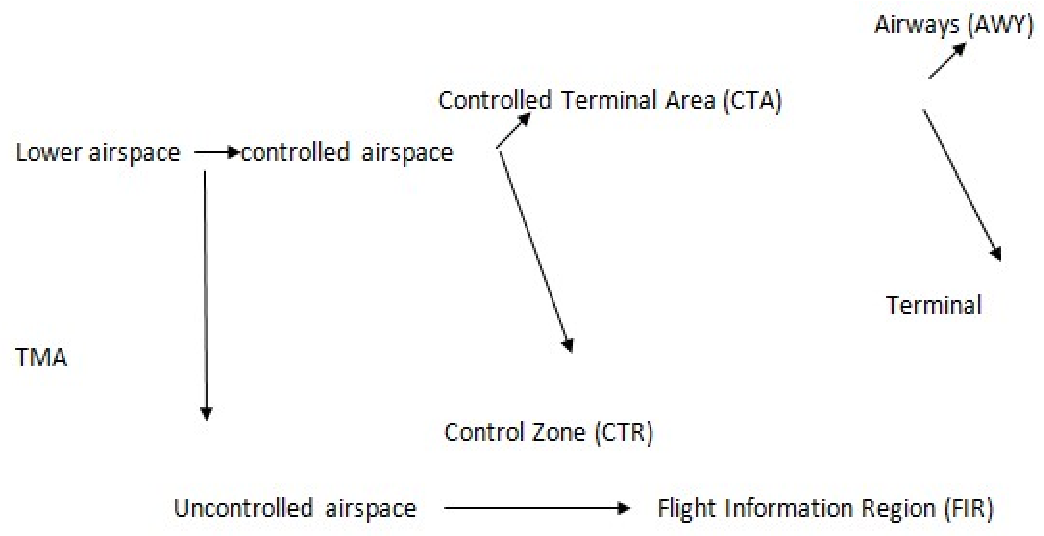


Figure 2-5 :Lowerairspaceorganization.

- **UpperAirspace:**

It spans from FL245 with no ceiling limitation, see figure (II.3).

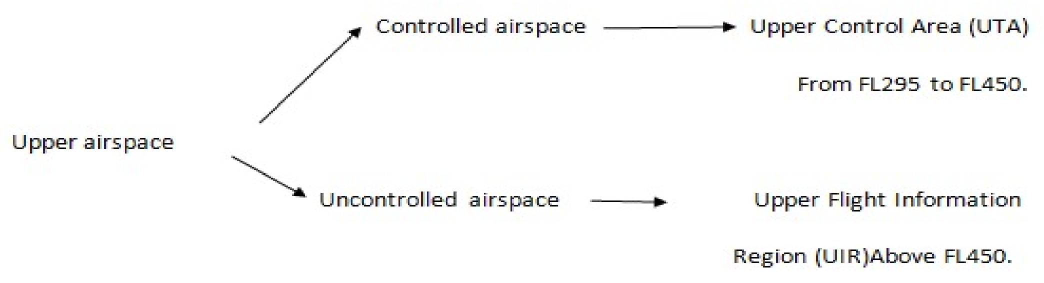


Figure 2-6:Upper airspaceorganization.

2.8.4 Special Status Airspace:

Any airspace in which the movement of aircraft may be prohibited or regulated for any reason, either temporarily or permanently, and any airspace where a potential hazard to aircraft movement exists is categorized into three types of zones by ICAO.**[8]**

- **Prohibited Zones (P)**

The establishment of a prohibited zone should be subjected to particularly strict conditions, as the use of this space is entirely forbidden for overflight by all aircraft. This type of zone is typically established only to protect important state facilities, critical industrial complexes whose damages resulting from an aircraft accident could become catastrophic, or sensitive specific installations essential to ensure national security. They are identified by the letter "P" followed by a number.

- **Restricted Zones (R)**

These are defined areas over a state's territory or territorial waters, where aircraft flight is subject to specific conditions, which can even extend to a penetration ban. A restricted zone serves to safeguard military activities and might allow civil aviation under certain circumstances, requiring coordination between military and relevant civil authorities. The aircraft in this zone is under the responsibility of the zone manager. They are identified by the letter "R" followed by a zone number.

- **Dangerous Zones (D)**

Certain areas pose a particularly hazardous character to air navigation due to the activities occurring within. Penetrating a dangerous zone demands heightened vigilance from the pilot, and in some cases, it's advisable to avoid it when active. Dangerous zones in upper airspace are managed differently than those in lower airspace.

Regarding the letters of agreement with military organizations, it is specified that during operational time slots, these zones are impermeable to civilian traffic, even if there is no prohibition to enter them according to the rules of the air. They are identified by the letter "D" followed by a zone number.

Chapter 3 : Free routing and direct routing

3.1 Introduction:

For the last years the application of the Fixed Route Network concept, was responsible for the restructuring of the regional and international ATS routes, involving implementation, realignment and elimination of several of routes.

The next 20 years will be a period of transformational change for the aviation sector, especially for air traffic management (ATM) and flight operations. Already, new types of aircraft and airspace users are introducing next-generation innovations, integrating advanced technologies and sophisticated operational decision-making processes and among these new strategies and innovation ,The adoption of concepts such as DCT (Direct Routing) or FRA (Free Route Airspace) and the desire to have a flexible adaptation, real time of the sectorization according to the available means and manpower and taking into account the air traffic flows freed from the constraints of ATS routes. .

However, the natural evolution of the Airspace Optimization is the use of Free Routing Airspace, as provided in the Global Air Navigation Plan. The use of Fixed ATS Routes is no longer capable to deliver the required efficiency for airspace users to allow the corresponding fuel savings, flexibility and reduction of greenhouse gas emissions.

The free route concept is really a European concept, it is a work piloted by the euro-control for several years and several weeks and little by little they have built and validated options so that everyone implements this regulation in a coherent way with the same technical tools and so that also all the operators of the users can be there finding more or less the same way and publish it in the different AIP of the different countries, that is understandable.

In this chapter we will discover the new concept which is "free routing “, we will also talk about the free route airspace “FRA", its operation, the potential advantages of the adoption of direct routes in the optimization of traffic flow and the effect of this concept on the reduction of flight distances, improved flight times and reduced fuel consumption.

3.2 Civil/Military Cooperation in Air Traffic Management:

3.2.1 Introduction:

Global standards, uniform principles and agreements are needed to ensure the technical and operational interoperability of the ATM system. However, ATM system interoperability needs to be considered in the broader context of governance, not just technology and procedures, while bearing in mind the requirements users place on the system. After all, ATM aims to enable all airspace users, including the military, to operate their preferred flight/mission profiles, cost-efficiently and effectively, without compromising flight safety or national security.

Communications, navigation and surveillance (CNS) systems, and advanced information management technology are to be used to functionally combine the ground-based and airborne system elements into a fully integrated, interoperable ATM system open to all users.

Interoperability can be considered as the ability of “systems” (not exclusively technical systems) to provide information and services to, and accept information and services from, other systems and to use the information and services so exchanged. Interoperability constitutes the driver of standardization, integration and cooperation.

Global standards, uniform principles and agreements are needed to ensure the technical and operational interoperability of the ATM system. However, ATM system interoperability needs to be considered in the broader context of governance, not just technology and procedures, while bearing in mind the requirements users place on the system. After all, ATM aims to enable all airspace users, including the military, to operate their preferred flight/mission profiles, cost-efficiently and effectively, without compromising flight safety or national security.

Interoperability specifics, however, are not always well-defined when considered in relation to the CNS/ATM field. They are often situation-dependent, come in various forms and degrees and can occur at various levels, i.e., strategic, operational, and technical.

From the aforementioned, it can be concluded that civil/military coordination and interoperability are very similar. Interoperability can be identified as strategic/political or operational/technical.

3.2.2 Strategic and/or political interoperability:

At the strategic/political level, the concept of interoperability can be considered as an enabler for coalition building. It facilitates meaningful contributions by aviation coalition partners, both civil and military. At the highest level, interoperability of aviation issuesfocuseson harmonizing global (e.g., ICAO) or regional (e.g., European Union) views, doctrines and, foremost, a regulatory framework. One main element at this level is the political willingness to cooperate and coordinate over the long term, to achieve and maintain shared interests in aviation safety, environment, efficiency, and capacity.

The price of strategic and/or political interoperability at national as well as international levels can be high and finding a common ground can be difficult to achieve. National considerations and culture are potential disablers of affordable interoperability. Nevertheless, one can assume that the aviation chain is as strong as its weakest link and that it is therefore in everyone's interest to cooperate and invest in order to achieve the highest level of interoperability.**[4]**

3.2.3 Operational and technical interoperability:

Interoperability at the operational level occurs when strategic, political, and technical interoperability come together, not only to help all aviation partners to shape the environment and manage crisis, but also to support any anticipated aviation growth and its associated impact on aviation safety, environment, efficiency and capacity.**[4]**

The benefits of interoperability at the operational and technical level generally derive from the interchangeability of system elements or operational procedures. An example is the system-wide information management (SWIM) concept which is or will be used in a civil (SESAR/NextGen) as well as in a military (Network Centric Warfare) environment. These concepts enable users to randomly use that portion of information viable for their respectiveoperation and can be achieved only through the interoperable technical feeders of the network. For this reason, States and military organizations should endeavor to define mutually interoperable systems early in their design phase.**[4]**

Another benefit of interoperability is modularity, which allows for the possibility of collecting only those technical facilitators that are necessary to conduct one's operation. An example of this is the all-purpose structured.**[4]**

Euro-control surveillance information, known as the ASTERIX protocol, used for radar data exchange. This exchange protocol, in combination with a multi-radar tracker, can enable a civil air navigation service provider (ANSP) to use externally provided radar data, without necessarily procuring its own radar system, by using radar data provided by military sensors. States and military organizations should ensure a level of modularity in their respective systems to allow those systems access to a free exchange of information as required.**[4]**

Costs associated with interoperability at the operational and tactical level very often derive from inefficiencies caused by a number of factors outside the direct control of the involved parties, such as strategic objectives, system impossibilities and institutional or governmental changes. States and military organizations should consider interoperability from the early stages of system design to ensure that costs are kept low and to ensure system compatibility.**[4]**

3.2.4 Regulation and standardization:

CNS/ATM regulations in any form can have an impact on the military either when military ground systems are integrated into a CNS/ATM network, when military units provide air navigation services to civil aviation or when carriage requirements are imposed on airspace users. Therefore, States and service providers implementing regulations or designing procedures should consider and minimize the impact of such actions on military users and systems (ground or airborne).**[4]**

Existing civil standards and specifications are adequate to support technical compliance of civil CNS/ATM systems but tend to overlook the specific characteristics of available military CNS/ATM systems. To enable solutions that would promote civil/military interoperability, States should ensure that such specifications respond to the fulfilment of defined performance levels, using multiple means of compliance, rather than mandating particular equipage fits.**[4]**

Historically, the supporting technical infrastructure enabling military operations, comprising multiple ground-based and airborne CNS/ATM systems, has been procured with the primary objective of satisfying the very demanding wartime requirements of military command and control.**[4]**

The resulting lack of interoperability between the underlying civil ATM infrastructure and many military ground systems and tactical aircraft avionics is difficult to overcome due to:**[4]**

a) lengthy military procurement cycles.
b) Publicbudgets constraints.
c) lackofspaceinthecockpitforextraavionics.
d) absenceofsupportingmilitaryrequirements.

e) lackofrecognizedcertificationprocesses.

f) securityandinstitutionalaspects;and

g) difficultymonitoringcivilCNS/ATMdevelopments.

Oneofthemostsignificantconsequencesofthissituationisevidencedwheneveramilitar yaircraftthatintendstousecivilroutestructureshastobeaccommodatedusingspecialhandlingor byapplyingexemptionpoliciesorderogationsfortheairborneequipage.Itneedstoberealizedthatt heneedforanexemptionforStateaircraftshouldbebasedoncompellingtechnicalormilitaryreaso nsandusedonlyasameasureoflastresort.

WiththefuturepredominanceofstrategicATMcapabilities,reductionoftacticalintervention sandconsequentautomationoftheassociatedATCtoolsandinformationflowsinanetwork-centricenvironment(SESAR/NextGen),militaryplatformsmayfaceseriousdifficultieswhenatt emptingtofreelyaccesstheairspacedesignatedforcivilaviationiftheylacktherequiredlevelsofco nnectivitywiththeunderlyingcivilATMsystem.

Thispossiblesituationentailstheurgentneedtoidentifyvalidsolutionsforinteroperabilit ybetweencivil andmilitaryCNS/ATMsystemsatanearlystageintheirdevelopmentandtodefineamigrationpath towardslong-termavionicsconvergenceandintegration.Statesandserviceprovidersshouldestablishaforma lprocessofconsultationwithmilitaryusersatanearlystageoffutureavionicsdevelopmentwi順theaimofachievingmaximumsysteminteroperabilitybetweencivilsystemsandmilitaryuni ts.**[4]**

3.2.5 Civil / military collaboration – a new global challenge:

Historically, State agreements between military aviation units and ANSP have focused on the needs ofState defence, security and emergency procedures as well as military readiness and response requirements. There is now a clearly defined need to establish procedures that support the efficient integration of military and civil aviation in day-to-day operations.**[3]**

Collaboration begins with good communication. ATM stakeholders should meet regularly to betterunderstand the needs, desires, constraints, and challenges that each operator and service provider face in operating within State airspace. Good communication and mutual understanding enable building collaboration upon a solid foundation. Good civil/military communication and collaboration are the key to success for ATM around the world.**[3]**

ATM stakeholders should approach and decide on each change-process on a collaborative basis.

Optimized decision-making is the result when the interests of all ATM stakeholders are represented and the impact of the required changes is weighed and balanced against the needs and issues of military, civil and State aviation.

Aviation operations of all types contribute significantly to the economy of a State, and, as such, theirgrowth needs to be protected and encouraged. In this regard, each State will benefit from a strong commitment to civil/military collaboration. Collaboration on the design and management of State airspace, technical requirements, and data and information collection and dissemination will allow civil aviation to flourish and military aviation to perform their required missions. Further, aviation is a global business with an economic impact that crosses State borders. StrongState commitments to civil/military collaboration will be conducive to international harmonized approaches to aviation and the building of national and international agreements that benefit State and international civil aviation stakeholders alike.**[3]**

This circular provides several examples of successful State civil/military collaboration resulting in benefits to airspace management and ATM system operations. These examples demonstrate that collaboration:**[3]**

a. attains higher levels of safety.
b. increases airspace capacity.
c. enhances national security; and
d. increases operational efficiencies through:
    i. interoperability of civil and military aircraft.
    ii. reduction in distances flown.
    iii. establishment of optimal flight profiles; and
    iv. reduction in fuel consumption and carbon emissions.

3.2.6 Improve Civilian-Military levels of Coordination:

The strategic, pre-practice and tactical level:**[8]**

- **Strategic Level:**

The strategic level of the DSO involves high-level planning activities. To this end, a high-level airspace policy body (HLAPB) is established to:**[8]**

- Formulation and revision of national MA&S policy

- Periodic evaluation of the national airspace and air route network
- The establishment of flexible airspace structures (for example, AUS), including the conduct of relevant safety assessments and periodic reviews
- Coordination of major events such as large-scale military exercises that require additional separate airspace.
- Establishment and revision of airspace allocation (level 2) and tactical management (level 3) procedures.
- The joint civilian-military body with a high level of representation of military (Ministry of Defence) and civilian (Ministry of Transport) entities.

➢ **Pre-Tactical Level:**

The pre-tactical level of airspace management involves daily airspace allocation activities in order to optimally meet the demands of different airspace users. These activities are normally conducted by a joint civilian/military Airspace Management Cell (AMC). The degree of discretion and authority of the CMA is determined by the HLAPB at the strategic level.**[8]**

The airspace management cell collects requests for airspace reservations, drafts in accordance with established procedures and priorities, and produces the airspace use plan (AUP). **[8]**

The pre-tactical level normally ranges from D-6 (i.e., six days prior to activities) to D-1 (when the airspace use plan is promulgated). Between D-6 and D-2, available airspace plan information is published in the draft AUP. This facilitates coordination in case of conflicting demands, so that appropriate solutions can be found in advance.**[8]**

After promulgation of the AUP on D-1, a change in airspace allocation may be required due to, for example, cancellations or new requests. In this case, an updated AUP (UUP) is created and promulgated during the AUP's validity period. **[8]**

➢ **Tactical Level:**

Measures to improve tactical coordination (coordination between ATS units and appropriate military units) should be taken to directly support aviation safety and effectiveness. To do this, it is necessary to identify the different stakeholders, actors and authorities involved in tactical decisions, establish means of communication, and establish simple coordination procedures. At a minimum, the following stakeholders should be involved in improving tactical coordination:**[8]**

a. All civilian ATS units: the different sectors and respective supervisors.
b. All appropriate military units: military units providing ATS, combat control centers, ranges, and respective supervisors; the Airspace Management Cell (AMC), ifestablished.
c. Regional or sub-regional ATFM center; and any stakeholder directly involved in day-to-day operations, including tactical decision-making authorities, such as duty officers, officers with delegated authority for daily flying activities, or responsible officers, etc.

The tactical level includes activities related to the implementation of the AUP/UUP, such as the activation and deactivation of SUA, the reallocation of airspace, the resolution of specific airspace problems and situations between civilian ATS units and military control units. Examples include OAT flights crossing ATS routes, GAT flights crossing TRA, deactivation of hazardous areas due to the need for aircraft in distress to cross this airspace, etc.**[8]**

Airspace users, who have previously requested airspace, inform the CMA of changes to their planning (for example, activity completed earlier than planned, cancelled, or reduced in time or volume) so that the airspace can be available for one or more additional periods of time compared to what was planned.**[8]**

The tactical level of the DSO is based on the use of real-time data, including flight data (flight plans, estimates, etc.) as well as controller intentions and plans. System support tools are often available, such as electronic coordination functions, OLDI messages (e.g., XRQ - traverse request), etc.**[8]**

3.2.7 Airspace Management Principles:

Airspace Management (ASM) is the process of equitably meeting the different needs of all airspace users. The ultimate objective of the MA&S is to achieve the most efficient use of airspace based on actual requirements and, if possible, to avoid permanent segregation of airspace. **[8]**

3.2.8 Flexible Use of Airspace (FUA)

As we said previously in the first chapter “generalities” where we talked about several mains definitions that’s will help us in our research, and among them, we talked about The Flexible Use of Airspace (FUA) concept which is a fundamental framework in aviation management that aims to optimize the utilization of airspace while ensuring safety and efficiency.

The FUA concept was developed to address the increasing demand for airspace capacity and the need to accommodate various types of airspace users, including commercial airlines, military operations, general aviation, and unmanned aerial vehicles.**[8]**

1) **Collaborative Approach:** FUA promotes collaboration and coordination among various stakeholders involved in managing and using airspace. This includes civil aviation authorities, military organizations, air traffic management providers, and other airspace users. The goal is to create a shared understanding of airspace requirements and constraints.

2) **Dynamic Allocation:** FUA recognizes that airspace is a finite and valuable resource. Instead of assigning fixed portions of airspace to specific users, FUA allows for dynamic allocation of airspace based on real-time needs and priorities. This dynamic allocation can change throughout the day or in response to specific events, such as military exercises or emergencies.

3) **Safety as a Priority:** Safety is paramount in aviation, and FUA does not compromise on safety standards. The concept ensures that all airspace users operate within established safety parameters and that potential conflicts are managed effectively. Safetyis a non-negotiable aspect of FUA implementation.

4) **Optimizing Capacity:** FUA aims to maximize the efficient use of airspace capacity. By allowing for flexible allocation and prioritization, it helps minimize delays, reduce congestion, and optimize routes for aircraft. This is especially important in busy airspace regions or during peak travel times.

5) **Air Traffic Management Tools:** To implement FUA successfully, modern air traffic management systems are crucial. These systems include advanced technologies such as radar, satellite-based navigation, and communication systems that allow for real-time monitoring and control of airspace.

6) **Coordination Mechanisms:** FUA relies on coordination mechanisms such as collaborative decision-making (CDM) processes and airspace management cells. These

mechanisms facilitate communication and information sharing among airspace users, helping to resolve conflicts and allocate airspace efficiently.

7) **Military-Civil Integration:** One of the key challenges in implementing FUA is the integration of military and civil airspace operations. FUA seeks to strike a balance between military training and airspace access for civil aviation, ensuring that both can coexist harmoniously.

8) **Environmental Considerations:** FUA also considers environmental factors, such as noise pollution and emissions. By optimizing flight routes and reducing delays, it can contribute to minimizing the environmental impact of aviation.

Overall, the Flexible Use of Airspace (FUA) concept is a forward-looking approach to managing airspace that prioritizes safety, efficiency, collaboration, and adaptability. It enables the aviation industry to meet the growing demands for airspace capacity while maintaining high safety standards and addressing the diverse needs of airspace users.

In order to improve the quality and flexibility of air routes and to meet the needs and demands of airspace users, civil aviation has introduced a new concept called FRA (Free Route Airspace);The Flexible Use of Airspace (FUA) concept and Free Route Airspace (FRA) are related concepts within the field of air traffic management, and they both aim to Both FUA and FRA aim to achieve more efficient, safe, and flexible use of airspace while accommodating the diverse needs of airspace users. However, they are not the same thing, as FRA is a specific implementation FUA concept.

3.3 Free routine airspace of the broader&free routine:

3.3.1 Free Route Airspace:

3.3.1.1 Concept of Operations:

The 37th Session of the International Civil Aviation Organization (ICAO) Assembly (2010) directed member States to increase efforts to meet the global needs for airspace interoperability while maintaining its focus on safety. ICAO therefore introduced the Aviation System Block Upgrades (ASBU) initiative as a programmatic framework that: **[9]**

a) develops a set of air traffic management (ATM) solutions or upgrades.

b) takes advantage of current equipage.

c) establishes a transition plan; and

d) enables global interoperability.

As part of the ASBU, four Performance Improvement Areas (PIA) have been set up:

a) Airport Operations.
b) Globally Interoperable Systems and Data – through globally interoperable system-wide information management.
c) Optimum Capacity and Flexible Flights – through global collaborative ATM.
d) Efficient Flight Path – through trajectory-based operations.

Performance Improvement Area (PIA) three of the ASBU deals with "Optimum Capacity and Flexible Flights – through Global Collaborative ATM" – here we can find Block B1-FRTO (Free-Route Operations): **[9]**

3.3.1.2 What is Free Route Airspace?

"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) waypoints, without reference to the fixed ATS route network, subject to airspace availability and consideration of restrictions. Within this airspace, flights remain subject to air traffic control."**[9**

It is a volume or cellule from FL195 to FL 660, planning rules (route planning for ifm) for the are described with:

1) Entry (E) and exit (X) points.
2) Intermediate points (I) (to plan a change of level, bypass an active military zone, avoid saturation of sectors, and control the orientation and flows by ATC etc.).
3) Arrival and departure connection points (A and D), to allow good connectivity of flight plans and organize traffic that ends up on relatively large aerodromes with significant flows.
4) Rules for the use of points published in the FDR (ROUTE ADIBILITY DOCUMENT) it is a catalogue of rules of use of the points of arrival/departure edited by control every 28 days as the national AIP, but which compiles the restrictions of use on a European scale by the euro control.

Free route airspace (FRA) is a concept of providing air traffic services in which an operator can choose their route subject to only a few limitations (e.g., fixed entry and exit points and the need to avoid danger areas, TRAs or TSAs) as opposed to the situation where standard airways should be used. In most cases the straight line between an entry point and an exit point will be chosen. If for some reason this is not appropriate (e.g., a danger area needs to be avoided) additional turning points can be specified. These can be navigational aids, published navigational points or points with specified coordinates. The following diagram gives an overview of the main FRA rules:

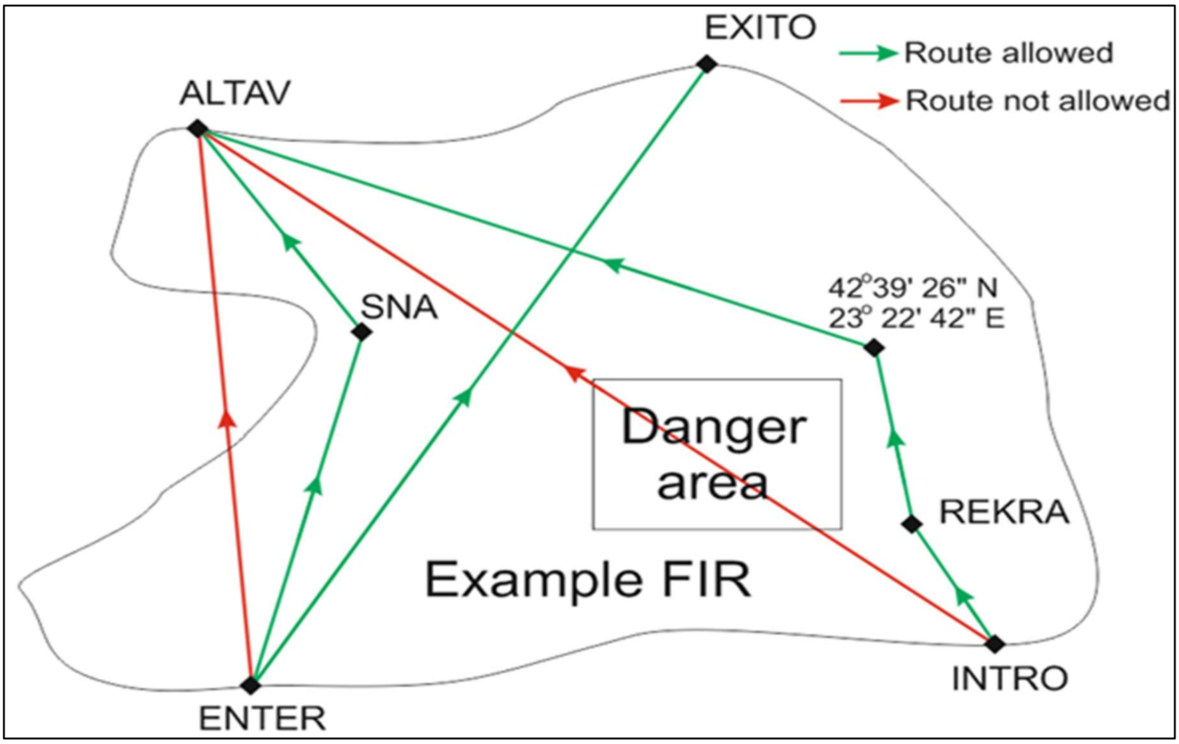


Figure 3-1: Example of allowed and not allowed FRA routes to be considered during the pre-flight planning.

In the example FIR depicted, INTRO and ENTER are entry points, ALTAV and EXITO are exit points, SNA is a VOR and REKRA is an RNAV point. When FRA is implemented, the green routes would be accepted, and the red routes would be rejected by the ATC flight plan processing system. The reasons for rejection include the crossing of a danger area (INTRO-ALTAV) and the requested route not remaining within the FRA (ENTER-ALTAV). The approved routes can be either direct from an entry to an exit point (e.g., ENTER-EXITO) or with intermediate points (navigational aids (SNA), published points (REKRA) or randomly selected points (42°39’26” N, 23°22’42” E)).

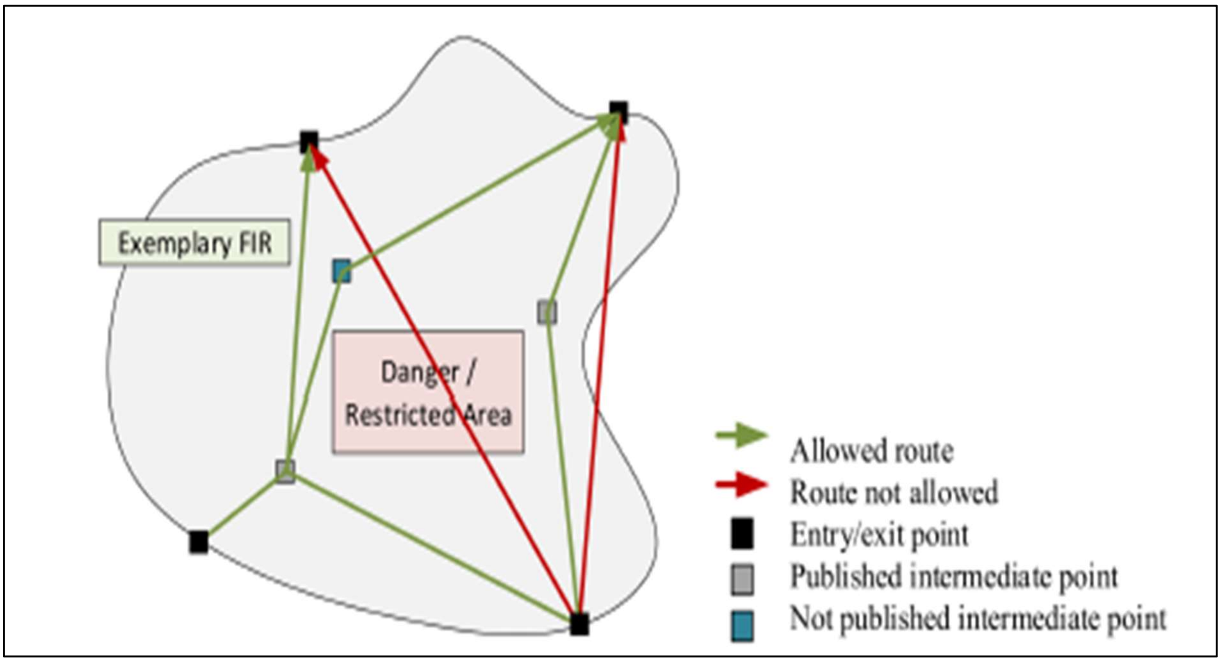


Figure 3-2: Exemplary FIR with allowed and not allowed routes indication.

Free route airspace allows airspace users to fly an efficient preferred trajectory between a defined entry and exit point (and potentially via intermediate waypoints, if desired), subject to air traffic control, rather than fly existing fixed ATS-Routes with the result to provide operational, environmental, and financial benefits for airspace users.

Free Route Airspace provides an unmatched performance in terms of flight trajectory efficiency through cooperative air traffic management.

➢ ***Considerations to analyses before the B1-FRTO implementation.***

a) Publication of the 'Free Route Airspace Concept, Requirements and Restrictions' in the State AIP. An example of State AIP

b) Trial period can be considered for evaluation.

c) Consider/integrate military requirements from the beginning, but also convince the military to benefit of the use of Free Route Airspace

d) Defining the 'Area of Applicability' and its lateral dimensions

e) Safety is addressed with focus on human aspects.

f) Validate that the involved ATM systems can process FPLs with LAT/LONG WPT's in FIRs boundaries not predefined on the databases.

g) Defining the segment length restrictions of Free Route Airspace segments

h) Trajectories shall not be planned closer than xx NM (to be defined) to the Free Route Airspace lateral border.

i) Compulsory Connecting Routes for main departure/arrival flows (marginal flows connect via any Arrival/Departure points) within the Free Route Airspace dimension to reduce complexity. High density segregated departure and arrival routes may require PBN capabilities.

j) Generally, flights may not be planned through active Prohibited-, Restricted- and/or Danger-Areas. Intermediate points can be used to avoid the active areas.

k) Where designated, the existing ATS route network within the 'Free Route Airspace Area of Applicability' may remain initially and in parallel during a transition period, but the ultimate goal shall be to remove the fixed ATS-Route network in its entirety in the designated area.

l) Cooperate with neighboring/adjacent Free Route Airspaces: The larger the Free Route Airspace area – the larger the benefits.

m) A SWIM Concept sharing dynamic ATM information enhances the establishment of Free Route Airspace

Figure 3-3: main principles of FRA.

3.3.1.3 Terms and description pointof the free route airspace:

As we said previously, the FRA is a generic term used to express the operation of a flight within established free-route airspace, in accordance with clear-route airspace procedures and without reference to the network of fixed ATS routes, if available, it is mains description points are:**[8]**

- **FRA (A):** is a published significant point to which FRA operations are permitted for arriving traffic to specific aerodromes.

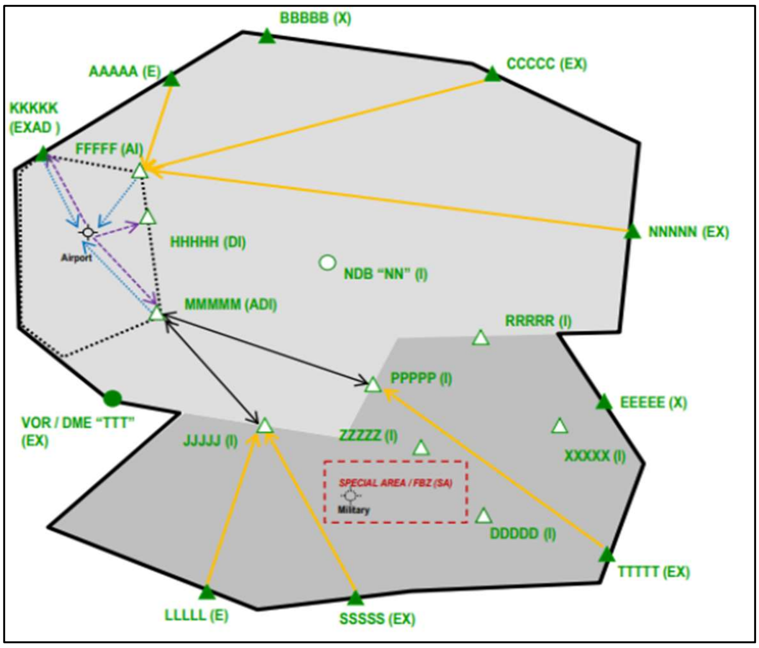


Figure 3-4 : FRA arrival point(A)

- **FRA Departure Point (D):** is a published significant point from which FRA operations are authorized for traffic from specific aerodromes.

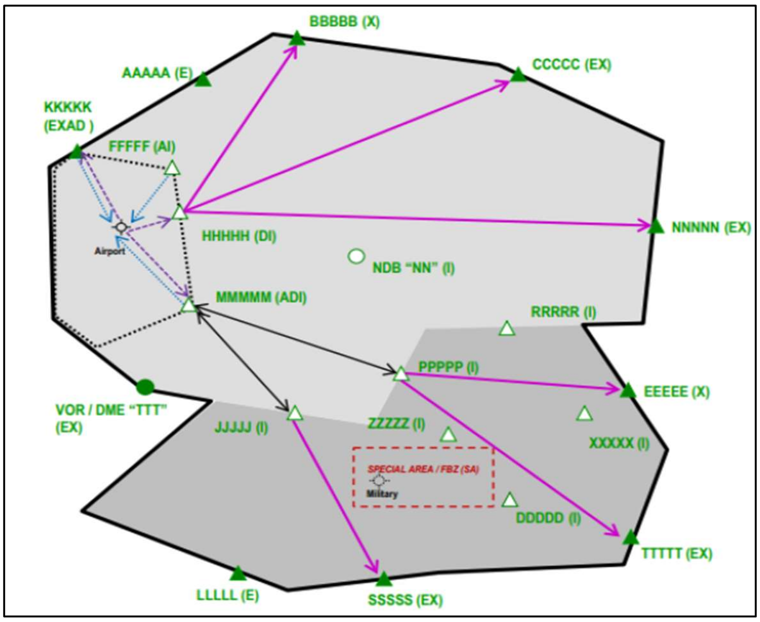


Figure 3-5 : FRA departure point (D)

- **Intermediate point FRA (I):** is a published significant point or an unpublished point, defined by geographical coordinates or by a bearing and distance, through which FRA operations are authorized.

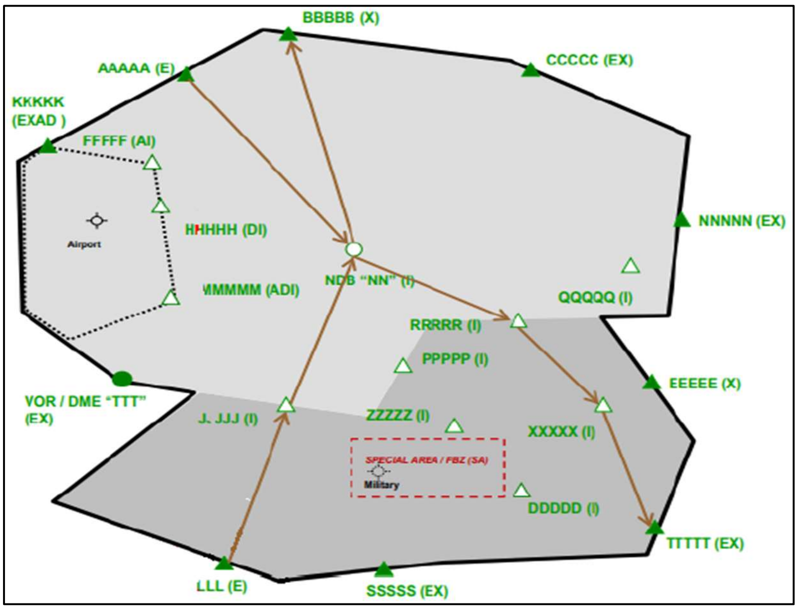


Figure 3-6: FRA intermediate point (I)

- **Horizontal FRA (E):** is a published significant point on the horizontal airspace boundary of the clear route from which FRA operations are authorized.
- **Horizontal Exit Point FRA (X):** is a published significant point on the horizontal airspace boundary of the free route to which FRA operations are authorized.

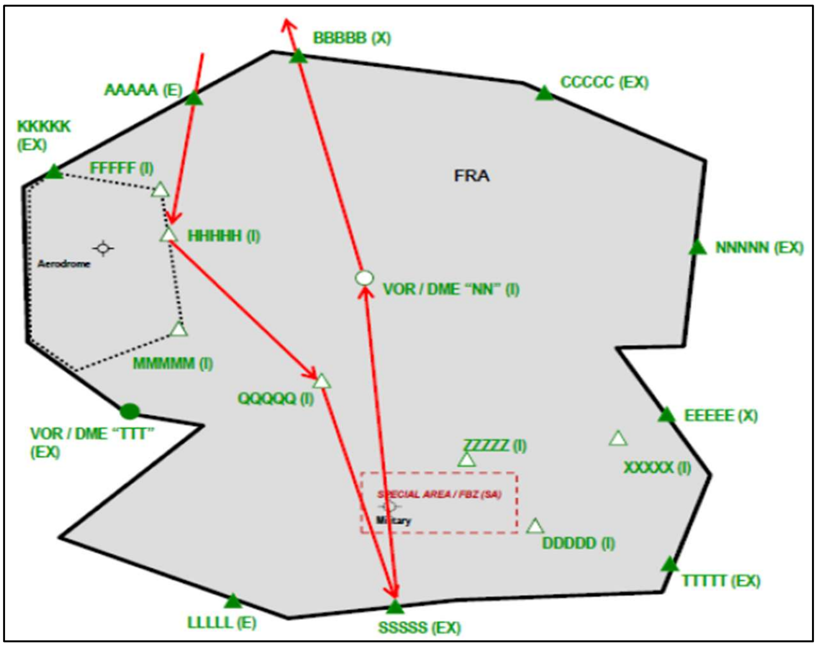


Figure 3-7: FRA entering (E)/exit (X) points.

3.3.1.4 Limits of FRA and Their Publication:

- **Horizontal Limits of FRA and Their Publication**

The horizontal limits of the FRA shall be published in national AIS publications. In order to gain full benefits from its applicability, the horizontal limits shall be preferably based on operational requirements, not necessarily on FIR/UIR or ATC unit AoR boundaries.

- FRA Horizontal Entry/Exit points into/out of the FRA shall be published in national AIS publications with a clear reference to the FRA and to the nature of the point (Entry, Exit or Entry/Exit point). **[10]**

- FRA Horizontal Entry/Exit points into/out of FRA shall take into account adjacent airspace where FRA is not implemented. FRA Horizontal Entry/Exit points will be defined to allow for a structured transition between the two operational environments, this may not necessarily be at the FIR/UIR or ATC unit AoR boundary. **[10]**

- **Vertical Limits of FRA and Their Publication**

This FRA Concept is aimed at facilitating the harmonized implementation of FRA wherever and whenever a State/FAB/ANSP decides to do so. In this context, there is no specific recommendation on the minimum FL of such implementation. **[10]**

- The vertical limits of the FRA shall be published in national AIS publications.

- The setting of the lower limit of FRA shall not adversely impact adjacent areas where FRA is not yet implemented or where only limited application of FRA is in place.

many recommendations being made to harmonize the airspace structure across the European network, which are:

a) The lower vertical limit shall be coordinated at European network level to ensure interconnectivity with adjoining airspace, and this could vary in different areas or at different times within a particular FRA.

b) The minimum level should be the lowest.

3.3.1.5 Benefits:

FRA is a way of overcoming the aviation sector's efficiency, capacity, and environmental problems by helping to reduce fuel consumption and emissions, while improving flight efficiency. At the same time, it paves the way for further enhanced airspace design and ATM operational concepts.

With free route airspace projects now in place across more than three quarters of European airspace, the region's flight efficiency targets are within grasp. Route extension - the difference between the flight flown and the corresponding portion of the great circle distance – due to airspace design went down **from 3.58% in December 2007 to 2.00% in December 2021**, thanks in part to initiatives like free route airspace and despite significant disruption in the network.**[11]**

FRA is a key landmark in achieving free routing across European airspace on the route to SESAR's business trajectories and 4D profiles. It will make it possible to meet the demands of future airspace users over the next 50 years, including civil and military unmanned aircraft systems (UASs), supersonic and hypersonic transport, spaceplane operations to sub-orbit and orbit, high altitude pseudo satellite (HAPS) platforms, plus balloons and airships.**[11]**

3.3.1.6 We can recapitulate what we said previously in these points:

a) Improved predictability through the "File it – Fly it" concept.

b) Elimination of constrains caused by the fixed ATS-route network structure; congestion points will disappear. Freedom (even if gently limited in practice) of route selection,

c) No change shall be required to existing ATC procedures.

d) Using the entire airspace (effective use of airspace) as a 'resource' – traditional 'unused airspace' is made available to either civil or military users (through flexible and optimal use), less conflicts, as an effect of aircrafts spread over bigger area.

e) Enhanced planning flexibility for operators

f) Reduction in CO_2 (and other gases) emission and fuel waste, as a consequence of reduced flight time. We call it air quality consideration.

g) reduced flight time, as an effect of choosing the shortest routes possible, and delay reduction

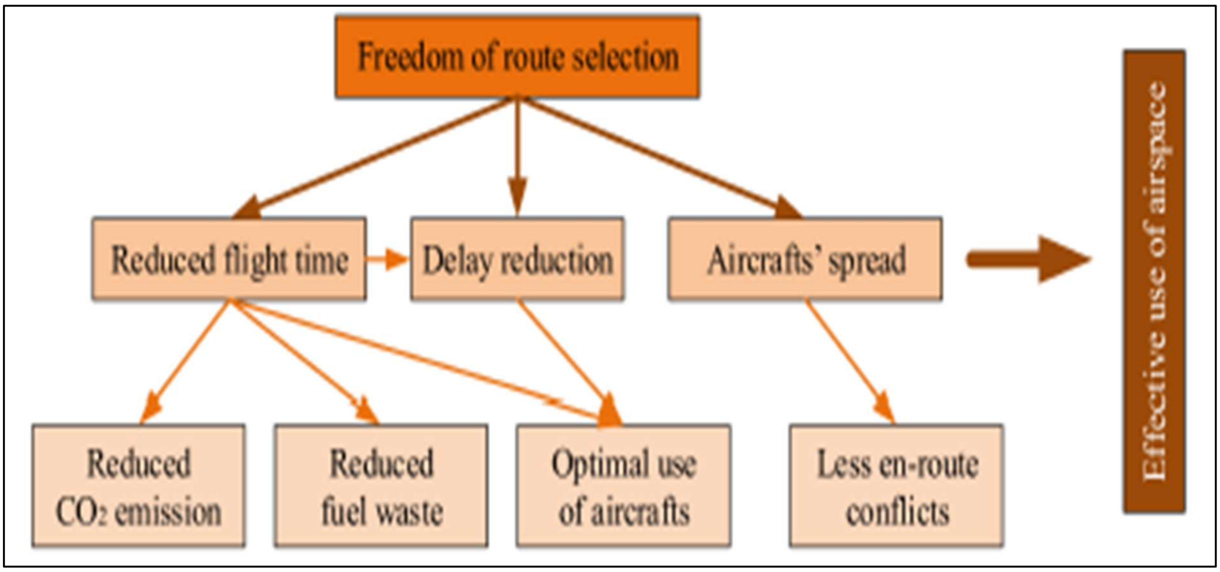


Figure 3-8: benefits of FRA implantation.

3.3.1.7 For airspace users:

The move from routes to free route airspace availability offers significant opportunities to airspace users.**[13]**

Once fully implemented at European level, these improvements should allow the following savings, compared with the current situation:

Figure 3-9: the current situation in Europe.

3.3.1.8 For air navigation service providers:

Operating an FRA environment offers improved traffic predictability thanks to more stable trajectories. At the same time, it enhances the use of conflict detection tools. The FRA concept can lead to a better spread of conflicts compared with the concentration of conflicts generated by the former fixed ATS route network.

- All air traffic controllers (ATCOs) working with free route airspace are adamant that they do not want to go back to a fixed ATS route network. Previously, aircraft received tactical directs from controllers to shorten their route, but there was no logical correlation between the fixed ATS route network and how the aircraft actually flew. Free route airspace offers airspace users the ability to fly directly according to their filed flight plan route while ensuring efficiencies in fuel planning, consumption, and costs.

3.3.1.9 The challenges:

FIRs as the bigger the airspace with free route selection the bigger the benefits of its implementation.

As any new technology and procedure in aviation, FRA poses a number of challenges to the users. These do not outweigh the benefits but need to be addressed properly in order to gain the best of FRA. Such issues and challenges are:

1) **Increased Conflicts:** The spread and increased number of possible conflicting points could make it harder for air traffic controllers (ATCs) to detect and manage conflicts effectively. With more aircraft following diverse routes, conflicts may occur more frequently.

2) **Changes in Separation Methods:** Traditional separation provision methods, like vectoring aircraft for conflict resolution, may become less effective since most aircraft will already be on the most direct route available.

3) **Vectoring Challenges:** Instructing flight crews to resume their own navigation after vectoring may pose challenges, especially when they have planned their routes using geographical coordinates.

4) **Vigilance during Transfer:** Controllers need to be even more vigilant during the transfer/acceptance of control, particularly when conflicts arise shortly after entering an ATC sector.

5) **Coordinated Approach:** A coordinated approach to FRA implementation is essential to ensure efficiency benefits are realized over large areas and to prevent aerodromes from becoming bottlenecks.

6) **Cross-Border Coordination:** If FRA extends beyond state borders, there is a need for enhanced coordination between Air Navigation Service Providers (ANSPs) to manage airspace efficiently.

7) **Odd/Even Level Assignments:** Traditional rules for assigning odd and even levels may not align with FRA routes, potentially causing confusion.

8) **Sector Boundary Considerations:** Aircraft flying along sector boundaries may face an increased risk of loss of separation if they deviate from their planned routes, such as due to weather.

9) **Special Use Areas:** Aircraft flying near special use areas (e.g., danger areas) without built-in safety buffers may require special attention to avoid conflicts.

10) **Sectorization Optimization:** Optimizing sectorization to accommodate new traffic flows can be challenging, especially when FRA implementation is time limited.

11) **Risk of Blind Spots:** The absence of fixed routes could lead to blind spots within ATC sectors and near borders, requiring careful monitoring and management.

12) **Safety Assurance:** Maintaining a high level of safety in air transport is paramount. Implementing new ATM functionalities like FRA should not compromise safety.

13) **Conflict Detection:** Efficient en-route conflict detection mechanisms must be in place to address potential conflicts, especially in areas close to FRA arrival and departure points.

14) **ATC Workload:** Controllers may face increased workload and complexity as they adapt to managing traffic in an FRA environment.

15) **Compatibility and Cooperation:** Ensuring compatibility between ATC sectors and other ATM functionalities, as well as fostering cooperation between neighboring countries, is crucial for the successful implementation of FRA.

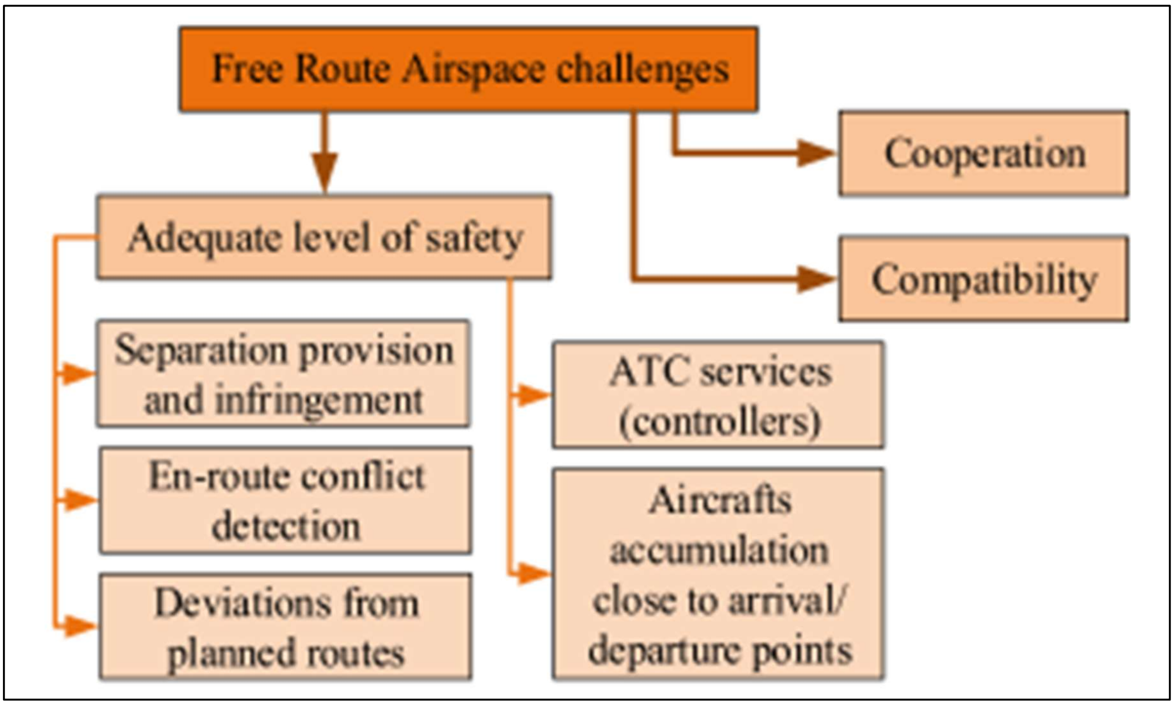


Figure 3-10: challenges of FRA implantation.

3.3.1.10 Strategy for introducing the Free Route Airspace:

A concept of operations for application of Free Route Airspace in the Region should be developed or incorporated into the regional PBN Concept of Operations. In this last case, the name of the document itself should be changed to reflect the need of Optimization of the Airspace and PBN would be "only" one of the available tools to concrete this objective.

It is important to note that the present PBN Concept of Operations for the Airspace in some way presents the need of implementing Free Route Airspace. However, it still addresses the use of fixed routes based on PBN as a main strategy for the optimization of en-route phase of flight. A full amendment of the PBN CONOPS should be made.

Taking into consideration that the en-route operations implementation is being carried out by the ANI/WG Performance-Based Navigation (PBN) Implementation Task Force Meeting, the name of these meetings should be changed to reflect the new method of implementing an En-Route Optimization based different strategies being one of them free routing.

3.3.1.11 What does not change if FRA is established?

It is important to understand:

- The same space classes and therefore the ATC service rendered (control, information, alert) and then the same way to make the control service.
- The sharing of ground and shore responsibilities remains the same:
- respect of clearances by the pilot: it is not because it is a space FREE ROUTE the pilot will do what he wants as he wants.
- Respect flight plan: there are exactly the same restrictions as in a normal space the difference is that in space FREE ROUTE the rules and possibilities of route planning are wider but once the route planning is done and the program deposit is done, there are the same obligations as the classic space.

It is not changing the way to control it is simply to provide more opportunities for live planning, in other words it is the planning aspect.**[12]**

3.3.1.12 What does not necessarily change if FRA is started:

- Centre Boundaries (ACC)
- The area limits.
- Entry and exit points.
- The orientation of flows**[12]**

3.3.1.13 Maximizing Efficiency of FRA:

To maximize the efficiency of FRA and to ensure safe and efficient transfer of flights, all efforts need to be made to ensure any required realignment of the fixed ATS route network in adjacent airspace not applying FRA.

Wherever a fixed ATS route network will remain in operation below the FRA, this underlying ATS route network shall be refined and coordinated at network level to take into account the needs of FRA operations in the airspace above.

- **Access To/From Terminal Airspace**

Access to/from Terminal Airspace and connection to/from specific aerodromes will need to be considered and appropriate refinements to TMA structures initiated, including the definition of additional SIDs/STARs to permit more flexibility.

The definition of FRA connecting routes to facilitate flight planning for departing/arriving traffic might also be required. This could have implications for the management of Terminal airspace.

3.3.1.14 Airspace Reservations:

In the context of FRA Concept, "airspace reservation" refers to airspace of defined dimensions for the exclusive use of specific users, including TRA, TSA, CBA, D/R/P areas and any specially activated areas. These are special designed areas within which both civil and military activities could take place.

Airspace reservations are permanently active (such as prohibited areas) while others are active for varying periods of time and at varying levels. (e.g., TSA and similar exercise areas). Active airspace reservations are crossed or avoided depending on the degree of coordination (including civil/military coordination) and the status of the activity in the area. This will remain the case in FRA.

There is a potential for airspace reservations to be reconfigured to meet different task needs.

In areas where coordination procedures (including civil/military coordination procedures) and airspace conditions permit, the airspace users are permitted to flight plan routings through airspace reservations.

In some cases, tactical rerouting will be given if airspace is not available for crossing. The expected maximum additional length of a tactical rerouting shall be promulgated through national AIS publications.

In other cases, when such airspace is not available for crossing, FRA Intermediate points will be defined to facilitate flight planning clear of the airspace reservation and ensure sufficient separation from the activity. The promulgation of these FRA Intermediate points shall be ensured through the national AIS publication. If these points are to be used only for avoidance of airspace reservations, specific conditions for the use of these points for flight planning shall be provided in the Route Availability Document (RAD). An overall standardization of the separation from airspace reservations will be required, in the longer term, especially for cross-border operations.

Publication of activation time of airspace reservations should be considered.

Note: The possibility of using geographical coordinates should be considered.

Procedures shall be developed between the Network Manager Operations Centre (NMOC) and all interested parties to ensure a harmonized application of procedures for the avoidance of airspace reservations.

3.3.1.15 Sectorization:

The present sectorization scheme may need to be restructured to accommodate traffic flows both within FRA and according to the underlying fixed ATS route network. Instead of having regularized flows of traffic along the ATS route network crossing at recognized points, the traffic will potentially be spread across the whole of a sector.

Sector design will need to respond to this change and may need to be more flexible as traffic demand varies. The Free Route Airspace sectors should be:

- Unconstrained by FIR/UIR or State boundaries.
- Capable of being reconfigured to meet demand. A structured methodology where sectors are taken from a library of designs already known to the internal and external systems is likely in areas where there are significant fluctuations of traffic flow orientation. Changes to sector definition will need to be notified to the Network Manager Operations Centre (NMOC) and should be transparent to adjacent units.

Sector Design Criteria should, at least, take into account:

- the principaltraffic flows and orientation.
- minimizing short transits through sectors.
- minimizing sector and ACC re-entry.
- positions of airspace reservations.
- coherency with adjoining fixed ATS route network
- sectors and connecting ATS routes to SIDs/STARs.
- civil/military coordination aspects.

Sectors shall be aligned as far as possible so that the number of flights with short transit times is reduced to a minimum. If this is not feasible such traffic should be exempted from Network Manager traffic counts. Appropriate rules shall be set in this context.

More flexibility in defining a larger number of elementary sectors/airspace volumes and sector configurations will need to be explored. Sectors will need to be designed to minimize short transits and to avoid sector/ ATC unit re-entry of flights. Operationally designed, cross-border sectors may be needed where FRA is implemented in adjacent areas.

A more extensive application of cross-border sectors is likely to be required to reflect better variations of traffic patterns. Local FMPs will have to take a more proactive role in the selection of optimum sector configurations. Active sector configurations shall be dynamically communicated to the Network Manager Operations Centre (NMOC).

3.3.2 The Free Route concept:

3.3.2.1 Background of Navigation Evolution:

At the earlier stages of flying, pilots used visual markers to navigate from one point to another e.g., landmarks, rivers, mountains, and cities etc. Later, as a result of invention of navigational aids e.g., Non-Directional Beacon (NDB), VHF Omnidirectional Range (VOR) and Distance Measuring Equipment (DME) traditional navigation was improved. In modern times, a more accurate navigation systems have been made available to pilots e.g., satellite-based navigation systems such as Global Position Systems (GPS), with far much better accuracy. Equipped with both Flight Management System (FMS) on-board aircraft and satellite-based navigation system, pilots can now navigate through a user preferred route trajectory (UPR) without reference to ground systems under the performance-based navigation (PBN) criteria and within a level of precision that were not available before.

3.3.2.2 Definition of “Free Route”:

Free Route operations enable airspace users to fly as closely as possible to their preferred trajectory without being constrained by fixed airspace structures or fixed route networks. Free Route Airspace can be defined as an airspace within which users may freely plan a route from a defined entry point to a defined exit point (may require an intermediate waypoint) subject to airspace availability. In an FRA airspace, all fixed route networks can be removed. However, flights remain subject to air traffic control.

The direct routes are designed to be as short and efficient as possible, allowing aircraft to travel the distance between the two points as quickly as possible, while saving fuel and reducing greenhouse gas emissions

The term “Free Route” is a high-level title under which two different types of implementations can occur. Therefore, distinction is to be made between “Direct Routing

Operations" (DRO) and "Free Route airspace" (FRA) operations. It is envisaged that Direct Route Operations will precede the implementation of Free Route Airspace. DRO is just but a series of directs between certain waypoint and can be flight plannable (not tactical). DRO can also provide an opportunity for ANSPs to study, collect data and familiarize themselves with the concept of FRA.

3.3.2.3 Operation of direct routing/free routing:

1. Route planning: When planning flights, airlines and air navigation services look for routes that allow for direct routes where possible. These routes are selected based on distance between the two points, airspace configuration, operational restrictions, and weather considerations.
2. Flight Authorizations: Once the routes have been defined, airlines submit their flight plans to the civil aviation authorities to obtain the necessary authorizations. These plans include the details of the planned route, including the direct routes or route segments that are part of it.
3. Air Traffic Control: Once in flight, the aircraft follow routes approved by air traffic controllers. If conditions permit, controllers may allow pilots to follow direct routes or shortcuts during flight to improve efficiency.
4. Performance Based Navigation (PBN): Performance based navigation is a technology that allows aircraft to track precise and optimized trajectories, including direct routes, through the use of advanced navigation systems and information provided by air traffic control systems.
5. Constraints and adjustments: Although direct routes are desirable, not all flight paths can be direct due to various constraints, such as no-fly zones, military airspace, adverse weather conditions or operational restrictions. In these cases, aircraft must follow alternate routes or detours to avoid these constraints.

3.3.2.4 Fly over with the FREE ROUTE concept:

- **Cross-border FRA areas**

Cross-border FRA expansion might be achieved by:

a) A single FRA area, representing a merge of the airspaces of existing FRA area.

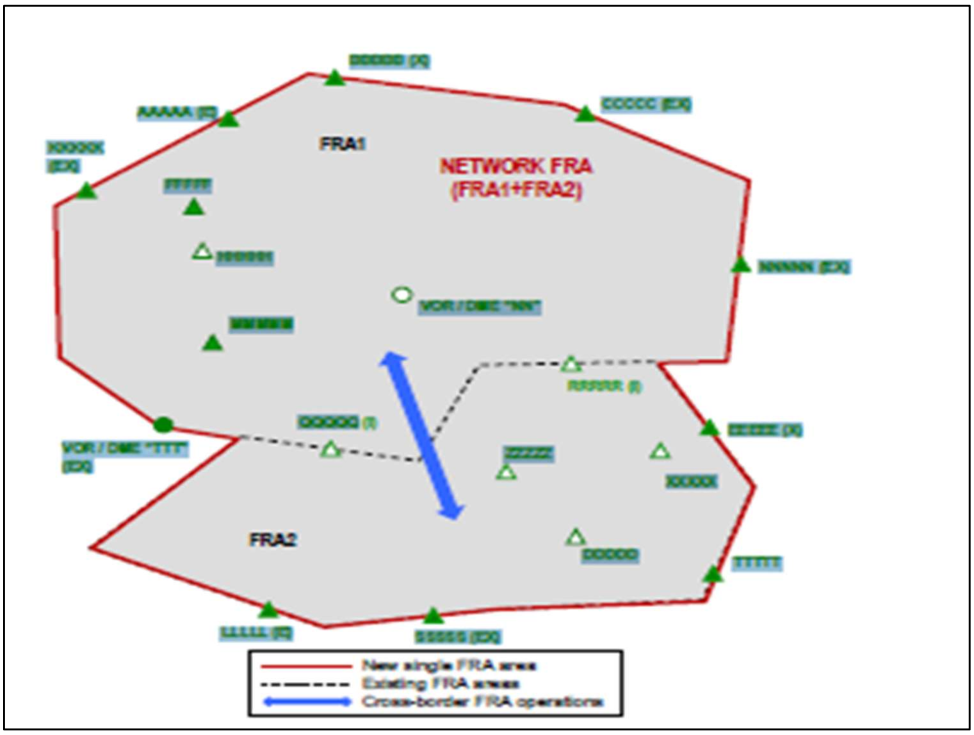


Figure 3-11: example of "cross border" FRA area/ single FRA area.

b) Multiple FRA areas (each as a single continuum), allowing cross-border FRA operations between them.

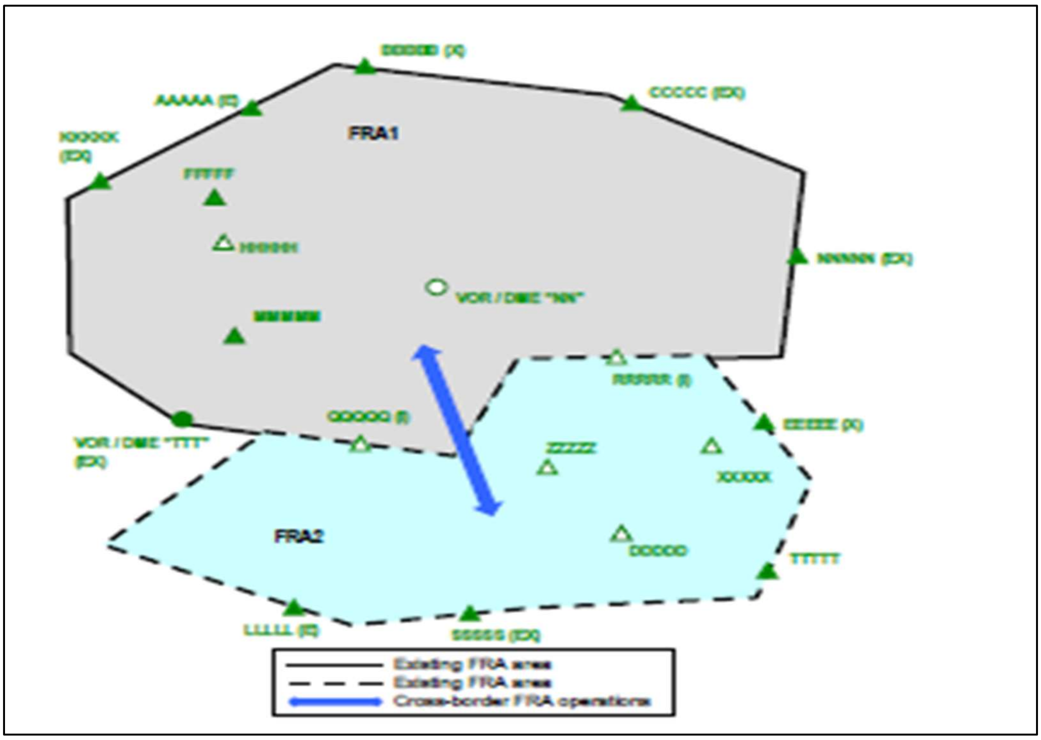


Figure 3-12: example of "cross border" FRA area/ MULTIPLE FRA areas.

- **between the limits of any FIR**

To plan live between the limits of any FIR, a number of direct trajectories over several hundred nautical that are authorized, point A at the entrance and point B at the exit and there is nothing in between, for it to work.

- accurately describe all trajectories authorized for planning.
- describe precisely which sector the aircraft will serve, and when the information must arrive on that sector.
- describe any intermediate benchmarks they may have even if not planned on the route.

That is to say, it is necessary to realize a complete description of all that concerns the route.

3.3.2.5 Creation of new points:

The FREE ROUTE concept can go as far as allowing the operator to create their own points with latitude and longitude that suits them to create the most optimal trajectory as it already exists in northern Europe where the density of air traffic is low, or the number of points published is low. At some places to have an optimal trajectory, the operator has no points since there was no crossing of routes historically existed, he does not find the ideal point to calculate to hang a change of level of cruise, so it creates points of the inflection of their route.

3.3.2.6 The degree of freedom:

The degree of freedomleft of space when we talk about free routing is not at all the same, it depends on the geographical interest and also the state of sophistication of the ATM systems and the tools given to the controllers to manage the traffic, between:

1.a very large and very little frequented space (ex-northern Europe or northern Norway) there are few constraints, so the degree of freedom is great.

2. A space with a high flight density (e.g., central Europe), the stress rate therefore increases the degree of freedom is small.

-Among the principles of FREE ROUTING is to try to optimize the complete use of space and flexible management of space; that is, we must try to make all the space usable as long as it is not reserved by the defense in the R zones, D, TSA, TRA.

3.3.2.7 Direct planning:

So, the need is to have the planning of the use by the defence which becomes mandatory what is to be implemented and it is almost finalized with an activity managed by national cd of space management and co-manage civilian/ military or:

- Defence needs are expressed.
- Negotiation spaces and sometimes priority rules.

The result of this planning is sent to the Euro control which acts J-1 17h loc (emission of the AUP) sends a European plan of the use of space with all the planning of the reserved spaces for the route.

The direct planning offered in the free route space is compatible with the maintenance of safety and capacity is part of the imperatives where we will not degrade neither safety nor capacity and according to that, not all direct planning is possible because there are some that would be difficult to ensure security, and others not necessarily problematic from a security point of view but that would degrade the capacity of the entire system. This is why some are prohibited at first but depending on the evolution of traffic and ATC systems, their future can be considered.

By definition when we have FREE ROUTE spaces, we do not say that we are not allowed to use or try to plan routes through active military zones for a fixed period, we simply say if:

- Are not planning ACTIVE, flight plan will be accepted.
- Are scheduled ACTIVE, the flight plan will be rejected, and re-planning must be done to avoid this active military area.
- Possibility of modification until h-4 for imperatives of technical problems or meteorological evolution.

And therefore, to block the planning by the civil planes only during the planned actual hours of activation of the zones.

3.3.2.8 Free route using “Direct Routing”:

- **Tactical phase 1**

Where States/ANSPs have implemented adequate ATM-CNS infrastructure, air traffic controllers are able to provide flights with direct routings between waypoints to reduce track miles or at times to reduce the complexity of traffic. These direct routes become ***tactical direct*** and therefore are not flight plannable. In order to provide benefits of such ATM-CNS infrastructure, these tactical directs should be available to flight dispatch so they can leave unnecessary fuel on the ground at departure aerodrome. Tactical directs are usually an indication of States/ANSPs readiness towards implementation of FRA.**[14]**

- **Flight plannable: phase 2**

Taking into consideration the existing airspace design, operational procedures, technologies, and Air Traffic Flow Management (ATFM); the maturity of Flexible Use of Airspace (FUA), Free Route operations implementation is possible. Through operationalization of predictable *"direct routings"* for all phases of flight e.g., in cruise, climb and descent; States/ANSPs can implement Direct Routing Operations.

DRO can be implemented across FIRs borders even in a highly complex environment, provided there is coordination with adjacent FIRs. DRO can be applied to a block of airspace or to an entire FIRs. The airspace defined therein can be referred as ***D**irect **R**oute **A**irspace.*

Direct Route Airspace (DRA). A DRA can be defined within an identified route or combination of route segments or a block of airspace or an entire FIR and takes into consideration traffic flows. Just like FRA, DRA could be implemented with limitations of time, flight levels or blocks of airspace.

3.3.2.9 Direct Routing Operations in a Direct Route Airspace

- **Airspace organization:**

Direct Routing airspace refers to an airspace defined laterally and vertically with a set of entry/exit conditions where direct routings are available. Direct Route Airspace is an extension of the concept of published en-route DCTs (Directs) across the FIR.

- **Vertical Limits of Direct Route Airspace (DRA) and publication**

Whenever a Direct Routing Airspace is established in a Flight Information Region (FIR), its vertical limits will be published in the relevant national AIS Publications. The upper and lower vertical limits will be coordinated with neighboring Flight Information Region (FIRs) to ensure smooth connectivity with the underlying fixed ATS route network.

- **Horizontal Limits of Direct Route Airspace and publication**

Whenever a Direct Routing Airspace is established, its horizontal limits will be published in the relevant national AIS Publications. In order to gain full benefits from its applicability, the horizontal limits should be preferably based on operational requirements, not necessarily on FIR/UIR or ATC unit boundaries.

- **Boundary limitations**

In order to gain full benefits from its applicability, the vertical and horizontal limits of Direct Route Operations should be based on operational requirements and not necessarily on FIR/UIR or Air Traffic Services (ATS) Unit boundaries.

- **Air traffic control**

Within direct route operations airspace, flights remain subject to Air Traffic Control (ATC). Pilots will adhere to the relevant publications for each State as stipulated in the relevant documents.

3.3.2.10 Direct -routing network:

A Direct Routing, by definition, is a succession of Direct Segments and ATS route segments.**[13]**

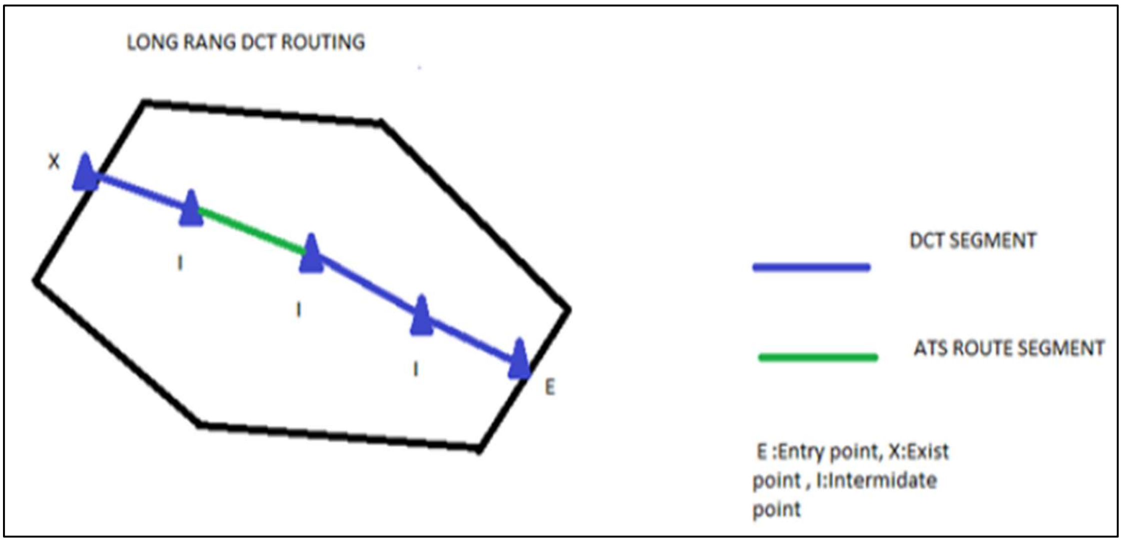


Figure 3-13: Long Rang Direct Rout.

With regard to optimum Direct Segment length from Flight Operation Centre/Aircraft perspectives, short direct segments will allow both efficient flight planning and safe flight monitoring during the execution phase.

As far as possible the fixed ATS route network will be maintained inside Direct Routing Airspace so as to provide more flight planning options to all airspace users.

Wherever a Direct Routing Airspace (DRA) is published (with or without a fixed ATS route network), entry and exit points of the Direct Routing Airspace, as well as any intermediate points of the Direct Routing Network, will be published in AIS publications.

The interconnectivity between Direct Routing Network and the underlying/adjacent fixed ATS route network can be ensured by the use of published points interfacing the Direct Segments of the Direct Routing Network to the fixed ATS route network.

Direct Segments defined within the Direct Routing Airspace can be used as per DRA vertical limit.

Wherever a Direct Routing Airspace is published (with or without a fixed ATS route network), its entry and exit points will be connected to the underlying and to the adjacent fixed ATS Route Network.

- **Direct routing efficiencies:**

Direct Routing in high complexity environments aims at offering Airspace Users an airspace volume where the network of Direct Routings is optimized enabling maximization of flexibility in flight planning. The significant number of Direct Routings is part of the environment complexity.

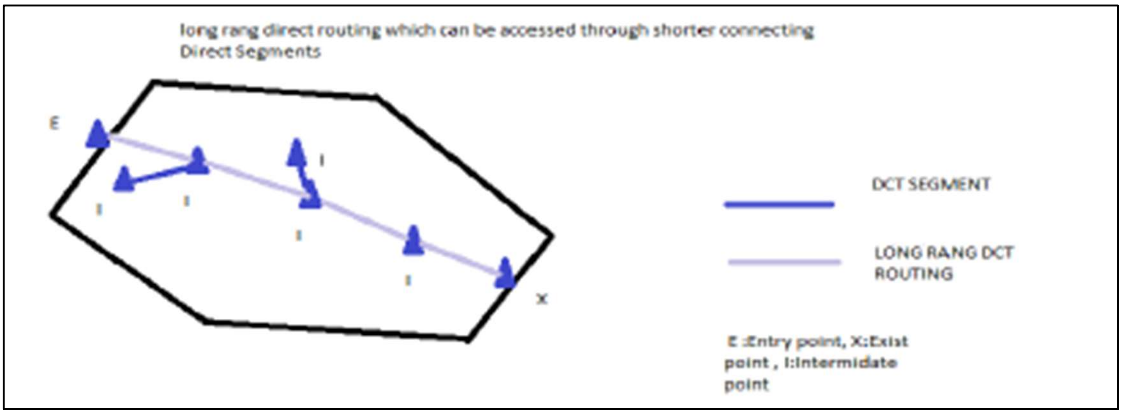


Figure 3-14: Long rang direct routing accessed by short direct segments.

In order to facilitate flight planning while allowing aircraft operators' flight planning flexibility, Long Range Direct Routings - i.e., large geographical scale cross-border Direct Routings structured along the main traffic flows and accommodating the in-demand traffic will be used to optimize the En-Route Direct Routing Network.

The efficiency of a Direct Routing Network will be maximized by a good access to Long Range Direct Routings which can be provided by shorter connecting Direct Segments and by the use of Intermediate points allowing for joining in or leaving the long-

RangeDirect Routings for any reason and/or at any time. The promulgation of these Intermediate points will be made through relevant national AIS publications with a clear indication of the nature of these points (i.e., intermediate points).

- **Free route through "direct routing" - Airspace Characteristics:**

- Airspace Classification: Free Route operations airspace will, in principle be classified as Class C airspace, with certain agreed exemptions.
- Flight Level Orientation: The Flight Level Orientation Scheme (FLOS) applicable within Free Route operations airspace will be promulgated through the relevant national AIS publications.
- Airspace Organization: Airspace reservations will remain.
- Concept and Civil/Military Coordination should be taken into account in order to ensure harmonized procedures and service provision for the benefit of all the airspace users.
- Publication and maintenance of ATS Route Network: Waypoints (5LNC) and possible fixed route network will be published in AIS publications.
- Sectorization: The present sectorization scheme may need to be restructured to accommodate traffic flows within FRA.
- Letters of Agreement (LoA) and Coordination Procedures: In case of cross border FRA, Letters of Agreement will be adapted to reflect the specificities of Free Route operations in regard to transfer points, links with the fixed route network, high fluctuations in traffic flows, possibility to leave/enter the airspace at random points, etc.

In case of cross border FRA, the automatic exchange of flight data between ACCs will need to consider the possibility of transfer at random points using dynamic Co-ordination Point (COPs). This would be facilitated by exchange of FPL field 15 (via ATS Interfacility Data Communication (AIDC) or On-Line Data Interchange (OLDI).

In case of cross border FRA, Transfer procedures and restrictions currently stipulated in the existing Letters of Agreement may no longer be applicable in airspace allowing for Free Route operations. Appropriate procedures will be defined to reflect these new provisions. **[15}**

- ATS delegation: In areas where operational boundaries do not coincide with FIR/UIR boundaries, and delegation of ATS is effective, if one ATC unit has implemented Free Route Airspace but the adjacent one has not, the operational boundaries of Free Route Airspace will be published in the national AIS publications of both States. The Letters of Agreement between the concerned ATS units will be amended accordingly to reflect any changes to the applicable procedures in the airspace where ATS is delegated.

3.3.2.11 The operational needs to support safe and efficient Direct Routing operations:

- **Aircraft capabilities:**

1) communication:

- Technical capability, both in pre-departure and during execution, to receive by ACARS from FOC and easily load in airborne Navigation functions 3D trajectories based on published routes (SIDs, Airways, STARs).
- Progressive capabilities for Air / ground data link exchange of CPDLC messages.

2) Navigation: Basic navigation capabilities to manually modify, delete, add route segments of waypoints in the FMS (Flight Management System)
3) Surveillance: ACAS Resolution Advisory transmitted to the ground station via e.g., Mode S Transponder and ADS-B-Out as per standards DO260/260A.
4) Airborne Safety net: Airborne Safety Net, i.e., ACAS II 7.1.

- **ATS capabilities:**

Free Route operations will impact the current working methods of the ATC operators, so it requires appropriate support tools to maintain sector capacity without a detrimental effect on safety. A variety of controller support tools should be considered such as:

a) Ground-based Safety nets: Ground-based safety nets will be of prime importance in complex Direct Routing Airspace as the last ATC barriers against collision / airspace infringement hazards.
b) Short-Term Conflict Alert (STCA) is a ground-based safety net intended to assist the controller in preventing collision between aircraft by generating, in a timely manner, an alert of a potential or actual infringement of separation minima. STCA parameters setting might require being adapted in order to better fit this purpose in Free Route environment.
c) Area Proximity Warning (APW) is a ground-based safety net intended to warn the controller about unauthorized penetration of an airspace volume by generating, in a

timely manner, an alert of a potential or actual infringement of the required spacing to that airspace volume, which require attention/action.

d) Conflict Detection and Resolution (CD/R) Tools to provide automated assistance to the Planning Controllers (PC), as well as Tactical Controllers (TC).

e) Monitoring Aids (MONA) to help controllers to reduce the workload associated with traffic monitoring tasks by providing warnings if aircraft deviate from a clearance or plan and reminders of instructions to be issued and providing conformance monitoring triggering trajectory re-calculation essential for the CDT.

f) System supported co-ordination (SYSCO): The concept of SYSCO is the provision of system support capability and the development of procedures to automatically electronically co-ordinate and transfer flights in sectors of an ATS unit or between adjacent ATS units, based on a shared set of flight data.

3.3.2.12 Separation minima:

No change in En-Route separation minima (i.e.,Vertical, and horizontal separation minima based on ATS surveillance) is needed in relation to Free Route operations.

Separation minima between aircraft are expected to continue to be based on guidance, regulations, and factors used in today's environment (ICAO Doc 4444 Procedures for Air Traffic Management, especially Chapter 5, Differences from DOC 4444 standards (if any) are to publish in national AIPs,).

3.4 Potential benefits of adopting direct routes in optimizing traffic flow:

The adoption of direct routes which aim to provide the most efficient and streamlined paths between origin and destination points, have the potential to revolutionize how the aviation industry manages its airspace. While optimizing traffic flow is essential for any mode of transportation, it is especially critical in aviation due to the unique challenges posed by three-dimensional airspace and the complex web of air traffic; in the optimization of air traffic flow has many potential benefits for airlines, passengers, and the environment. The expected and potential benefits are:

1) Reduced flight times: Direct routes allow aircraft to fly the shortest route between departure and arrival points. This leads to a reduction in flight times, which can be beneficial for passengers by reducing the total travel time.

2) Fuel savings: Direct routes reduce the distance travelled by aircraft, resulting in lower fuel consumption. Airlines can achieve significant fuel savings, which can have a positive impact on their operational costs.
3) Reduced CO2 emissions: Less fuel burned also means a reduction in greenhouse gas emissions, especially carbon dioxide (CO2). The adoption of direct routes contributes to a more sustainable and environmentally friendly aviation.
4) Airspace Utilization Optimization: By using direct routes, air traffic controllers can optimize airspace utilization by avoiding complex trajectories and detours. This can reduce congestion in areas with high traffic density and improve the efficiency of traffic flow.
5) Reduced delays: Direct routes allow aircraft to follow more predictable and efficient routes. This can reduce delays related to unexpected detours or route changes.
6) Improved passenger experience: Reduced flight times and more efficient flights can improve the passenger experience by providing shorter, more direct journeys.
7) Better profitability for airlines: Fuel savings and reduced operational costs can improve airlines' profitability, which can have a positive impact on fares for travelers.
8) Operational flexibility: Direct routes can offer greater operational flexibility to airlines by allowing them to choose routes that are more adapted to the needs of the moment, such as avoiding bad weather zones.
9) Reduced noise emissions: By reducing flight time, direct routes can also contribute to reduced noise emissions from low-level aircraft movements near airports.

In short, the adoption of direct routes in the optimization of the air traffic flow can bring many benefits both economically and environmentally. This requires careful planning, coordination between stakeholders and the use of cutting-edge technologies to ensure the safety and efficiency of air traffic in this specific direction.

3.5 The reduction of flight distances, the improvement of flight times and the reduction of fuel consumption with the free route concept:

the use of direct routes is a key strategy for all three aspects: reducing flight distances, improving flight times, and reducing fuel consumption. In the coming years, it will become an essential element in optimizing flight routes and promoting environmental sustainability in the aviation industry:

3.5.1 Reduced flight distances:

Direct routes are designed to connect two geographical points in a straight line, allowing the shortest possible distance between these points. When direct routes are used, aircraft avoid complex trajectories and detours that would be required on less direct routes. As a result, this results in a significant reduction in the total distance travelled by aircraft between the departure and arrival points.

- Shortest Route: The direct routes follow the arc of the great circle, which is the shortest route between two points on the surface of the Earth. In aviation, this means that the aircraft follows the shortest possible trajectory between the departure airport and the destination airport.
- Minimization of distance: By following this direct path, the aircraft travels a minimum distance to reach its destination. This reduces the total length of the flight compared to a route that might require more detours or turns to avoid certain areas.
- Fuel Savings: Reduced distance travelled results in significant fuel savings. Less fuel is needed to travel the same distance, which reduces operating costs for the airline.
- Reduced greenhouse gas emissions: Less fuel burned also means less greenhouse gas emissions, especially carbon dioxide (CO_2). This helps reduce the carbon footprint of each flight, which is increasingly important as environmental concerns increase.
- Reduced flight time: Travelling a shorter distance also reduces flight time. This can be beneficial for airlines in terms of aircraft productivity and scheduling.
- Improved operational efficiency: Direct routes contribute to airlines' overall operational efficiency by reducing fuel costs and enabling more efficient use of resources, such as crews and aircraft.
- Flight Plan Optimization: Modern flight planning systems use sophisticated algorithms to automatically calculate direct routes based on various factors such as weather conditions, airspace restrictions, operational costs, and aircraft performance. This ensures that optimal routes are used whenever possible.

3.5.2 Improved flight times:

Reducing flight distances naturally leads to improved flight times. By following a direct trajectory, aircraft take less time to travel the distance between the departure and arrival points. This translates into shorter flights, which can be beneficial for passengers by reducing the total travel time.

- Shorter distance: Direct routes are the shortest routes between two points on the Earth's surface. Using these routes, aircraft travel a minimum distance between the departure airport and the destination airport. This automatically reduces the total flight time, as the aircraft takes less time to travel a shorter distance.
- Constant Speed: Airliners generally fly at a constant cruising speed at altitude. By following a direct route, the aircraft can maintain this speed for longer without having to make frequent course changes or adapt to complex trajectories. This reduces the time spent flying.
- Avoidance of unnecessary detours: When a flight follows a direct route, it generally avoids unnecessary detours caused by airspace restrictions, hazardous weather zones or other constraints. This helps to maintain a smoother and faster trajectory.
- Reduced in route delays: Direct routes also minimize time spent in route, which can reduce the risk of in-flight delays, such as air traffic delays or unforeseen weather delays. Direct flights provide a more predictable and efficient trajectory.
- Optimal flight planning: Airlines use sophisticated flight planning systems that automatically calculate the fastest routes based on current conditions. These systems take into account factors such as high-altitude winds to optimize flight duration.
- Improved punctuality: By reducing flight duration, direct routes can help improve flight punctuality, as it is easier to meet scheduled schedules when flight duration is reduced.
- Fuel savings: While the primary goal of direct routes is not necessarily to save fuel, flying a shorter distance reduces fuel consumption, which in turn can help to reach the destination faster.
- Network optimization: Airlines can regularly review their flight networks to identify opportunities to add direct connections or improve connectivity between airports.

- Coordination with aviation authorities: Operators must obtain approval from civil aviation authorities to use direct routes, which may require coordination with other aviation stakeholders.
- Use of technology: Modern aircraft are equipped with advanced navigation systems that accurately track direct routes. Pilots are trained to use them effectively.

3.5.3 Reduced fuel consumption:

By travelling shorter distances through direct routes, aircraft burn less fuel during flight. Fuel consumption is directly related to the distance travelled by the aircraft. By reducing the total distance travelled, airlines can achieve significant fuel savings.

- Shorter flight distance: When an aircraft follows a direct route between two points, it travels the shortest possible distance between those points. By avoiding detours or indirect routes, the total distance travelled is reduced. This reduction in distance is the first and most obvious way that flying overusing direct routes saves fuel.
- Less aerodynamic drag: Aerodynamic drag is the strength that air exerts on a moving aircraft. When an aircraft follows a direct route, it is more likely to fly at a constant altitude and optimum cruising speed. This minimizes aerodynamic drag, as the aircraft does not need to change altitude or speed frequently to adapt to detours or heading changes.
- Altitude Economy: Altitude changes are times when the aircraft must use more power to maintain its trajectory. When an aircraft follows a direct route, it is more able to maintain a constant altitude, which reduces fuel consumption. Climbs and descents are often necessary when an aircraft follows a route with many stages or detours, which increases fuel consumption.
- Less time spent in flight: Direct flights are shorter in terms of flight time, which means that the aircraft’s engines operate for a shorter period of time. Less time in flight results in reduced fuel consumption, as the engines run for less time.
- Weight savings: Aircraft generally carry enough fuel to cover the intended flight distance, plus a margin of safety. When detours or indirect routes are avoided, aircraft can carry less fuel, reducing the total weight of the aircraft. A lighter aircraft requires less power to maintain its trajectory, which helps save fuel.

Reducing fuel consumption has several advantages:

- Cost savings: Fuel consumption is one of the main operational costs for airlines. By reducing the amount of fuel used through direct routes, airlines can achieve significant financial savings.
- Reduced CO2 emissions: Less fuel burned also means a reduction in greenhouse gas emissions, especially carbon dioxide (CO2). The adoption of direct routes thus contributes to a more sustainable and environmentally friendly aviation.

3.6 Conclusion:

To conclude this chapter on the concept of direct routes, we can draw several essential lessons:

We examined FRA and FREE ROUTING what a direct route is in the context of air transport and its operation allowed us to understand in depth their importance in optimizing the flow of air traffic.

Direct routes allow aircraft to fly more efficiently by choosing the shortest path between two points, avoiding unnecessary detours. We also understood how modern navigation systems and coordination with air traffic controllers are essential to implement direct routes safely.

We explored the potential benefits that the adoption of direct routes can offer for optimizing the flow of air traffic. These benefits include improved airspace utilization, reduced flight times, reduced airport congestion, fuel economy, and an overall improvement in the efficiency of the air transportation system.

It has clarified the mechanisms by which benefits are realized. By reducing flight distance, direct routes reduce fuel consumption, improve flight times, and reduce the environmental impact of aviation.

In short, direct routes represent a major innovation in the field of civil aviation. They bring significant improvements in terms of operational efficiency, profitability for airlines, reducing the aviation industry’s carbon footprint, and improving the overall passenger experience. However, it is essential to recognize that the implementation of direct routes is not without its challenges, particularly with regard to coordination between aviation stakeholders, flight safety and the adaptation of air traffic control systems. In the following chapters, we will explore in more detail the implementation and operational considerations of these direct routes.

Chapter 4 :Optimization of Algerian airspace through the adoption of direct routes for west-east traffic flow

4.1 Introduction:

In our research, we utilized data from the year 2019, which serves as the benchmark year for air traffic control and aviation in general. During the period from 2006 to 2019, the global air traffic exhibited an average growth rate of 5.9%. This growth has been accompanied by shifts in global traffic flow patterns, influenced by factors such as interest rate fluctuations, changes in economic growth, and regional conflicts. This dynamic nature of air traffic necessitates the adaptation and development of air route networks to remain relevant. To achieve this, it is essential to embrace new concepts recommended by ICAO, such as PBN (Performance-Based Navigation) and Direct Routes (DCTs).

Enhancing an existing air route network entails the creation of new routes or modifications to existing ones with the following objectives in mind:

1) Meeting the demands of airspace users.
2) Attracting traffic flows by providing routes tailored to their requirements.
3) Ensuring a consistent flow of traffic by offering a higher quality of service.
4) Adapting to evolving traffic patterns.
5) Addressing issues related to air traffic management.
6) Complying with new navigation standards and environmental regulations.

With the goal of developing a new route within the Algiers FIR, our study aims to achieve the following objectives:

1. Reducing workload through strategic conflict resolution.
2. Increasing sector capacity.
3. Offering users, the most optimal routes possible.
4. Aligning with the national PBN plan.
5. Preserving existing traffic flows and actively seeking to attract additional traffic.

6. Contributing to environmental conservation by reducing greenhouse gas emissions.

4.2 Identification of Current Network Problems and Inefficiencies:

In order to enhance air transportation, it is crucial to closely examine the current functioning of the route network. This examination can identify areas of congestion, frequent delays, indirect routes, and other issues that can impact flights. Such analysis can pave the way for corrective measures to optimize routes, reduce flight times, and enhance aviation safety in Algeria. Among the most notable issues are the following:

- **Airspace Congestion:** The aviation sector has been experiencing constant growth since its inception. This growth particularly affects certain airspace regions more than others, such as Europe, America, or Asia, leading to significant congestion problems. These challenges push air traffic control services to their capacity limits, even leading to overload and saturation. Air congestion is a universal issue, especially for major airports and Regional Control Centers, resulting in a degradation of service quality and an increased risk of accidents. When supply does not match demand, it results in queues, causing delays and disruptions in the aviation system. Delays are a source of numerous complaints, especially from passengers, due to the time lost and its impact on their other activities.
- **Exceeding Air Sector Capacity:** Each air traffic control system has a capacity in terms of the number of aircraft it can handle per hour. When demand surpasses supply, not all flights can be accepted simultaneously, risking the sector's overcapacity. A control sector is a limited area in airspace, traversed by air routes, where a team of controllers ensures flight safety. The capacity of a control center is determined by its ability to handle air traffic with maximum safety and optimal regularity. The more aircraft in a sector, the higher the control workload. There is a limit beyond which the controller in charge of the sector cannot accept additional aircraft, leading to sector saturation.
- **Controller Workload:** For controllers, the concept of capacity in terms of hourly flow rate is insufficient. They perceive peak traffic as more significant than the average flow rate. For example, 25 aircraft per hour over a short period generate more stress than 55 aircraft per hour evenly distributed. Workload depends on factors such as the number of high-conflict situations, conflict complexity, evolving traffic, mixed traffic, close proximity of routes, the presence of military zones, and weather disturbances.

- **Infrastructure Capacity Limit:** In addition to control capacity limitations, there are constraints on the capacity of airport infrastructure. This is even more challenging to overcome due to the substantial investments required. An airport runway serves as a bottleneck where traffic concentrates, limiting its throughput by the number of available runways. Typically, only one aircraft at a time can take off or land on a runway, so the maximum throughput cannot exceed 40 movements per hour for a single runway. At Algiers Airport (Houari Boumediene, DAAG), for runway 23 (equipped with ILS) and during an "OA" holding procedure, the theoretical sequence is 6 minutes (the shortest sequence in Algeria), allowing for a maximum of 10 landings per hour, which may seem sufficient. However, in any case, congestion at Algiers can occur. Another factor contributing to insufficient capacity is the allocation of airspace to military flights. During the summer of 1999, due to the Kosovo war, airspace corridors were requisitioned in Southern Europe. This situation was largely responsible for significant delays observed in 1999.

- **Coordination Issues: Air traffic** control faces another problem - coordination between countries. The juxtaposition of around thirty administrations and security systems hampers the smooth flow of flights across multiple countries. The complexity of transitioning from one national system to other results in significant time losses.

- **Allocation of Routes and Flight Levels**: A common problem in transportation research is routing vehicles on a network. In the case of air traffic, this involves determining the routes, flight levels, and even take-off slots allocated to planned flights for a given day. This problem is addressed from a planning perspective, mainly in the pre-tactical ATFCM framework, a few days before take-off. The objective is to minimize potential conflicts to reduce controller workload. This problem aims to streamline flight plan submissions.

- **Dynamic Rerouting**: In cases of extreme and hazardous weather conditions or military activities preventing overflights of certain airspace areas, the dynamic rerouting problem involves finding a trajectory for an aircraft that avoids disturbance areas while minimizing additional fuel consumption. This issue is almost within the realm of real-time air traffic control.

- **Indirect Flight Routes:** Indirect flight routes refer to flight paths that do not follow the shortest path between two points. This can be due to various factors such as airspace restrictions, weather conditions, traffic constraints, or international navigation agreements. These indirect routes can result in longer and less efficient flights. The problem with indirect flight routes is that they can lead to longer and less fuel-efficient flights, resulting in higher costs for airlines and increased greenhouse gas emissions. Another issue related to indirect routes is that they can cause delays and discomfort for passengers, as flights may take longer than expected. Moreover, this can also lead to congestion at airports and increased air traffic.

- **Extended Flight Times:** Extended flight times refer to the increase in the duration of a flight due to various factors such as indirect routes, detours, delays, or adverse weather conditions. This can lead to more time spent in the air and potential delays in reaching the destination.

4.3 Impact of Current Network Problems on Safety and Flight Time:

The network inefficiencies mentioned above can impact flight time and safety (for operators and infrastructure) in several ways:

- **Effect on Airlines and Passengers:** Air congestion results in local overloads, causing delays in traffic flow through sectors, leading to economic and financial consequences, reduced productivity, and potential losses that can amount to billions of dollars globally for airlines, passengers, and society as a whole. Costs for airlines have two origins:

1) **Direct costs**, often borne directly by airlines, which may include compensating passengers and expenses related to their operations, especially at hubs that require flight rescheduling even after a single delay. Airlines also face long-term loss of competitiveness and potentially degraded working conditions for employees. These operational costs can be associated with primary or induced delays.

2) **Indirect costs,** such as those related to anticipating delays. Costs incurred by passengers are mainly associated with the fact that delays equate to lost time. The cost of delays for passengers is an opportunity cost measured by their time valuation.

Effect on Flight Safety: Regarding safety, network problems can lead to increased air traffic in certain areas, raising the risk of conflicts between aircraft. Moreover, network issues can also result in communication problems between pilots and air traffic controllers, compromising flight safety. Thus, it is crucial to promptly address network problems to ensure safe and efficient flights Congestion can increase the risk of collisions between aircraft on the tarmac or in airspace corridors. Additionally, indirect flight paths can lead to increased air traffic in certain areas, raising the risk of conflicts between aircraft. Therefore, effective congestion management and the promotion of direct flight paths are essential for ensuring flight safety.

- **Effect on Flight Time**: Concerning flight time, various issues can lead to:

1) Delays in take-off and landing, prolonging the total flight duration.

2) Increased flight time due to extended distances, causing inconvenience for passengers and airlines.

3) Delays and flight cancellations, resulting in route changes and detours, ultimately extending the total flight time.

- **Environmental impact:**

1) Increased energy consumption leads to higher pollutant emissions.

2) Noise pollution affects residentsnearairports.

- **OtherPotentialEffects:**

1) Lack of safety and the risk of accidents due to collisions.

2) Detours and extended waiting times due to congestion can lead to increased fuel consumption, resulting in a negative impact on the environment.

3) Additionalcosts for airlines.

4.4. The purpose and concept of the study:

The purpose of the study which will be presented in this chapter is the creation of a direct route (DCT)**WEST – EAST** almost parallel to the UA411, through the south **ORAN** or **MOS**, to optimize the airspace for a distance less than the ordinary until the exit of FIR this, strategically protected with MORJA by adopting the concept of direct routes (the key element of the FRA), Initially, the controllers' opinions were considered, drawing from the practices of the latter, which included route clearance and direct clearances (DCTs);
this optimization was done by progression.

- Best solution through this long research, it was the route DCT **ORSUP -DIAMO** since there is a forbidden zone that forced us to deviate our route to **ESNAM.**

- Otherwise:
  - The route DCT [ORSUP-DIAMO] has a lot of constraints regarding military zones.
  - The general aspect :

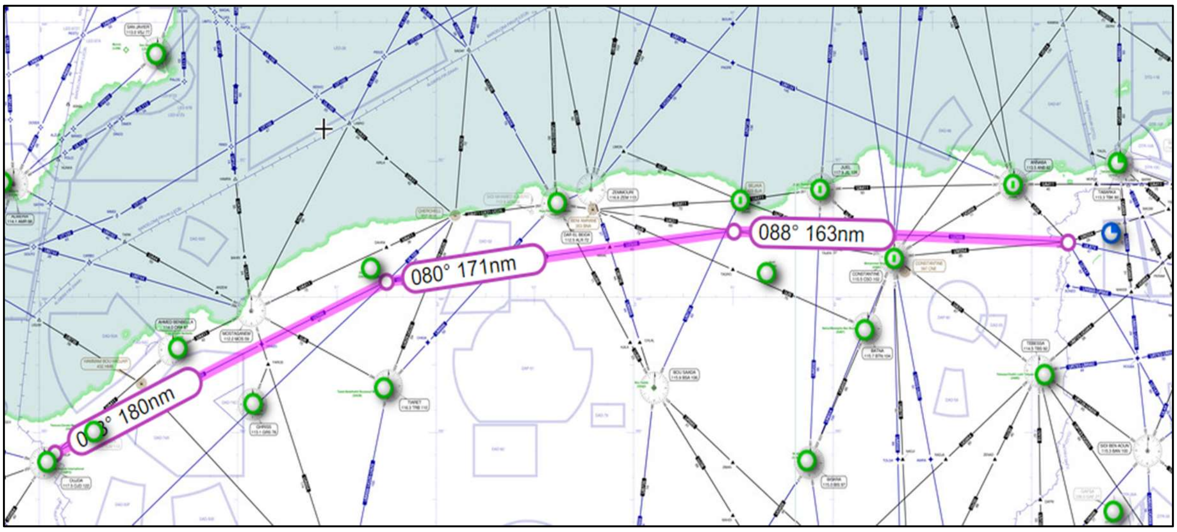


Figure 4-1: Route Routing (ORSUP-ESNAM-BABOR-DIMAO)

In accordance with appendix B citing exemples of airspace concepts based on the navigation specifications of ICAO 9613 (PBN Manual) in its 4th point En route continental airspace. It was decided that the spacing between two routes:

Conditions:

- The PBN principles adopted (RNAV 5) rectilinear bidirectional "The case of FIR Algiers".
- 18 NM compliance in a RADAR environment with the minimum for route separation.
- DCT acceptable, for the FREE ROUTING it is necessary to have the activation of the civil/military coordination in defined processes, reliable and effective.
- Implementation of the ATFM system linked with flight plans (but this is not the case in civilian/military coordination and eurocontrol, it can have 100% ATFM euro-control only in the case of civilian takeoffs only given the diplomatic precautionary measures).

At the beginning the proposed route is not reliable because of crossing of the route CHERCHELLE – TIARET.

The proposed direct route **ORSUP - ESNAM –BABOR- DIMAO** will provide a strategic lateral separation of 18NM with the UA411 until through CHE, in order to extend the latter to through ORA; we propose that the ESNAM connection be changed by a new point defined by the crossing of the line **BABOR - ESNAM** and the line **TRB - CHE** materialized by the PT3(see Figure No 1).

4.4.1. Creation of waypoints (amendment):

Amendment of the route according to some conditions

- We propose the creation of the following new waypoints.

➢ At the North-East and Central Boundary (PT1);

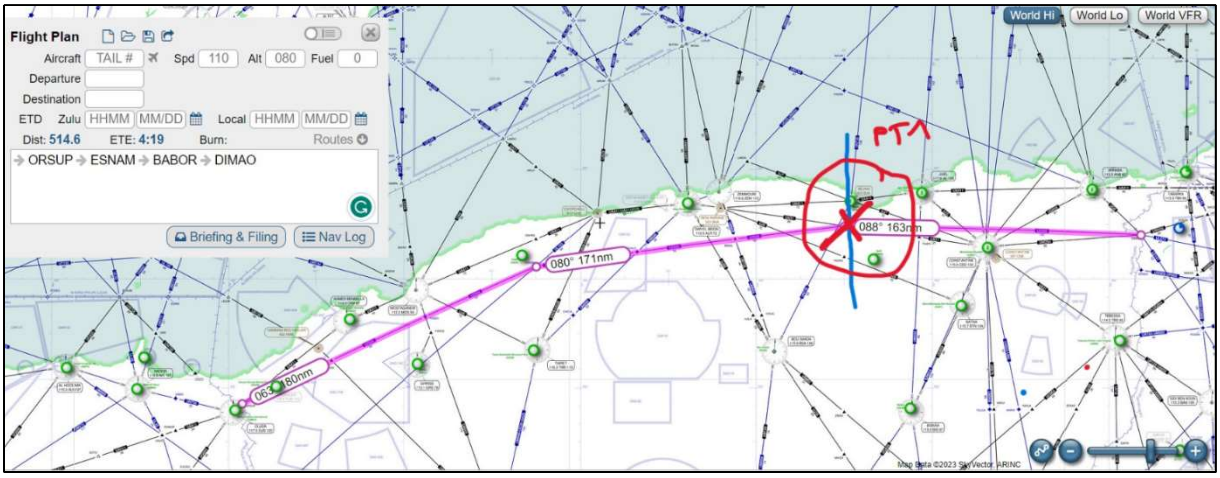


Figure 4-2: the intersection of the principale route with the North-East and Central Boundary

➢ At the intersection of Highway UB726 (PT2);

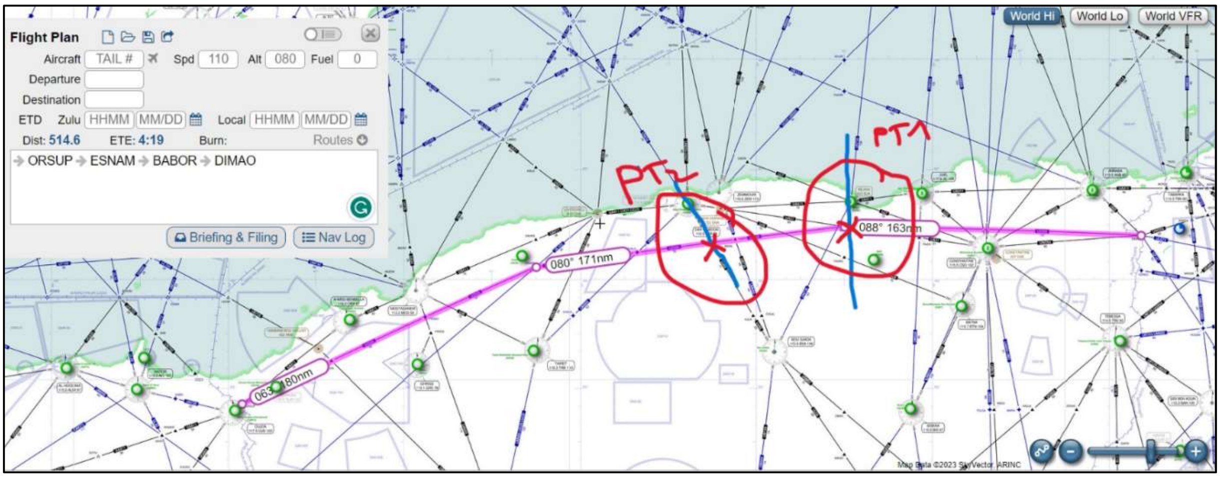


Figure 4-3: the intersection of the principal route with the route UB726.

- At the intersection of UM986 (PT3);

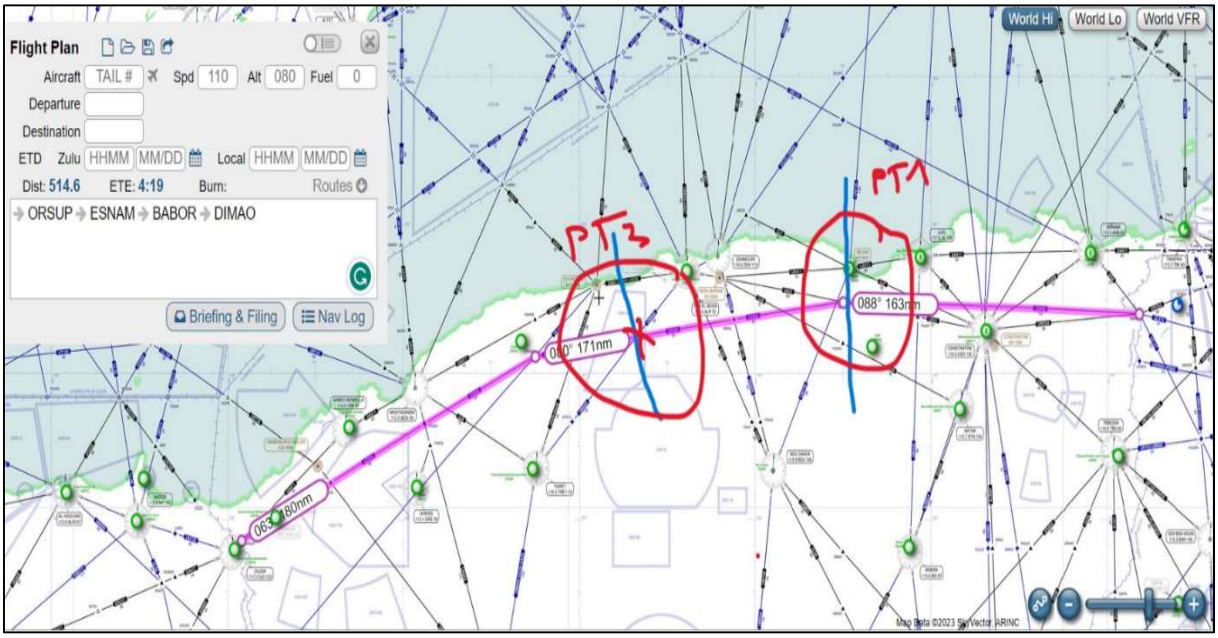


Figure 4-4: **the intersection of the principal route with the route UM986**

- At the Central and North-West Sector Boundary (PT4);

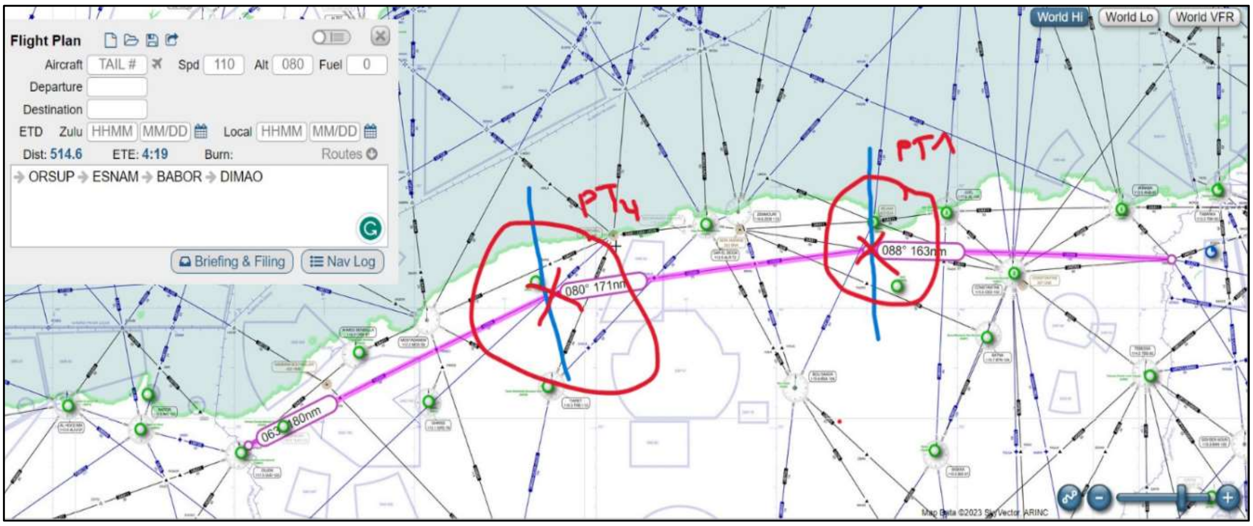


Figure 5-4: the intersection of the principal route with the North-West Sector Boundary

- At the intersection of UA604 (PT5);

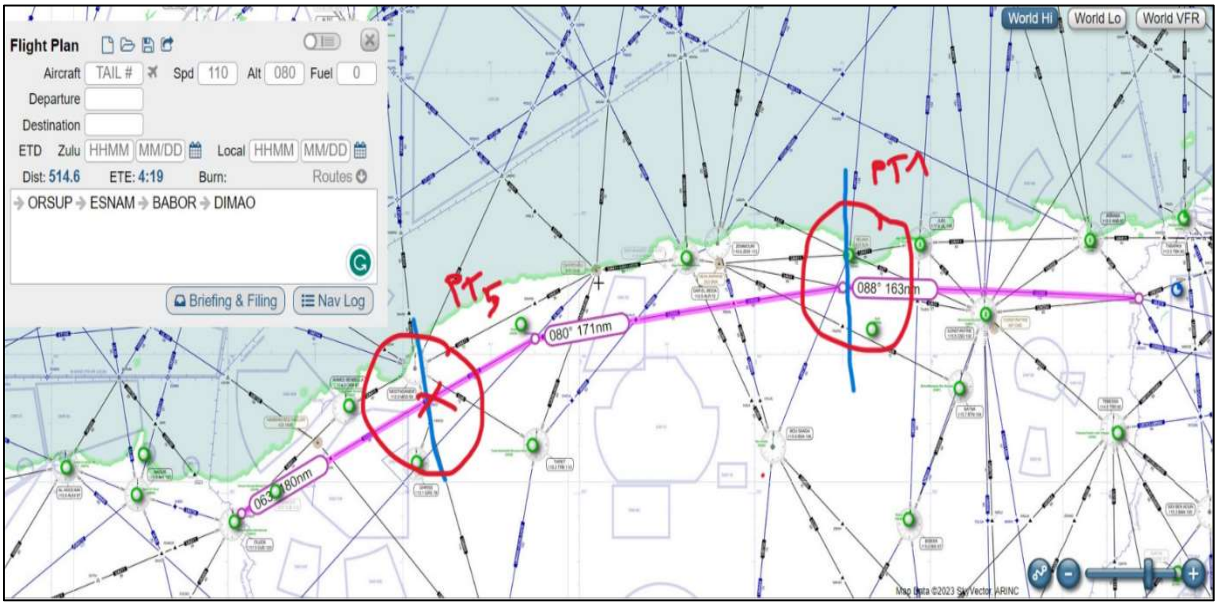


Figure 4-6: the intersection of the principal route with the route UA604

- At UB738 (PT6)

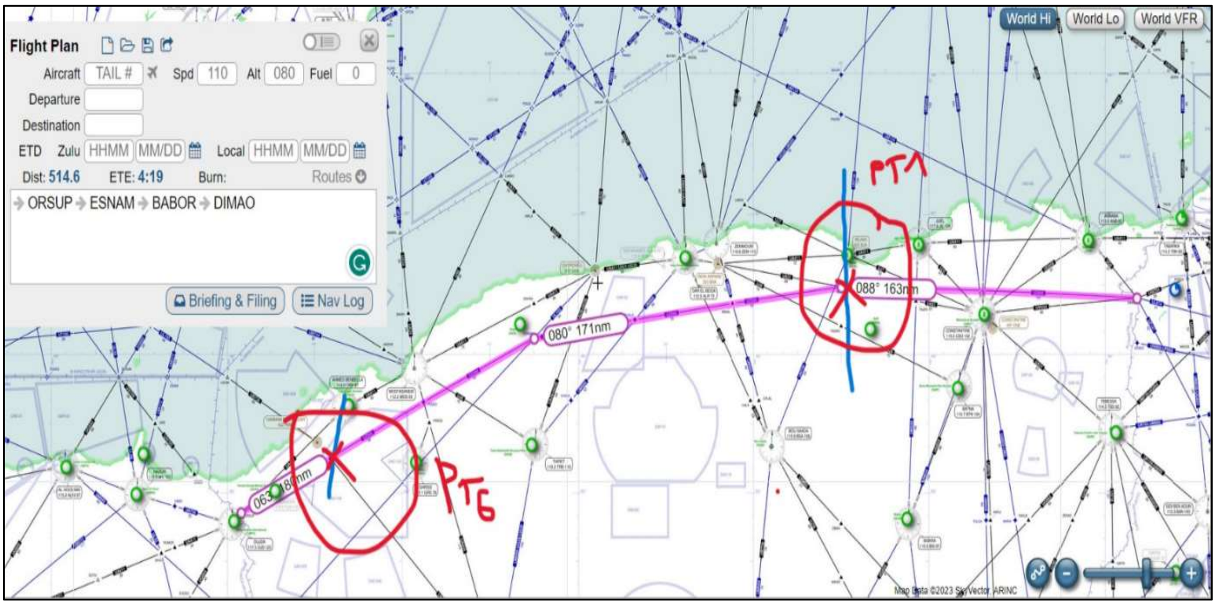


Figure4-7: the intersection of the principal route with the route UB738.

- And finally we will have:

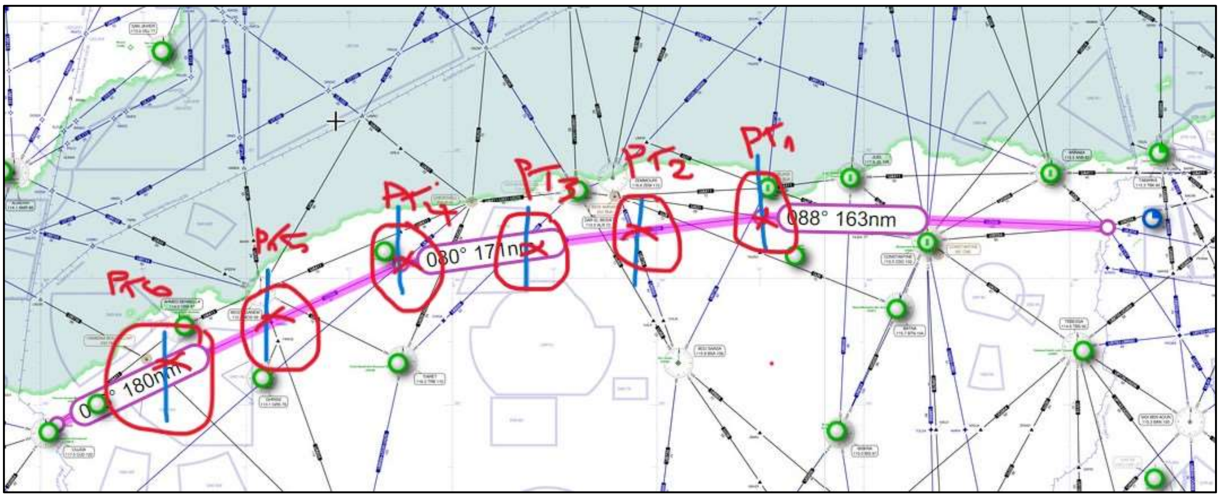


Figure 8-4: the finale route that we had connecting all the intersections

4.5. Traffic flow :

The route **ORSUP - ESNAM –BABOR- DIMAO** will mainly interest the flow of traffic from the FIR CASA (Morocco) to the FIR Tunis and vice versa because the route is bidirectional.

4.5.1. Analysis and evaluation of the proposed solution:

- The study phase related to security and safety of flights.

This route for which will have a 100% efficient solution, it is better to calculate the entry point ORSUP (optimization of the existing).

The proposed solution, based on the opinion of the controllers and the software that been used, the route ORSUP- ESNAM -BABOR- DIMAO shows that the point ORSUP will become the main entry point of the traffic passing through the FIR CASA to join the FIR TUNIS.

- **Analysis statistics at ENNA :**

In order to demonstrate the analysis results and the feasibility and effectiveness of our study, it was important to visit the ENNA (national air navigation establishment). We were lucky to have real and raw data extracted from the relevant department.

The staff of the department offered us a data simulation already realized which concerns our study.

Note: the filter of the data provided is by the DIMAO point, under the pretext that the proposed route ORSUP – ESNAM-BABOR- DIMAO for the "west-east" traffic flow is bidirectional (the upper route is even-odd, and the lower route is also even-odd). It is true that we can also say DIMAO- ESNAM-BABOR-ORSUP. That is why we can compare the existing by the optimized.

Calculates the traffic load at the two MORJA and DIMAO points after creating our scenario during the month of August 2019:

- Scenario (1): actual traffic;
- Scenario (2): Route (ORSUP – PT03- DIMAO).

4.5.2. Results :

- **Traffic Load at DIMAO:**

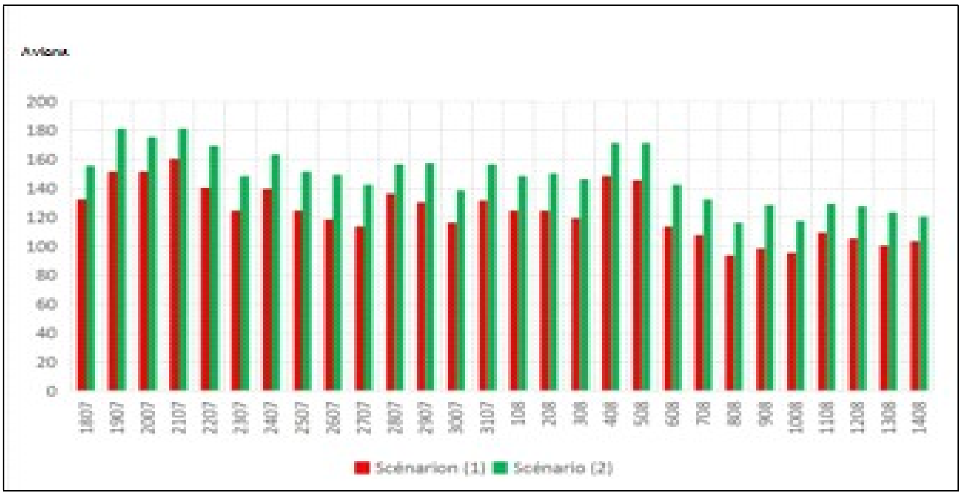


Figure 4-9: traffic charge per day at DIMAO.

- **Traffic Load at MORJA**

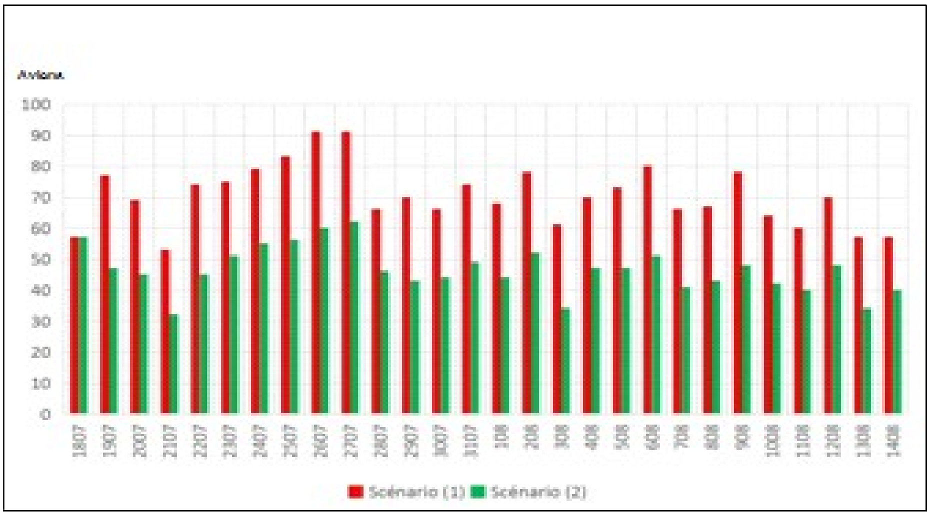


Figure 4-10: traffic charge per day at MORJA

- **DISCUSSION:**

Graph N° 1 shows the real traffic experienced at **DIMAO** during August of 2019 against the simulated traffic, the latter shows a visible increase in the traffic load at the **DIMAO** point of an average of about twenty flights per day.

Graph No 02 shows the real traffic experienced at **MORJA** during August of 2019 against the simulated traffic, the latter presents a visible decrease in the traffic load at the **MORJA** point of an average of twenty flights per day.

In reality the simulation tells us that the flow of traffic passing through the FIR CASA to reach the FIR TUNIS will be interested in the **DIMAO** point instead of MORJA, this can be explained by the geographical position of Morocco compared to Tunis but also by a gain in distance (thus in flight time) offered by the new route (see table No 05).

- Using FRA as a concept, using DCTs

- **Scenario:** ORSUP-DIMAO DCT.

Advantages: In theory, this scenario offers the optimal solution by establishing the most direct air route from the FIRs entry till exit, covering the shortest distance possible.

Inconveniences: existence of many important military zones.

Result: Rejected (unfavourable) scenario.

- **Scenario:** the route DIMAO- ESNAM-BABOR-ORSUP.

Advantages:

- Route based on DCT's direct route concept
- The road path travelled is shorter than the first scenario
- Route based on the concept of both DCTs and PBNs.
- Reduce the number of orientations and changes of course
- Comply with Algiers' FIR restrictions
- it is the best that respects the military zones, the operational and the existing means (VOR/DME/NDB/radar…..).

- Result: Maintained; it is the best that respects the military zones, the operational and the existing means (VOR/DME/NDB/radar…..).

So, to have an upgrade and an optimization in this case the favorite scenario is this one.

4.6. RESULT N° 1:

Since the east-west route, the aim is to shift the ORSUP point to the north or to the south by 18NM, and seen that the route is bidirectional and because of the optimization, the study is done east-west west is easier to compare because:

• We have the gap (gap between MORJA and DIMAO) in the study from left to right clarifies even better.

The creation of the route DIMAO –PT03- ORSUP, will offset the usual flow of traffic passing through MORJA to reach the point ORSUP at the point DIMAO, in this case MORJA is taken by traffic from or to the FIRs France, BARCELONA or SEVILLE.

The route will provide the following benefits:

- Decongestion of UA411, providing ATCs with better traffic visualization and this will be valid for the 3 northern sectors.
- Will allow smooth climbs and descents at departures and arrivals on ALGIERS and ORAN and TUNIS when it comes to east-west traffic.
- Provide users with a shorter route (flight time savings and workload).

4.7. RESULT N°2:

We benefit by creating a route parallel to the exciting but it is desirable to create a route that begins with the SOUTH ORSUP entrance by a new waypoint minimum offset by 18NM PBN to have the protection of the two separate routes.

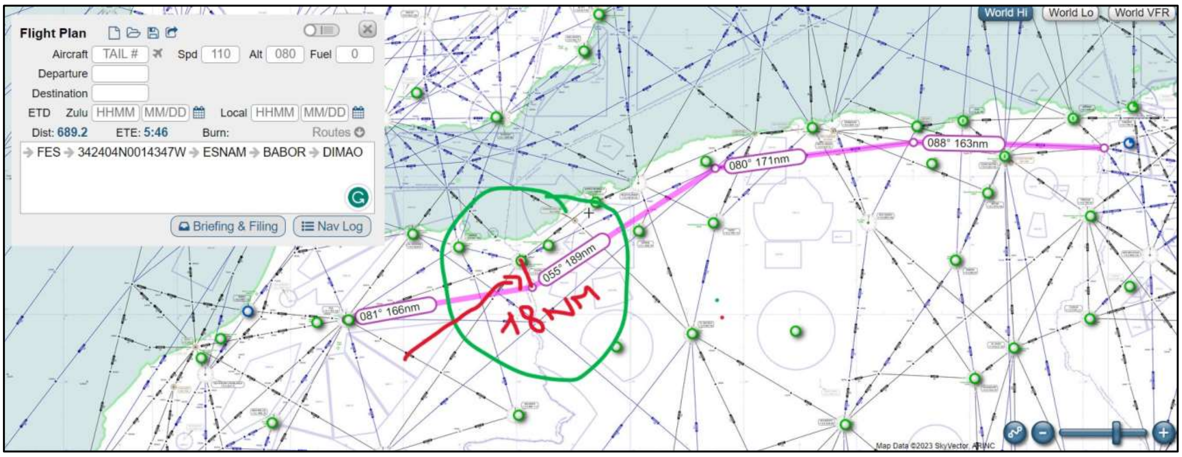


Figure 0-1: New route

4.8. The recommendations:

- It is better that the optimization will be made of the FIR's entry not in the middle, by shifting the ORSUP as an entry point to the south at least by 12NM but even better 18NM.
- The ideal we created a route that started with ORSUP by 18NM towards ASNAM (the realization of a route that converges with other routes is not logical); therefore:
- Either we move ORSUP up with 18NM.
- Either we move ORSUP down WITH 18NM.
- The point is between ORSUP-ARIAM (18NM-18NM) PBN concept.
- The proposal of a new route from the north routing in case of the French/ European strikes.

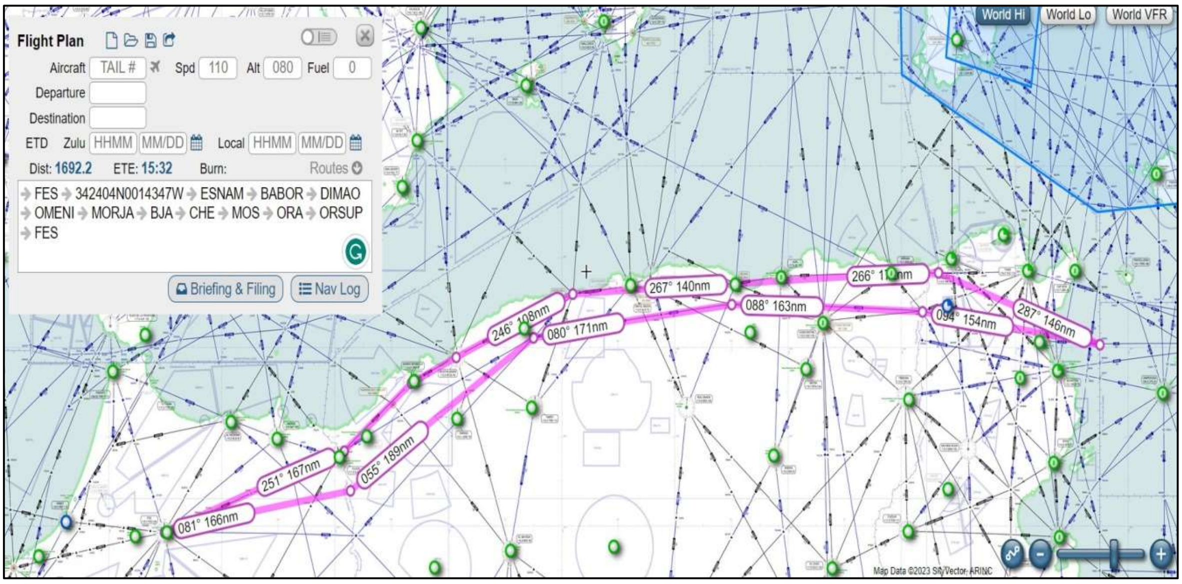


Figure 0-2: Parallel routes

4.8.1. Operational benefits and gains:

- Route protection has been maintained.
- FIR entry optimization to FIR exit.
- Create Para-routing
- Route capacity will be multiplied by 2
- Conflict Minimization
  - Ability to accept more traffic and flights.

	DCT	ENTERING / EXITE WAYPOINT	RTE INITIALLY		RTE with DCT		ENTERING / EXITE WAYPOINT
			RTE	Dist (NM)	RTE	Dist (NM)	
1	ORSUP-ESNAM-DIMAO	ORSUP	UA411 BNA UA31 CSO UW254	525NM 972KM	DCT ESNAM DCT	952 KM	DIMAO
2	ORSUP-UA411-MORDJA	ORSUP	UA411	537NM 995KM	UA411 CHE *POSSIBILITY CHE* ***DCT*** *ORSUP*	991 KM	MORJA

Table 0-1:gain in distance of two routes each started by MORJA and DIMAO

4.8.2. Principle of software used:

-Visualization of the existing flow (past);
-Creating news cenarios
- The simulation of this scenarios
- Comparison of passing traffic flow.
- Gain/loss, deficit/surplus results.
- The study phase related to security and safety of flights.
- The updated phase DCR (Data Base).

4.9. Conclusion

In this chapter the concept of free routing was applied, from the results concluded above, we managed to achieve the optimization of a parallel route to the existing FIR entry to the exit for the flow of traffic west –east.

In addition we could also propose another alternative route for a new flow of traffic.

This new concept will emerge airspace users in profits and gains on everything in relation to time, distance and fuel consumed.

Appendix A

1. Global Air Navigation Plan GANP

GANP is an important planning tool for setting global priorities to lead the evolution of the global air navigation system and ensure that the vision of an integrated, harmonized, globally interoperable and homogeneous system become a reality. GANP provides information at four different levels, such as previously mentioned:

1. Global Strategy.
2. Global Technology.
3. Regional.
4. National.

Specifically, in terms of the global technical level, this includes three technical frameworks, the (BBB, ASBU and performance frameworks, which include performance targets and key performance indicators (KPIs) and a dashboard performance.

The BBB framework describes the basis of any robust air navigation system. This is not new, but it corresponds to the identification of essential services that must be provided by States to international civil aviation in accordance with ICAO Standards and Recommended Practices (SARPs). These essential services are defined in the areas of aerodromes and ground aids (AGA), ATM, search, and rescue (SAR), aeronautical meteorology (MET) and information management (AIM). In addition to essential services, the BBB framework identifies the end users of these services, as well as the communications, navigation, and monitoring (CNS) infrastructure needed to provide them.

ASBU is a flexible global system engineering approach that enables all states to advance their air navigation capabilities according to their specific operational needs. The ASBU is integrated by (as illustrated below):

• ASBU thread: key area of the air navigation system.
• ASBU module: a group of elements of a thread.
• ASBU element: a specific operational improvement.
• ASBU catalyst: Component (standards, procedures, training, technology).
• ASBU block: specific concept of operations. Deadline for making available element.

2. II: Aviation System Block Upgrade (ASBU).

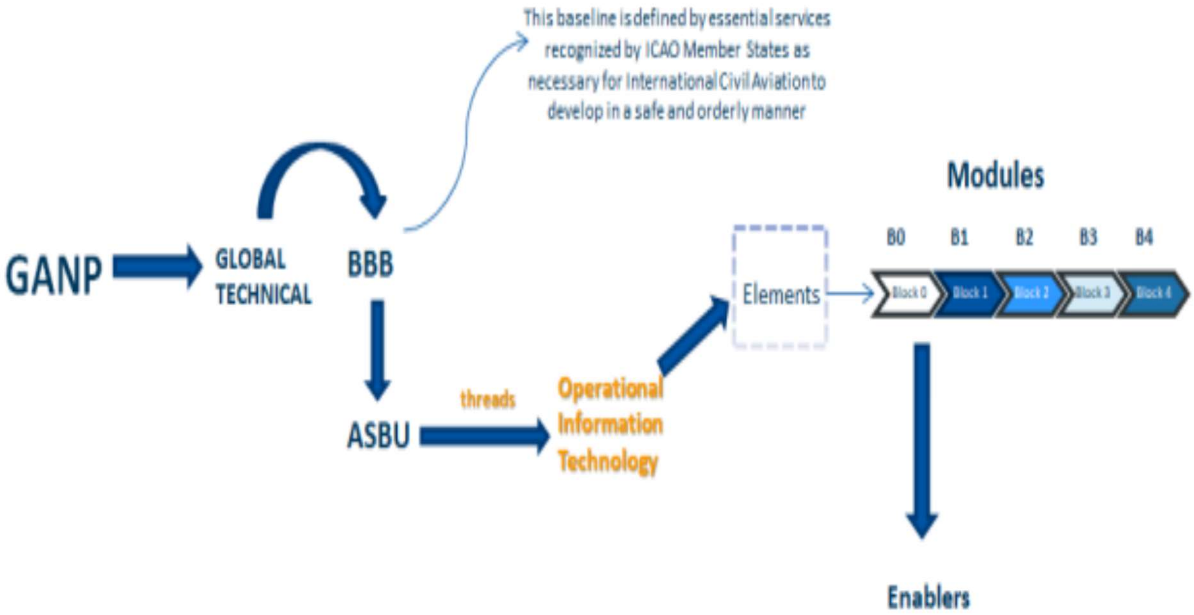


Figure 1: Elements integrating the ASBU.

Attachment B

SAMPLE AIRSPACE CONCEPTS BASED ON NAVIGATION SPECIFICATIONS

1. PURPOSE

This attachment provides information on airspace concepts whose safe operation is based on navigation specifications published in this volume. These concepts arose from the need to create systems of parallel ATS routes, initially in oceanic and remote continental areas, and, subsequently, in other continental airspace. They therefore reflect route criteria that are in use in several parts of the world, and conditions of operation that are associated with them.

2. BACKGROUND

2.1 The spacing between ATS routes may be determined, in part, by the navigation performance of the aircraft that are expected to use them, and by the communication and ATS surveillance services that are available to those aircraft. Prior to the widespread use of GNSS, an aircraft's navigation performance often depended on the NAVAID infrastructure along its route; and so, navigation performance in oceanic and remote continental areas differed significantly from that in other continental areas and in terminal areas. Route spacing for oceanic and remote continental areas was largely based on the performance of aircraft using inertial navigation systems, whilst the spacing for other continental ATS routes was typically based on the performance of aircraft navigating by VOR.

2.2 The publication of ICAO's RNP Concept in the late 1990s resulted in route spacing based on area navigation. The publication of ICAO's Performance Based Navigation

Concept (which replaces the RNP concept) means that route spacings will continue to be based on the use of RNAV systems for RNAV and RNP ATS routes.

2.3 Over the last few decades, several regional route spacing studies have been undertaken, primarily for en route airspace in oceanic, remote-continental, and continental areas. Information on these studies was published in various ICAO documents: Attachment B to Annex 11: the appendices of the Airspace Planning Manual for the Determination of Separation Minima (Doc 9689) and PANS-ATM (Doc. 4444).

2.4 Part of this attachment reproduces material that was previously published in Attachment B to Annex 11.

3. OCEANIC & REMOTE CONTINENTAL AIRSPACE

3.1 Two route spacings are commonly used in oceanic and remote continental airspace: 50 NM and 30 NM.

3.2 Parallel routes across the North Pacific, the Tasman Sea, and the Bay of Bengal use 50-NM route spacing.

3.2.1 Basis: Safety assessment, performed by the United States Federal Aviation Administration, to determine the maximum tolerable rate of gross lateral errors in a system of parallel routes using 50 NM track spacing, and meeting a target level of safety of 5×10–9 fatal accidents per flight hour.

3.2.2 Minimum ATS Requirements:

NAV – All aircraft need operational approval for RNAV 10 (RNP 10) for the routes or tracks to be flown. During 95% of the fleet's flight time, aircraft lateral deviations from route center line must be less than: 7 NM if the route system carries same-direction traffic on adjacent routes; 6 NM if the route system carries opposite-direction traffic on adjacent routes.

COM – Voice communication through a third party. However, in areas of frequent convective weather or other hazards, direct controller-pilot communication is highly desirable, and may be necessary. SUR – Procedural pilot position reports.

Other – System safety must be monitored. The occurrence of large lateral deviations from route center line must be recorded, and the rate of such deviations estimated periodically. A route system can be expected to meet the target level of safety (TLS) of 5×10-9 accidents per flight-hour if the rates of such deviations do not exceed the values shown in the relevant row of table A-1 (for same-direction traffic) or table A-2 (for opposite-direction traffic).

4. EN ROUTE CONTINENTAL AIRSPACE

4.1 Four spacings are used in en route continental airspace. They vary with the availability of ATS surveillance and with traffic characteristics.

4.2 16.5 NM route spacing for straight unidirectional tracks and 18 NM route spacing for straight bi-directional tracks have been derived by comparison to a high-density continental reference system (VOR spacing) described in Attachment A to Annex 11.

4.2.1 Minimum ATS requirements:

NAV — RNP 5 (pre-PBN). The NAVAID infrastructure must be sufficient to support RNP 5 operations.

COM — Direct VHF controller/pilot voice communication.

SUR — procedural pilot position reports.

Note: The navigation performance of RNP 5 (pre-PBN) is the same as RNAV 5.

4.3 16.5 NM route spacing for straight unidirectional tracks operated with ATS radar surveillance, and 18 NM route spacing for straight bi-directional tracks operated with ATS radar surveillance, have been derived for European continental airspace by comparison to a reference system (VOR Spacing) described in Attachment A to Annex 11.

4.3.1 Minimum ATS requirements:

NAV —All aircraft need an RNAV 5 operational approval valid for the routes or tracks to be flown, and the NAVAID infrastructure must be sufficient to support RNAV 5 operations.

COM — Direct VHF controller/pilot voice communications.

SUR — with radar surveillance.

Notes:

1. This spacing is not applicable to remote or oceanic airspaces, which lack VOR infrastructure.

2. For general ECAC application, spacing of 16.5 NM for same-direction routes, and of 18 NM for opposite-direction routes, was shown to produce an acceptable intervention rate. Moreover, route spacing could be safely reduced to as little as 10 NM provided the resultant intervention rate was considered acceptable. In the event that ATS radar surveillance was not available, route spacing needed to be increased, and could be as great as 30 NM in a high-traffic-density environment. (Also note that route spacing needs to be increased at turning points because of the variability of aircraft turn performance. The extent of the increase depends on the turn angle).

4.4 Eight to nine nautical mile (8 to 9 NM) route spacing for straight tracks in a high-density continental en route system using ATS radar surveillance, has been derived by independent collision risk analyses undertaken separately by the Federal Aviation Administration of the United States of America.

4.4.1 Minimum ATS requirements:

NAV — All aircraft need an RNAV 2 operational approval valid for the routes or tracks to be flown, and the NAVAID infrastructure must be sufficient to support RNAV 2 operations.

COM — Direct VHF Controller/pilot Voice communication.

SUR — Radar surveillance.

4.5 7 NM route spacing for straight and turning tracks (with turns not exceeding 90 degrees) in a high-density continental en route system using ATS radar surveillance, has been derived by independent collision risk analyses undertaken by EUROCONTROL.

4.5.1 Minimum ATS requirements:

NAV — All aircraft need an Advanced RNP operational approval (with a navigation accuracy of at least 1 NM either side of track 95% of the flight time) valid for the routes or tracks to be flown, and the NAVAID infrastructure must be sufficient to support Advanced RNP operations.

COM — Direct VHF Controller/pilot Voice communication.

SUR — Radar surveillance.

Appendix C

FLEXIBLE USE OF AIRSPACE

SAMPLE MANUAL

1. Objective

1.1 The Flexible Use of Airspace (FUA) Manual (henceforth referred to as the "manual") for (*State XYZ*) has.

been prepared by (*Insert any of…* CAA/ANSP/DGCA/AIR FORCE/NAVY/ARMY/…etc.,) It provides comprehensive.

guidelines for matters pertaining to implementing ASM/FUA in (State XYZ) in a harmonized fashion.

1.2 The FUA Manual considers the guidance of the International Civil Aviation Organization in this regard (*Insert any of…ICAO Doc 10088, ICAO Doc 9750…etc.*). FUA shall be facilitated through strategic cooperation, pre-tacticalcooperation, and tactical coordination to enable dynamic interaction, thus allowing the implementation of optimal flightpaths and reducing the operating costs of airspace users while protecting the environment. All of this is to be achievedwhile paying due heed to security considerations and providing for military operational requirements.

2. Scope

The FUA Manual — (*State XYZ*) has been developed to be used in the (*Insert the name of FIR/FIRs*) taking into account.

operational improvements and airspace optimization initiatives in the short and medium term, and particularly in

accordance with ATS route network optimization in the region. This manual will apply to all civil and military use of flexible airspace structures.

3. National background

(Note. — Text is indicative only and may be expanded based on the State's analysis of civil-military

cooperation and FUA.)

3.1 Military aviation places great emphasis on a secure national airspace, and civil-military cooperation leverages effective real-time coordination.

3.2 The goal of civil-military cooperation and coordination should be based on a dialogue between civilian and military authorities, with a clear understanding that supporting the civil air navigation infrastructure is consistent with themilitary mission to defend the nation's interests. The objective is to make better use of mechanisms for airspace utilization such as the exchange of flight plan data and surveillance data.

3.3 An identified gap in the current system is a lack of policy and procedures for FUA, which hampers airspacedesign and management by not allowing the application of an optimal airspace structure and the use of optimum flightpaths. Among the limitations identified is the existence of permanently reserved airspace, primarily for military purposes, which although justified from a national security point of view, poses constraints on airspace planning, which prevents direct flights between airports of origin and destination and/or city pairs. Civil-military cooperation, done using FUA principles, should permit civil flights through such areas, when they are not being used by the military.

3.4 Improved civil-military coordination and cooperation strengthens airspace safety, allows for a more efficientair traffic services (ATS) route structure, and increases airspace capacity. It reduces miles flown and fuel consumption and, consequently, CO_2 emissions into the atmosphere. It also increases the availability of additional airspace for military usage, on a day-to-day basis, where the requirements cannot be met in the existing reserved airspaces.

4. BASIC AIRSPACE MANAGEMENT PRINCIPLES AND STRATEGIES

4.1 States should include the following principles in compliance with ICAO:

a) all available airspace should be managed in a flexible manner, whenever feasible.
b) airspace management processes should incorporate dynamic flight paths and provide optimal operational solutions.
c) when conditions require segregation, based on different types of operations and/or aircraft, the size, shape and time zones of said airspace should be determined to minimize the impact on operations.
d) the use of airspace should be coordinated and monitored to accommodate the conflicting requirements of all users and to minimize any constrains on operations.
e) airspace reservations should be planned in advance with changes made dynamically whenever possible. The system also needs to accommodate short-notice unplanned requirements.
f) the complexity of operations may limit the degree of flexibility.

4.2 Cooperation and coordination between civil and military authorities shall be organized at strategic,pre-tactical and tactical levels aimed at increasing airspace safety and capacity and improving the efficiency and flexibilityof air operations.

4.3 Consistency among airspace management, air traffic management, air traffic flow management (ATFM), andATS should be established and maintained at the three airspace management levels (strategic, tactical and pre tactical).

4.4 Airspace reservation for exclusive or specific use of certain user categories shall be applied temporarily onlyduring limited periods of time depending on actual use, and it shall be disregarded as the activity that motivated it ceasesto be. It shall follow the procedures set forth in ICAO Annexes and documents.

4.5 Air traffic service units and users will make the best possible use of available airspace.

4.6 Coordination and collaborative decision making by ATS and ATFM units and effective application of the FUA concept should be consistent and permanent during the strategic, pre-tactical and tactical phases of airspace management.

4.7 Adequate resources should be allocated for an effective implementation of the FUA concept, taking into account both civil and military needs.

4.8 Security of national airspace shall be paramount and shall not be compromised at any stage.

5. FUA MANUAL — STRUCTURE AND CONTENT

5.1 The FUA Manual considers the national security situation, the national background on civil-military cooperation, the current and future requirements as well as the best practices and principles of FUA enshrined in ICAO Annexes and documents.

5.2 The manual is organized as follows:

- *Chapter 1.* Definitions.
- *Chapter 2***.** Details of FUA implementation in (*State XYZ*). The strategic level embodies the three levels of flexible use of airspace (Level 1, 2 and 3), flexible airspace structure, particular application of the FUA concept, priority rules and transition to the FUA concept.
- *Chapter 3***.** Procedures pertaining to Level 1. Airspace changes proposals, joint design of airspace at thestrategic level, and allocation of airspace at the strategic level (**ATS-ASM-ATFM relationship * Subject to the implementation of ATFM).*
- *Chapter 4.* Procedures pertaining to Level 2 (pre-tactical management). Details of airspace management cells (AMCs), allocation and notification process, based on airspace requests.
- *Chapter 5***.** Procedures involved in publication, promulgation, and dissemination of FUA information. AIP, airspace use plan, updated airspace use plan, etc.
- *Chapter 6***.** Details of air defense requirements. Cooperation between civil and military unit providing ATS in case of air defense violations, interception of civil aircraft, ADIZ, etc.
- *Chapter 7***.** Processes and procedures at Level 3 (tactical management).
- *Chapter 8***.** Details on civil-military cooperation and the interoperability of their systems

Three Levels

- The FUA Concept is based on three Levels of ASM which have been identified as:

1) strategic ASM — Level 1.
2) pre-tactical ASM — Level 2; and
3) tactical ASM — Level 3.

- The three levels correspond with civil-military ATM cooperation and coordination tasks. Each level is related directly to, and impacts, the others.

Level 1 — Strategic management

Strategic FUA at Level 1 consists of a joint civil and military process within a *(Name of national CAOM)*, which formulates the national airspace policy and carries out the necessary strategic planning work, taking into account the requirements of national and international airspace users, within the framework of national security requirements.

In order to maintain a flexible airspace organization, there ought to be a continual assessment of the national airspace and route structures. At the strategic level, the working structures for Levels 2 and 3 should be determined andthe authority required to carry out their tasks should be given to them. The procedures to be followed at these pre-tactical.

and tactical levels and the priority rules and negotiation procedures for airspace allocation at Levels 2 and 3 should bedetermined by the *(Name of national CAOM)*.

Level 2 — Pre-tactical management

Pre-tactical FUA at Level 2 consists of the day-to-day management and temporary allocation of airspace through airspace management cells (AMCs).

The AMC has the authority to conduct ASM within the framework of the State's airspace structures, priority rules and negotiation procedures as laid down by the national CAOM. The AMC collects and analyses airspace requests. After coordination, the ATS authority promulgates the airspace allocation.

The airspace allocation information, consolidated into an airspace use plan (AUP) or updated airspace use plan (UUP), is published daily on the dedicated portal of the ANSP and provided to aircraft operators (AOs) for flight planning purposes.

Level 3 — Real-time use of airspace

Tactical FUA at Level 3 consists of the real-time activation, deactivation or real-time reallocation of the airspace allocated at the pre-tactical level, and the resolution of specific airspace challenges between civil and military units.

Real-time access to all necessary flight data, including intentions of controllers, with or without system support, permits the optimized use of airspace and reduces the need to segregate airspace.

FUA/ATFM relationship at the strategic level — Level 1

Note. — Both ASM and ATFM have a planning phase. At the strategic level, this consists of a periodic review of the use of airspace using traffic statistics and forecasts.

In this phase, ATFM identifies choke points, sector capacity and demand imbalances. This national periodic review process, involving both airspace and route planners, ACCs/FMUs/FMPs, and the airspace management cell, should keep pace with the development of improved navigation capabilities, advanced ATC techniques and changes in user requirements.

A national airspace review, including the review of CDRs, can assist in airspace planning, to establish solutions to identified bottlenecks for the longer term. The ANSP may consider the preparation and publication of a route availability document (RAD) which enables increased capacity by defining route restrictions via an organized system of major traffic flows and, at the same time, allows flight planning flexibility for aircraft operators. The RAD is therefore based primarily on permanent ATS routesand Category 1 CDRs and includes route restrictions as published in the national AIPs, LoAs, NOTAMs and AIPSupplements. The RAD includes a number of permanent routing suggestions to assist AOs in the preparation of their flight plans; these suggestions are advisory and not mandatory.

FUA/ATFM relationship at the pre-tactical level — Level 2

Note. — In the pre-tactical ATFM phase, the ATFM center highlights areas of insufficient ATC capacity. Routing scenarios have to be considered to solve capacity shortfalls in coordination with AMCs/ACCs/FMUs/FMPs concerned.

User requirements necessitating segregated airspace form the basis for requests and allocation of relevant SUA.

ATC/ASM/ATFM relationship at tactical level — Level 3

Note. — If a reduction in the activation time of a relevant SUA is agreed between units, the subsequent release of airspaceenables ACCs to open certain CDRs and reroute traffic flows at short notice. Similarly, ATS units and/or controlling militaryunits are able to use relevant SUAs at short notice, taking into account the general ATFM plan. To enlarge or combine relevant SUAs, ACCs may be able to allocate, at short notice, some flight levels of an ATS route segment for temporary use.

Appendix E:

Coordination and cooperation of civil and military air traffic

Appendix I of Resolution A40-4, adopted by the 40th Session of the ICAO Assembly *(Assembly Resolutionsin Force (as of 4 October 2019)* (Doc 10140) refers), describes the principles which should guide the development ofStates' regulations and ICAO provisions and guidance in relation to civil-military coordination and cooperation:

APPENDIX

Whereas the airspace is a resource common to both civil and military aviation, and given that many air navigation facilities and services are provided and used by both civil andmilitary aviation-*Whereas* the Preamble of the *Convention on International Civil Aviation* stipulates that signatories thereto had “agreed on certain principles and arrangements in order that international civil aviation may be developed in a safe and orderly manner and that international air transport services may be established on the basis of equality of opportunity and operated soundly and economically”;*Whereas* Article 3

a) of the Convention states that “This Convention shall be applicable only to civil aircraft, and shall not be applicable to state aircraft” and Article 3

b) requires that “contracting States undertake, when issuing regulations for their state aircraft, that they will have due regard for the safety of navigation of civil aircraft”-*Recognizing* that growing civil air traffic and mission-oriented military air traffic would benefit greatly from a more flexible use of airspace used for military purposes and that satisfactory solutions to the problem of cooperative access to airspace have not evolved in all areas.-*Whereas* the flexible use of airspace by both civil and military air traffic may be regarded as the ultimate goal, improvement in civil/military coordination and cooperation offers animmediate approach towards more effective airspace management.

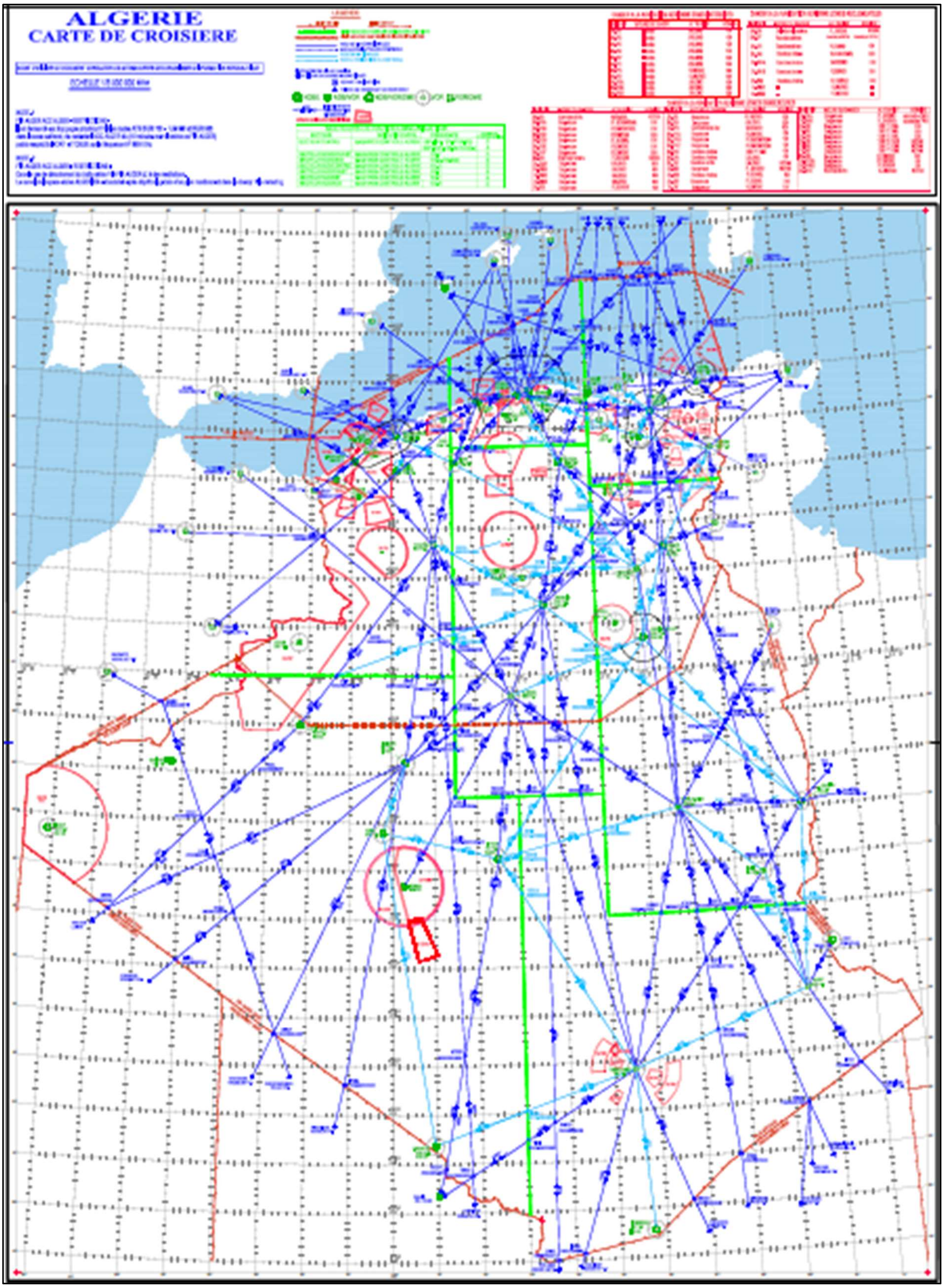
-*Recalling* that the ICAO Global ATM Operational Concept states that all airspace should be usable resource, any restriction on the use of any particular volume of airspace should be considered transitory, and all airspace should be managed flexibly.

The Assembly resolves that:

1. the common use by civil and military aviation of airspace and of certain facilities and services shall be arranged so as to ensure the safety, regularity, and efficiency of civil aviation as well as to ensure the requirements of military air traffic are met.
2. the regulations and procedures established by Member States to govern the operation of their state aircraft over the high seas shall ensure that these operations do not compromise the safety, regularity and efficiency of international civil air traffic and that, to the extent practicable, these operations comply with the rules of the air in Annex 2.
3. the Secretary General shall provide guidance on best practices for civil/military coordination and cooperation.
4. Member States may include, when appropriate, representatives of military authorities in their delegations to ICAO meetings.
5. ICAO serves as an international forum that plays a role in facilitating improvedcivil/military cooperation, collaboration, and the sharing of best practices,

and to provide the necessary follow-up activities that build on the success of the Global Air Traffic Management Forum on Civil/Military Cooperation (2009) with the support of civil/military partners.

APPENDIX D:cruise map



Appendix E: ASBU Aviation system block upgrades and DCT direct routes:

ASBU is a flexible global system engineering approach that allows all Member States to advance their air navigation capabilities according to their specific operational needs. The ASBU is integrated by (as shown below):

- ASBU thread: key area of the air navigation system.
- ASBU module: A group of elements in a thread.
- ASBU element: a specific operational improvement.
- ASBU Catalyst: Component (Standards, Procedures, Training, Technology).
- ASBU Block: Specific concept of operations. Deadline for making an item available.

1. The FRTO-B0/1 Direct Routing (DCT) module:

Main Objective:

Direct routes are established for the purpose of providing airspace users with additional route options for flight planning. flight planning on a larger scale through FIRs, so that the overall distances of planned legs are reduced compared to the fixed route network compared to the fixed route network.

The new capabilities:

Direct routes (DCTs) are established at national and regional levels and made available for flight planning (with published terms of use). CSDs should be seen as a first iteration of the concept of free movement airspace (FRA). Free Route Airspace (FRA) concept. Direct routing operations allow airspace users to optimize flight and fuel planning. flight and fuel planning.

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15. **ICAO AGENDA** ITEM 6 :free route airspace concept .

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