5. Free Route Airspace Implementation in European Airspace

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5.1 BRIEF FREE ROUTE AIRSPACE CONCEPT DESCRIPTION

The idea of Free Route Airspace (FRA) concept was launched at the beginning of 1998 in Central European countries and European Organization for the Safety of Air Navigation (Eurocontrol). The main principle of this concept is to enable users freely plan a route between a defined entry point and a defined exit point, with the possibility of route via waypoints, without reference to the Air Traffic Services (ATS) route network, subject to airspace availability. Within this airspace, flights remain subject to air traffic control [1].

A number of States, Air Navigation Service Providers (ANSP) and Functional Airspace Blocks (FAB) have proposed in 2007 development towards the implementation of FRA [2]. The common thread of these initiatives was the transition from reliance on a fixed route network to offering direct routes and tailored routes in order to contribute to airspace performance improvements on capacity, efficiency and environment.

These initiatives come at a time when there are very demanding economic and environmental pressures on Aircraft Operators (AO) and other stakeholders. The network has to respond to this and the States and ANSPs should look at innovative and obvious methods to make their contribution.

The implementation of FRA initiatives will, in the short term, go some way to meet the efficiency, capacity, and environmental challenges.

General Air Traffic (GAT) is provided along the ATS routes which were established in accordance with other existing activities, with the use of airspace, operational and technical possibilities of ATS units and level of on-board navigational equipment, herewith the requirements concerning flight safety, economical effectiveness (time, flight distance and fuel consumption) and environmental protection aspects (CO_2 and NO_x emissions reduction).

Every FRA project should be based on the safety case, enabling requirements for optimum use of airspace, taking into account existing air traffic flows, ensure compatibility with the global and regional ATS route network, be justified by their overall added value including optimal use of technical and human resources on the basis of cost-benefit analyses, ensure smooth and flexible transfer of responsibility for air traffic control between air traffic service units, ensure compatibility between the airspace configurations, optimizing current

flight information regions, comply with conditions stemming from the regional agreements concluded within the ICAO.

The FRA Concept forms the basis for a common understanding for all ATM partners involved in FRA implementation. The FRA Concept encompasses various FRA implementation scenarios that will [1]:
— meet the safety objectives;
— be compatible with existing operations;
— be sustainable through further development;
— be capable of expansion/connectivity to/with adjacent airspace;
— be capable of being exported to other regions.

Some of the core aspects of FRA are aligned with the improved solutions for airspace design, new airspace operating concepts and enhanced operational performance. Agreed airspace design solutions and airspace operating concepts need to be viewed from a pan-European network perspective and not only from a national perspective [3]. This will ensure that future developments will be fully aligned with the overall global and Pan-European network developments (Fig. 1).
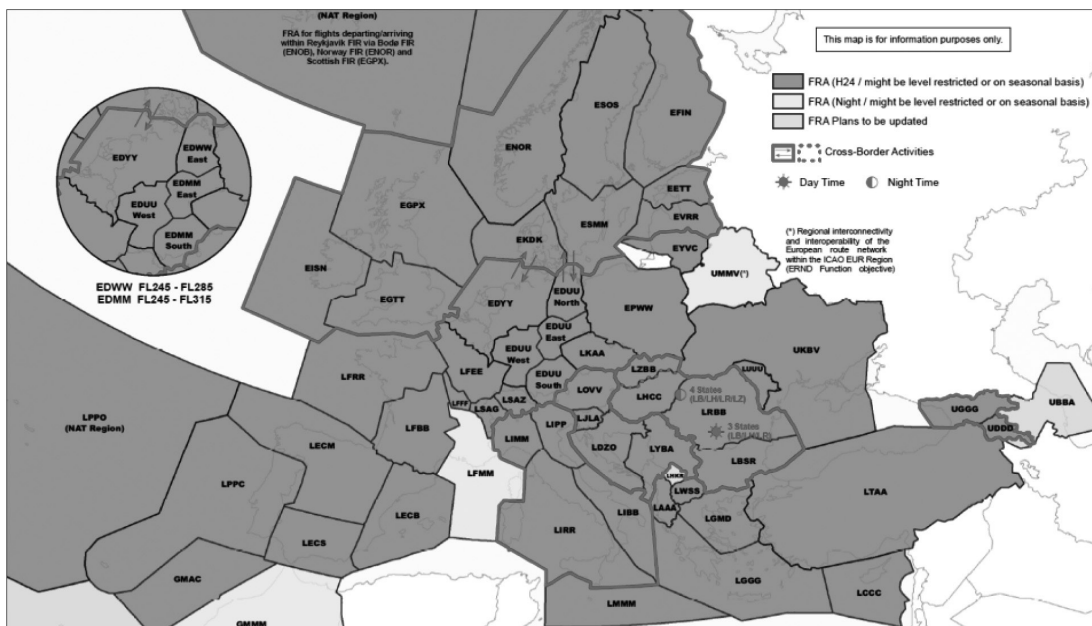

Fig. 1. FRA Implementation (End 2022)

5.2 FREE ROUTE AIRSPACE DESIGN

FRA forms an integral part of the overall European ATM network, interfacing vertically or laterally with adjoining fixed ATS route operations airspace [1].

FRA flight planning procedures need to be understandable, easy to use and coherent with procedures for the fixed ATS route network. Aircraft are expected to perform air traffic flow and capacity management (ATFCM) procedures within FRA airspace and in adjacent areas.

Developments of the FRA operational aspects are based on the following principles:
— FRA should be guided by operational approaches and provide significant benefits for all airspace users;

— military user's requirements should be considered in process of FRA implementation;
— European airspace design concept, general ICAO principles and technical specifications regarding airspace design should be taken in considered (stated in ICAO documents, European Route Network Improvement Plan (ERNIP), Part I, etc.).

Nevertheless, with goal being a harmonised airspace structure across the European network, the following recommendations are made [1]:
— the lower vertical limit shall be coordinated at the European network level to ensure interconnectivity with adjoining airspace and this could vary in different areas or at different times within a particular FRA.
— the minimum level should be the lowest feasible, taking into account the complexity of the airspace and the demand.

To maximise the efficiency of FRA and to ensure safe and efficient transfer of flight, 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 free route operations in the airspace above.

5.3 OPERATIONALLY DRIVEN APPROACH

With an Operationally Driven Approach (ODA), an optimal direct routes (DCT) can be structured within the airspace from which the sector families can be identified, taking into account the complexity of the airspace and the air traffic demand, on the ground of a number of grouped potential FRA scenarios on the basis of which the economic, social, military, institutional and other elements need to be considered.

The ODA for FRA design, as part of airspace design and operational coherence activity, will be based on operational requirements regardless of internal existing boundaries, within existing Control Areas (CTA)/ Upper Control Areas (UTA) with further consideration a common FRA within existing CTA/UTA.

The ODA is based on the following steps:
— sector design will need to be restructured to accommodate air traffic flows in both FRA and fixed ATS route network, which is below FRA and to be more flexible as traffic demand varies. Herewith, ATS sectors design should be based on areas of high complexity;
— in some cases it needs to review design of terminal airspace and, depending on airspace complexity, extensions may need to be investigated to ensure appropriate traffic segregation;
— if for some airports there are no suitable Standard Instrument Departure (SID) /Standard Instrument Arrival (STAR) available, flight planning through the use of DCT should be facilitated.

Identification of the required network enablers, in particular [2]:
— system adaptation and compatibility across the network;
— harmonised Aeronautical Information Services (AIS) publication;
— checklist of FRA implementation actions;
— Fast Time Simulation evaluations of workload and capacity;
— running of large scale Real Time Simulations;
— enhanced flight planning procedures;
— initiating work at network level to ensure that enablers will be available;

- supporting airspace design and ATFCM processes at network, FAB and local level;
- support to a co-ordinated deployment of local, sub-regional and network aspects of these initiatives;
- validation of airspace design and utilisation projects through the Network Manager Operations Centre (NMOC);
- coordination on the development of the network systems and operational procedures.

5.4 FREE ROUTE AIRSPACE SIGNIFICANT POINTS

FRA significant points will be published in national Aeronautical information publications (AIP) with a clear reference to the FRA and to indicate the FRA relevance of the point.

As navigation aids can be used as a FRA significant point, the publication of appropriate FRA relevance shall be considered for publication also for en-route navigation aids [2].

The FRA relevnce of the significant points shall be indicated by the following letters and published within brackets:
- (E) for FRA Horizontal Entry Point;
- (X) for FRA Horizontal Exit Point;
- (I) for FRA Intermediate Point;
- (A) for FRA Arrival Connecting Point;
- (D) for FRA Departure Connecting Point.
- Combinations of letters can be published in accordance with the matrix (Fig. 2)

E	EA		
X		XD	EXAD
EX	EXA	EXD	EXADI

I	IA	ID	IAD
	A	D	AD

Fig. 2. Combinations of letters for Significant Points

5.5 AIR TRAFFIC SERVICES ROUTE NETWORK AND FREE ROUTE AIRSPACE COMPATIBILITY

Historically, ATS routes have been the preferred tools to allow the safe and efficient management of high density air traffic and to facilitate the early detection of possible conflicts and their resolution. Based on ICAO provisions, there is no particular requirement for ATS routes to co-exist FRA where the ATS can be assured in a safe, efficient and sustainable manner.

States shall decide to maintain or remove the fixed ATS route network during FRA operations and all details shall be published in AIS publications. There is no mandatory requirement that the fixed ATS route network be either maintained or removed when FRA is implemented.

The availability of more direct route segments within FRA would provide more options and greater flexibility for airspace users at the flight planning phase. The opportunity to fly optimal flight profiles, reduced flight time/distance together with expected increase in airspace capacity and reduction of ATC delay should result in more efficient ATM while retaining a Target Safety Level (TSL).

The fixed ATS route network can be maintained for flight planning purposes [4]:
— within the relevant FRA area to ensure smooth vertical transition between FRA and non-FRA area;
— during the FRA applicability period to ensure smooth lateral transition between FRA and non-FRA period;
— for airspace users that would rather file their flight plans the traditional way;
— for airspace users that are not eligible for FRA operation.

In FRA areas where the fixed ATS route network is maintained [4]:
— there shall not be a specific requirement for flight planning by using only FRA flight planning procedures;
— parallel development of FRA and ATS routes cannot be considered as mandatory.

Compatibility between FRA and Fixed ATS route network should be adequately managed. Airspace redesign and changes to the route network are likely to be needed to facilitate efficient transfer of flights and to maximise capacity benefits within FRA.

In accordance with the definition of FRA, compatibility with the ATS Route Network will be realized through the significant waypoints within FRA. All these points are available as entry/exit (E/X) points, intermediate (I) points and arrival/departure (A/D) points. All details regarding FRA and ATS route network should be published in AIS publications.

The FRA Concept uses basic area navigation principles when aircraft can operate on tracks joining any two points, within prescribed accuracy tolerances, without the need for over-flight of specific ground facilities. This enables the airspace users to plan and fly aircraft between entry/departure points and exit/arrival points within FRA without reference to the ATS route network.

Establishment of a new FRA significant point shall not be supported by establishment of ATS route/s as all relevant new FRA options cannot be covered by ATS routes.

5.6 FREE ROUTE AIRSPACE DIMENSIONS

The airspace design within FRA should take into account the needs of all airspace user groups on a basis of the State priorities. Consequently, an important goal of the FRA airspace design is not only to enable equal access to the airspace for all users, but in the same time to ensure their specific needs and sometimes opposing needs under condition of limited airspace resource.

The example below (Fig. 3) shows different vertical FRA relevance expressed by FLs of point JJJJJ [5]. Duszan Augustyn
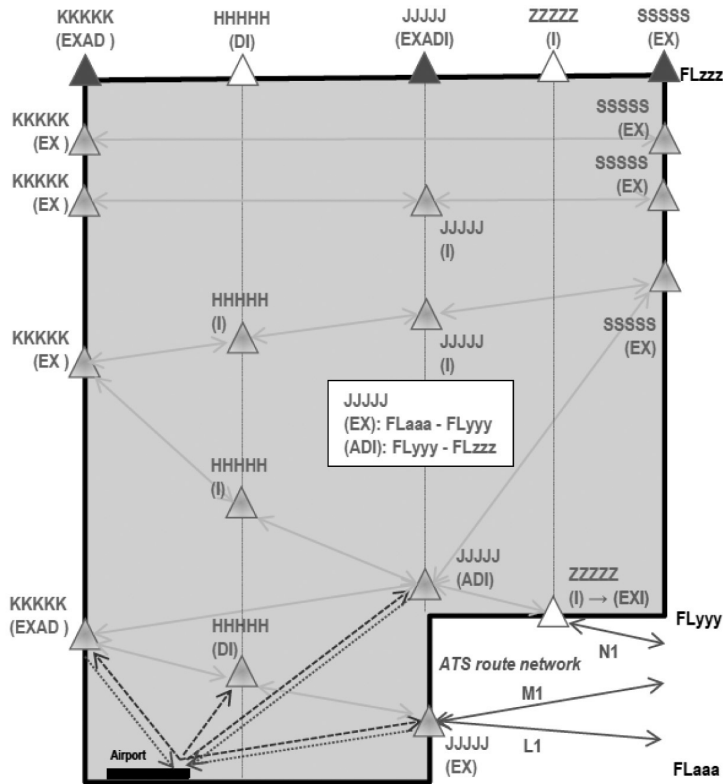
Fig. 3. Example of FRA point different vertical relevance

When reorganizing the structure of ATS sectors should be considered the following factors:
−   main air traffic flows;
−   transit flights avoidance, crossing sectors in short periods of time;
−   airspace allocation for military activities;
−   compatibility with adjacent ATS sectors and with terminal airspace;
−   civil-military co-ordination.

Vertical Limits of FRA

FRA Concept is aimed at facilitating the harmonised 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.
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. Nevertheless, with goal being a harmonised airspace structure across the European network, the following recommendations are made [1]:
−   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.
−   the minimum level should be the lowest feasible, taking into account the complexity of the airspace and the demand.

Horizontal Limits of FRA

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.

In areas where the shape of the lateral boundaries of an FIR/UIR or Air traffic control (ATC) unit are such that direct routings could lead to exiting for a short time into adjacent airspace, all efforts shall be made to ensure that applicability of FRA is organised based on operational requirements and appropriate arrangements are made with the adjacent ATC units/States. If such situations are unavoidable, the appropriate publication of FRA Horizontal entry/exit points shall be ensured.

If FRA is implemented in adjacent FIRs/UIRs, the publication of the FRA shall clearly reflect this cross-border application. The publication of FRA Horizontal entry/exit points on the common FIR/UIR boundary is not necessary from an operational perspective.

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 or ATC unit boundary.

In order to ensure overall European airspace structure interconnectivity, the FRA Horizontal entry/exit points from/into adjacent non-FRA shall ensure interconnectivity with the fixed ATS route network.

The Network Manager system is not checking the proximity of DCTs close to the FRA area border other than ±0.5 NM on both sides of the relevant border (Fig. 4) [6].
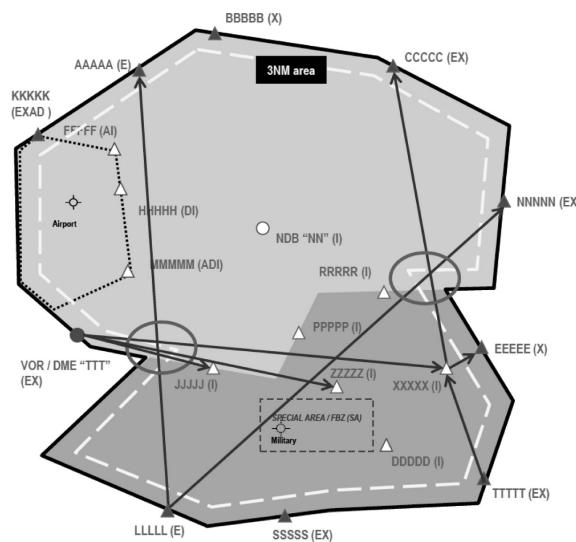

Fig. 4. Example of AUA FRA area border proximity violation

Vertical Connection between FRA and the underlying Fixed ATS Route Network

The vertical connection between FRA and the underlying fixed ATS route network should take into account the various climbing and descending profiles. The interconnectivity between FRA and the underlying fixed ATS route network [5] should be ensured through the availability of a set of waypoints reflecting the typical climbing/descending profiles (Fig. 5). The publication of extended SIDs/STARs or published connecting ATS routes are also operationally recommended options.
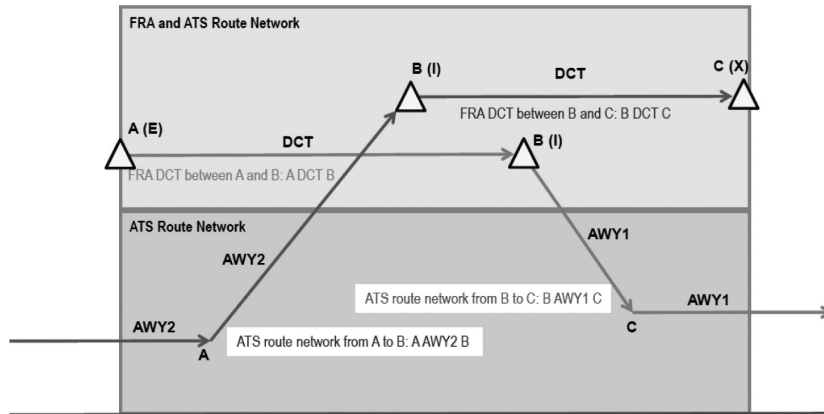
Fig. 5. Example trajectory of overflying traffic in FRA with ATS route network

5.7 FRA CONNECTION ROUTES

In the context of the FRA concept, access to/from terminal airspace and connection to/from aerodromes need to be considered. This may require definition of FRA connecting routes to facilitate flight planning, providing e.g. the route from FRA departure/arrival points to a published SID/STAR points at an aerodrome, or from/to an aerodrome within the Terminal Area (TMA), which does not have SID/STAR [5].

Proper access to/from terminal airspace and connecting to/from aerodromes located in close proximity outside the relevant FRA area may need to be considered.

This may require a definition of FRA Connecting Routes to facilitate flight planning and traffic distribution, providing the route from a specific FRA (A), FRA (D), FRA (AD) or FRA (I) points to a FRA (X), FRA (E) or FRA (EX) point or vice-versa.

FRA Arrival Connecting Routes may be established for aerodromes located either inside or outside the FRA area (Fig. 6).
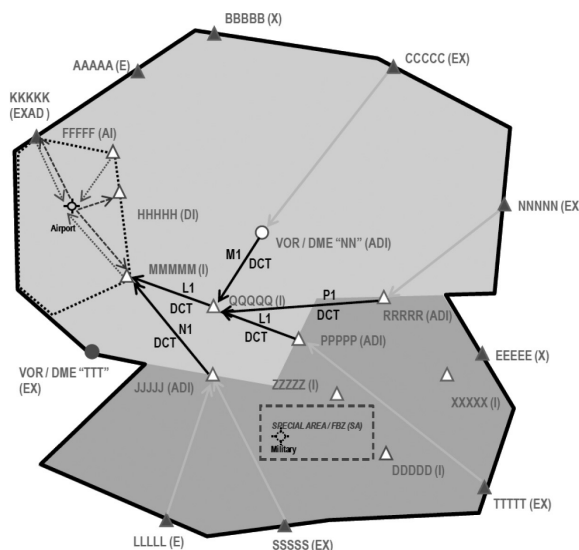

Fig. 6. Example of FRA Arrival Connecting Routes

When FRA (A) point is established outside relevantTMA any arriving flight can be planed via specifically defined (mandatory) FRA Arrival Connecting Routes which link the FRA (A) point with [4]:

− The first point of the STAR – for aerodromes with designated STARs; or
− Any FRA (I) point in close proximity to the relevant aerodrome described as connecting point for that aerodrome – for aerodromes without designated STARs.

FRA Departure Connecting Routes may be established for aerodromes located either inside or outside the FRA area (Fig. 7).

When FRA (D) point is established outside relevant TMA any departing flight can be planed via specifically defined (mandatory) FRA Departure Connecting Routes which link the FRA (D) point with [4]:

− the last point of the SID - for aerodromes with designated SIDs;
− any FRA (I) point in close proximity to the relevant aerodrome described as connecting point for that aerodrome - for aerodromes without designated SIDs.
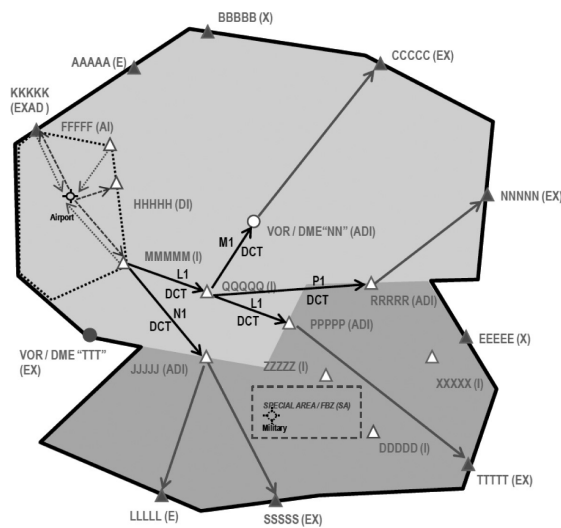

Fig. 7. Example of FRA Departure Connecting Routes

5.8 FLIGHT PLANNING

Within FRA, flight planning procedures are needed that are understandable and easy to use and that are coherent with procedures for the fixed ATS route network.

In addition to the normal flight plan validation rules within Integrated Initial Flight Plan Processing System (IFPS), the flight-planned route through FRA airspace shall be considered invalid if it:

− fails to comply with published FRA Horizontal entry/exit, FRA Departure/Arrival Connecting Points and any other airspace utilisation requirements;
− infringes an airspace reservation.

In order to benefit from the best operating conditions, airspace users may be allowed to use any intermediate unpublished points for flight planning defined by geographical coordinates or by bearing and distance.

In areas where civil/military coordination procedures and airspace conditions permit, the airspace users can be allowed to flight plan through airspace reservations. Tactical re-routings could be expected in case of areas not being available for civil operations.

5.9 AIR TRAFFIC FLOW AND CAPACITY MANAGEMENT

Large-scale applications of FRA or implementation of free route operations in adjacent ATC units will generate a large variation of trajectories. Real-time updates of the airspace situation with respect to both sector configurations and airspace reservations will be required in order to offer the most updated ATFCM situation at network/local levels.

Changes to sector configurations will need to be notified in real time to the NMOC to enable optimum network management actions. Appropriate procedures and system support to enable this flexibility shall be required. System support shall be in place to better predict trajectories in an environment where trajectories will be more volatile than in a fixed ATS route network.

Variable sector monitoring values, communicated in real time to the NMOC, will be required to reflect the changing traffic complexity.

The management of FRA is different to that of the fixed ATS route network and the NMOC will need additional system support and new procedures in certain areas such as [1]:
— taking into account routing schemes outside FRA;
— tools for ATFCM planning within FRA;
— tools for re-routeing;
— tool to calculate and manage traffic loads at a local level (Flow Management Positions) and central level.

5.10 MILITARY OPERATIONS

In order to enhance the airspace use flexibility, permanent airspace segregation should be avoided. Airspace allocation for the specific military activity should be kept to the minimum required in terms of time and volume.

Airspace, allocated for military operations, should be used during the published period of time and within the defined horizontal and vertical limits of specially established routes and areas (i.e. Temporary Segregated Areas, Temporary Reserved Areas and other AMC-manageable areas). Airspace management and civil/military coordination will be conducted in accordance with FUA rules and procedures.

The significant points shall be established in cases, if within the airspace allocated for military activities, ATS procedures are not provided and the level of civil-military coordination and activation status of activity in these areas do not allow GAT aircraft to cross that airspace. These significant points will facilitate flight planning and flight operations by means of bypassing this airspace.

In some cases re-routing could be provided at tactical level. GAT aircraft crosses or circumnavigates the activated airspace allocated for military operations, depending on the level of civil-military coordination and appropriate area status. In case Temporary Reserved Area activation the crossing of such area is permitted after an appropriate civil-military coordination procedures execution in accordance with FUA procedures subject

to the appropriate clearance. In order to perform various tasks there will be the possibility to change airspace configuration allocated for military operations.

Military exercises and training flights operations via specially established routes outside the published areas are provided by the establishing of airspace reservations on pre-tactical ASM level by the Airspace Management Cell (AMC) decision or by the appropriate ATM Centre decision by corresponding request for airspace usage taking into account the minimum influence to GAT.

The airspace reservation will be activated at tactical ASM level and GAT flights will be performed through this airspace after civil-military coordination procedures execution between ATS units and controlling military units according to FUA procedures. In certain cases, in order to provide the safe separation between GAT and Operational Air Traffic (OAT), there are possibilities for GAT flights to obtain ATC instructions for temporary change of FL or vectoring.

5.11 AIRSPACE MANAGEMENT

Airspace Management (ASM) in FRA will differ from that of the fixed ATS route network in that AOs will no longer be given information on which routes are available, but will need to know which airspace is available/ not available. For the transit period of a given flight through FRA, the airspace users will need to know the activity of all pertinent airspace reservations areas to enable the selection of a flight path that will avoid them.

ATC units, corresponding military authorities, airspace users and the Network Manager will need to know and share the same updated information with regard to activity of airspace reservations. Applicable procedures are available in ERNIP Part 3 – ASM Handbook – Guidelines for Airspace Management [7].

Airspace management of national airspace is implemented through FUA principles at three ASM levels: strategic, pre-tactical and tactical. These levels of airspace management cover the civil-military coordination tasks.

Airspace management at Strategical level provides measures to identify and, if necessary, revise the national policy on airspace management at strategical planning, in accordance with national and international requirements of airspace user's and ANSPs.

Airspace management at Pre-tactical level includes coordination procedures and daily airspace allocation to airspace users on a temporary basis in accordance with the State priorities.

Airspace management at tactical level comprises procedures on the day of operation related to activation, deactivation and real time reallocation of airspace, allocated at Pre-tactical level. Tactical level also means civil-military coordination procedures between appropriate ATS units and controlling military ATC units concerning possible conflict resolution during the air traffic service for GAT and air traffic control for OAT.

5.12 CIVIL-MILITARY COORDINATION

Civil-military coordination is performed in order to ensure safety of flights, airspace capacity, effectiveness and flexible use of airspace.

Civil-military coordination is carried out between civil and military authorities, other competent State aviation authorities in order to ensure safety in case of any activity potentially hazardous to civil aircraft operations is planned by any military authority, other state aviation authority.

Civil-military coordination at operational level is accomplished by AMC, ATM Centres with the appropriate military units in order to ensure safety of flights and effectiveness of air traffic during simultaneous flights of civil and state aircrafts, other airspace use activities and to control the order and compliance with national airspace usage rules.

5.13 COORDINATION WITH EUROCONTROL NETWORK MANAGER

The Eurocontrol Network Manager overall objective is to improve network operations and includes the following functions:
— develop an integrated ATS Route Network design;
— network management and operational functions improvements, including ASM and ATFCM.

The airspace design of FRA and ATC sectors shall take into account existing or proposed airspace structures designated for activities, which also require airspace reservation or restriction. With this aim, only such structures that are in accordance with the application of FUA shall be established.

The Eurocontrol Network Manager provides expert and software tools support for airspace design and sector capacity evaluation, such as Network Strategic Modelling Tool (NEST), The System for Traffic Assignment and Analysis at Macroscopic Level (SAAM), etc.

ATC units, corresponding military authorities, airspace users and the Eurocontrol Network Manager will need to know and share the same updated information with regard to activity of airspace reservations. ATC units, AOs and the Eurocontrol Network Manager should have the same information regarding the intended profile and routing of a flight, regarding both the initial flight plan and any subsequent revisions to that information.

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