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GIVING SUBSTANCE TO EUROPEAN FUNCTIONAL AIRSPACE BLOCKS

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**Abstract:**
This document presents an analysis of how functional airspace blocks could be defined, based on the analysis of past multinational initiatives, and a survey of the possible approaches which could be used.
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EXECUTIVE SUMMARY

The concept of Functional Airspace Block (FAB) is a cornerstone of the Single European Sky initiative. The principle is to define airspace portions independently of national boundaries constraints so as to allow for safety and efficiency gains in Air Traffic Services provision. Hence FAB appears both a tool for airspace design optimisation and service provision restructuring.

Although the concept seems easy to grasp, there is neither a clear method to map European FABs nor a clear-cut answer about the performed functions. What is known is that FABs shall adapt to future traffic pattern and maximise the efficiency of the ATM network. Also, the mapping of FABs shall take into account the assets of national providers, the transactions between Air Traffic Control Centres and ensure the configuration of upper and lower airspace.

From this background and to beef up the reflection on FABs, the objective of the paper is threefold: 1. it presents the FAB issue according to the expectations that have been progressively attached to it; 2. it reviews experiments and competing perspectives on FABs; 3. it discusses implementation processes.

The main findings of the paper read as follows:

1. **Expectations on FABs**

   In general terms, FABs have to be designed free from national boundaries constraint so as to increasing safety and efficiency in Air Traffic Services (ATS) provision. A key component to achieving that goal is reducing fragmentation in service provision. The task shall be considered in regard to the general functions assigned to FABs (i.e. adjusting to future traffic flow pattern, increasing the efficiency of the network). The general functions apply to optimising the components of ATS, namely; theoretical capacity for handling traffic or airspace design (routes and sectorisation); use of the capacity (Air Traffic Flow Management); operating Air Traffic Control (control of separations); ancillary services (services attached to Air Traffic Control such as meteorological services).

   The mapping of FABs requires to simultaneously defining the level of centralisation to optimising service components- and the degree of autonomy of providers in participating to FABs.

2. **Reviewing competing perspectives on FABs**

   Existing experiments and perspectives illustrate ways of considering FABs.

   A minimalist approach consists of fostering service co-ordination of providers on components of service (airspace design, ATFM, etc) over cross-border or airspace European regions by means of negotiated participation. An embryonic approach is the CHIEF project. Co-ordination plans would go deeper and be made binding.

   A step further is the creation of regional European Upper Airspace Centres (e.g. Maastricht, CEATS, NUAC) agreed under multilateral agreements. They include centralisation of operations, assets restructuring alongside with revenues sharing mechanism.
Not yet put to the test are three alternative approaches:

The first one makes use of mathematical algorithms to map regional European FABs. FABs are delineated to adjust the characteristics of air traffic flows, levels of traffic between city pairs, the search for direct routing and minimizing trajectory conflicts. Other variables such as Air Traffic Control Centres, can enter the modelling. The exercise has the advantage of mapping FABs from scratch independently of current airspace segregation and to draw comparison on performance with the existing situation. But although efficiency gains are studied from a theoretical perspective, the outcome is highly sensitive to changes in parameters values. In a way, rather than an overriding approach, the mathematical approach can come in support to the FAB decision-making process.

The second perspective defines FABs by focusing on the economic viewpoint. Congestion is the determining factor. It is concentrated in particular airspace portions. In these areas, service provision is more costly as it requires additional control staffing and investment. Airspace can therefore be divided into airspace clusters in proportion to required investment efforts. Then different charging levels taking into account difference in costs are attached to clusters. In other words, FABs are a tool for charging in proportion to cost of service and adjusting supply and demand accordingly. FABs are assumed to drive investment in congested areas and to enable convergence in charging at the European level. But, under such perspective, the airspace clusters do not necessarily define airspace continuums. So if economic FABs put first the allocation of resources, they do not guarantee for coherent physical division of airspace.

Finally, the third perspective takes the industry offering as a starting point. Here, industry does not refer to ATS providers but to Air Traffic Management equipment suppliers and third parties such as aircraft manufacturers, satellite providers. From the industry perspective, the technological progress already allows for speculating a complete rethink of Air Traffic Services provision (e.g. Boeing initiative, EADS alliance). The perspective envisions an airspace redesign that would replace the rigid system of control sectors and segregated flow zones. Although far-reaching perspective and only thinkable in the medium and long run, this new way of considering airspace blocks with flexible adjustments may offer promising insights for future developments on FABs. In particular it raises the issue of time frame in the completion of FABs. FABs shall not be drawn so that when operational they are already obsolete because using outmoded technology.

3. Implementation processes

The paper questions the implementation of FABs from three angles: 1. the integrative efficiency of FABs according to the reviewed perspectives; 2. the workability of the perspectives with regard to technology and the politics and economics of ATS; 3. the dynamic process of implementation, centralisation versus de-centralisation; bottom-up versus top-down approach.

Integrative efficiency

The paper considers integration as a source of efficiency gains: reducing fragmentation will enable benefiting from economies of transaction and scale although integration has a cost and may reach decreasing returns above certain level. The aim is to study to what extent, each perspective, taken in isolation, requires particular levels of integration in regard to the components of service provision: airspace design, ATFM, ATC operations.
For example, the minimalist co-operative approach on FAB, generalising the embryonic CHIEF project, would limit itself to the joint optimisation of sectors at borders (airspace design); the introduction of regional co-ordination mechanisms in flow management (ATFM); the exchange of sectors among existing ACC's and/or the provision of joint service under consortium structures (ATC operations). Under the circumstances, it will not necessarily entail a high level of integration of the current national ATS providers. Other more radical perspectives which foresee the grouping of large national airspace portions (increased centralisation in airspace design) alongside with restructuring (reconfiguration of ATC assets among national providers) would require higher level of integration.

**Workability**

Presumably, the higher the integration of services under FABs, the harder working them out. In that regard, the issue of workability can be examined from a three dimensional perspective: how far would the technology create uncertainty. Is the technology available and known? Will it be rapidly outmoded?; to what extent do the various perspectives on FABs raise institutional and political issues?; to what extent do the perspectives impact on economic regulation of service provision?

The three dimensional perspective covers a wide range of likely outcomes. For example, the CHIEF+ approach (limitation to optimising sectorisation at cross-border together with delegation to consortium of providers) is based on known technology. It simply requires increasing co-operation between national providers, presumably creating the conditions of systems interoperability and defining fair sharing revenue mechanism. In comparison, drawing FABs from a mathematical perspective, in isolation of current practice raise the issue of the robustness of the exercise. It requires arbitration at a European centralised level and convergence both in terms of redefining and managing airspace.

**Implementation**

The concept of FABs has so far been studied according to performing the optimising of service components. Under the proposed Single Sky regulatory package, the implementation process is laid out as follows: national providers are granted a European license to operate; a European Information Region is created above flight level 285; in this information region FABs are mapped out; member states agree jointly the provider(s) which will supply Air Traffic Services on FABs.

In setting the process into motion, the stress can be on particular approaches, which rely on a more or less degree of centralisation with a preferred bottom-up or top-down impetus. Thus, four alternatives are discussed: the combination of a fully de-centralised and bottom-up approach where independent corporatised national providers enter into alliances and assets restructuring, FABs being the outcome of commercial strategic moves from providers. A still de-centralised but more top-down approach, whereby national regulators under a European regulatory roof offer to tender delegation of service provision on chosen cross-border airspace portions. Then a more centralised European mechanism. It could be either based on European airspace design together with European regulatory contracts which are tendered to providers, or in even a more to-down approach, the mergers of national providers into a few European providers entities. They will be made responsible for managing regional European FABs.
GIVING SUBSTANCE TO EUROPEAN FUNCTIONAL AIRSPACE BLOCKS
The report is made of three sections: 1. it presents the FAB issue according to the expectations that have been progressively attached to it; 2. it reviews experiments and competing perspectives on FABs; 3. it discusses implementation processes.

**Section 1. THE FAB ISSUE**

To achieve a Single European Sky for Air Traffic Services, the European Commission proposes to implement transnational functional airspace blocks:

“The European Union Information Region shall be reconfigured into functional airspace blocks of minimum size on the basis of safety and efficiency. The borders of such functional airspace blocks do not need to coincide with national boundaries.”

(Article 5, paragraph 1, Proposal for a Regulation on the organisation and use of the airspace in the Single European Sky, submitted to the European Parliament, 10 April 2002, PR 465295EN.doc)

How to think these airspace blocks? What should be their ultimate purpose? Which principles would help defining their boundaries?

**1. Fragmentation and expectations**

A Single European Sky was on the political agenda forty years ago. The political attempt was to create a single European provider responsible for en-route Air Traffic Services.

As it failed, the definition of routes, sectors, the military airspace and the service provision have been managed under a national rationale. Co-operation, delegation of service between states has occurred on voluntary bilateral and multilateral air treaties. Within Eurocontrol Agency, which has lacked political power, the search for consensus has prevailed, preventing bold and binding initiatives.

Such architecture has reached its limits. The liberalisation of air transport has given rise to unprecedented traffic growth that national providers have proved unable to cope with – see Performance Review Commission reports and the European Commission documents ¹.

A key finding has been that fragmentation of airspace and service provision along national boundaries creates structural inefficiencies -sub-optimal flight routing, lack of interoperability, insufficient harmonisation of procedures. Among others, not only airspace is defined according to national boundaries but also vertically. Member States have organised differently in the definition and management of their lower and upper airspace. Impacts of their decisions on neighbouring countries have received scant attention. The European Commission has highlighted these drawbacks when considering delays:

“..many of the bottlenecks that cause delays stem from insufficient planning at the European level of national airspace design and air traffic control organisation .”

(Single European Sky, 2000, p.10)

Recently, the tragic accident of June the 30th over the lake of Constancy has reminded that national fragmentation not only caused delays but also proved a source of complication in co-ordinating Air Traffic Control operations.

Therefore both on safety and efficiency grounds, the baseline toward an integrated European management of airspace is reducing fragmentation.

However, although national boundaries are certainly not defining optimal solutions for airspace design, there is no clear view about what shall be the minimum size of a regional airspace block and what would be the associated efficiency gains. Reporting on the Single Sky European Commission proposal, the European Economic and Social Committee underlines:

“Would the reconfiguration of the upper airspace architecture bring the expected improvements with regard to routes, sectors and what would be the assessment criteria? …… in any case, will remain commercial interests that could well prevent the implementation of optimal regional functional airspace blocks.”

(European Economic and Social Committee, R/CES 312/2002 EN-RD/jg) – translation into English from the authors

2. Defining airspace blocks

The European Commission has commissioned three studies in year 2000, respectively on airspace design, market organisation and economic regulation. All three studies have converged on the need for re-organising the management of the European airspace alongside with the implementation of transnational airspace blocks. By freeing the organisation and the provision of ATM services from national historical and geographical constraints they expect increases in traffic control capacity, efficiency improvements and costs savings.

Each study has stressed on particular items.

The Airspace Design study refers to the concept of airspace continuum and the setting up of ‘Functional Airspace Blocks’ (FABs) which will no longer be dependent upon national boundaries. Airspace continuum is defined as:
“a coherent block of airspace designed on the basis of uniform principles and criteria. An airspace continuum will become an operating continuum if uniform airspace management procedures and safety standards combined with seamless ATS provision are applied.”

The following four elements are considered to be essential components of an Operating Airspace Continuum:
- Uniform high safety standards
- Uniform airspace design beyond national borders
- Uniform airspace management
- Seamless air traffic management (on a national and European levels).”

(Study for the European Commission on the regulation of Airspace Management and Design, 12 April 2001, p. 20)

The study advocates:

“A common Uniform Information Region (UIR) encompassing the upper airspace of the EU Member States, Norway and Switzerland and managed as a continuum would allow European planning to overcome regional bottlenecks…….The European Regulator would assume ultimate design responsibility for establishing an upper airspace continuum where responsibility of the Air Traffic Service Providers (ATSPs) would be delineated by respective Upper Control Areas (UTAs) that are irrespective of national borders. The design of UTAs should be taken as a unique opportunity to establish FABs as large cross-border areas wherein control responsibility is assigned to one ATSP or a group of ATSPs……. As an important measure it should be considered as a next step to establish FABs in regional airspace below upper FABs or separate where appropriate to solve cross border problems for medium haul intra European traffic…. At a later stage, a single Flight Information Region (FIR) Europe that encompasses lower and upper European airspace could be envisaged.”

(Study for the European Commission on the regulation of Airspace Management and Design, 12 April 2001, p. 23)

If not intently dealing with the restructuring of airspace, the two other studies – i.e. market organisation and economic regulation – refers to the need for setting up transnational airspace blocks.

Bearing in mind the impact of future technology, the market analysis points out:

“The responsibilities, tasks and liabilities of controllers and pilots will be changed. Sectors, especially but not exclusively in upper airspace, may become significantly larger and traverse national boundaries……. In order to maximise the benefits of investment in technological development, there will be a need to enable the consolidation of airspace to allow airspace to be treated and managed as a continuum. This requires two levels of cooperation:
(a) at the State legislative level to facilitate delegation of the provision of services in sovereign airspace
(b) at the service level provision level, to consolidate services, infrastructure, etc., in order to provide a joint service in the merged volume of airspace.”

(Study for the European Commission on Air Traffic Management (ATM) Market Organisation, 23 February 2001, p.28)
Moreover, to enable the impacts of advanced technologies, the Market Organisation study considers the scope for service provision restructuring:

“The approach to the development of transnational systems has generally been through the formation of a consortium of service providers to develop and implement the technology with the ultimate aim of providing the regional service. One method of undertaking this type of joint service offering would be through the formation of a European Economic Interest Group (EEIG).”

(Study for the European Commission on Air Traffic Management (ATM) Market Organisation, 23 February 2001, P.29)

As for the economic regulation study, the restructuring of the upper European airspace assumes the definition of airspace zones of operational co-ordination (ZOCs) in a perspective almost similar to FABs but with an emphasis on efficiency gains as a main driver to their definition:

“They (ZOCs) are cross-border airspace blocks where increase in efficiency will stem from co-ordination between national providers… Current voluntary co-ordination such as the CHIEF project (CH for Switzerland, I for Italy, E for Spain and F for France) has proved successful. This type of embryonic operational co-operation produces important efficiency gains. Generalising and deepening such agreed co-ordination would add efficiency gains. It could rely on defining and isolating ZOCs according to a set of primary indices (location of airports, traffic complexity, and density).”

(Study for the European Commission on Economic Regulation)

In order to make ZOCs effective, the economic regulation recommends them to be associated with Pooling Resources Alliances (PRA) responsible for operating them in respect of regulatory contractual agreements based on incentives to performance:

“Co-operation occurs by means of Member States delegation of service provision to ZOCs and by involvement of national services providers in setting up Pooling Resources Alliances (PRA) schemes. In setting up a PRA, the involved service providers attached to a particular ZOC will be free to choose the appropriate form of co-ordination and restructuring (contractual relationships, Joint Ventures, creation of service provision entities). To facilitate the management and mobility of human resources, controllers allocated to ZOCs will receive additional training (European specialisation degree) and be given special status…. Co-operation can be encouraged through economic regulation: making co-operation financially attractive and non co-operation a financial disincentive…. Unit Zone Rates will be introduced and be based on Unit Service (US), quality (Delays), service level targets…. The distribution of revenues from service provision on ZOCs will be agreed between the involved Member States.”

(Study for the European Commission on Economic Regulation)
Thus, the European Commission High level group report and studies carried out later make the implementation of transnational –i.e. cross border- FABs a prerequisite for an effective Single European Sky.

As it emerges from above, several perspectives and methodologies have been put forward. But none enters into sufficient detail to allow for drawing the geographical boundaries of European FABs.

The regulation proposal on the organisation and use of airspace in the Single European Sky, submitted to the European Parliament and the Council, do not provide with much additional technical guidance, but it restricts FABs to the upper airspace and stresses on assets restructuring in service provision:

 Artikel 3

 Definitions

 (1) "functional airspace block" means an airspace block of optimally defined dimensions"

 Artikel 4

 Creation of a European Upper Flight Information Region. The division level between upper and lower airspace shall be set at flight level 285

 Artikel 5

 Reconfiguration of the upper airspace

 1. The EUIR shall be reconfigured into functional airspace blocks of minimum size on the basis of safety and efficiency. The borders of such functional airspace blocks do not need to coincide with national boundaries. Functional airspace blocks shall be created to support the provision of air traffic services within area control centres responsible for an optimal size of airspace in the EUIR.

 3. Functional airspace blocks shall be defined in accordance with the procedure referred to in Article 16(2). The definition of such functional airspace blocks shall:

 (a). support efficiently the existing and future pattern of air traffic;
 (b). ensure that each airspace block is designed to maximise the efficiency of European airspace as a whole;
 (c). take into account the human and capital resources of various air navigation service providers;
 (d). minimise the transactions between various area control centres
 (e). ensure configuration of upper and lower airspace.

 (Commission of the European Communities, COM(2001) 564 final/2)
3. Functions

Mapping FABs is not only a question of size and boundaries. The functions attached to an airspace block define at the same time what is performed for a particular area –the purpose of the airspace block- and in accordance who will manage it.

But what are the functional criteria?

As a general meaning, functions refer to safety and efficiency rather than historical and political geography (see airspace design study p.64). But in generic terms, they do not provide with answers when it comes to operations. Nor is addressed the issue of potential trade-offs between safety and efficiency. It also refers to adjustment to future demand (traffic pattern), network effects and optimising transaction between area control centres.

These objectives can be studied in regard to the Commission market and economic regulation studies which split Air Traffic Services into four categories: airspace design (infrastructure), Air Traffic Flow Management, Air Traffic Control operations, ancillary services. Operating an airspace block will require combining the four services. In future ancillary services are likely to be provided through market forces. Therefore, they will less be a characteristic of FABs.

FABs shall be mapped as to optimised each category of service provision, and optimising means safety and efficiency criteria. Criteria shall apply to airspace design (the network of routes and sectors), to managing with traffic flows (organisation of ATFM); to Air Traffic Control operations (handling of flights).

4. FABs and the optimisation of service

Safety and efficiency criteria questions the adequate level of centralisation in service provision and consequently the size, number and purpose of FABs:

- Airspace Design: to what extent the route structure and sectorisation shall be handled centrally? What would be the appropriate number of large airspace blocks? Could European airspace blocks be isolated above a certain altitude –FL285 upwards (above FL300, overflights dominate)- on a European basis?

- ATFM: shall it be fully centralised and de-centrally run? What would be the regional relays for Collaborative Decision-Making processes? Should they be attached to operating airspace blocks?

- Air Traffic Control: the number of civil en-route ANSPs for the Eurocontrol area is 26 against 1 in the US for half the surface coverage. The number of en-routes centres is 58 (41 covering the EU) against 21 –see PRR4, April 2001. Shall airspace blocks be a tool for restructuring ATCs and ANSPs? What would be the optimal centralisation of Air Traffic Control operations?

It is not clear whether optimisation will require identical centralisation according to services and how could the centralisation levels match the mapping of FABs.
5. Finalising FABs

The sovereignty principle applies to Air Traffic Services provision. Even if provision can be delegated, nation states are held responsible for ensuring safety. Also charges shall not subsidise other services not related to provision.

Moving from national fragmentation to transnational FABs requires deciding upon a pathway. At the extremes FABs can either result from spontaneous voluntary member states initiatives or be centrally managed by a European entity.

In the case of voluntary bi or multilateral arrangements, incentives have to be devised so as to promote the interest of the member states to create or join in FABs -bottom up approach. At the other extreme, the fully centralised member states would comply with binding FABs mapped by a supranational authority –top down approach.

With no intent on dealing with the institutional perspective, how will FABs be regulated and what would be the relationship with national regulation and regulators? How would be organised regulation and constraints –a co-operative model based on Commission benchmarking and meetings with national regulators? What could be the meaning of a European regulator in relation to FABs?
Section 2. Elementary experiments and perspectives on FABs

Co-operation among service providers, delegation of service provision, European wide projects managed under the auspices Eurocontrol have been in place for long. The section gives account of some of them from public sources. Other approaches on airspace blocks are also singled out.

1. Precursors of FABs

Multinational and multi-centre co-operative projects aim at rationalising sectorisation and creating additional capacity. The most important ones relate to developing Trans-European projects such as “Highways of Sky”. Among them, the Area South of Europe project known as CHIEF –standing for Switzerland, Italy, Spain and France- makes up a regional airspace block from an airspace design restructuring perspective.

CHIEF looks for outcomes similar to airspace blocks in regard to the optimisation of airspace design. This form of co-operation does not entail the transfer of Air Traffic Control assets or changes in delegation of service. It simply requires a joint-decision mechanism on key items in order to increase efficiency in the system.

Generalising it to more binding cross-border re-sectorisation could further enhance the co-operative approach. Mapping of FABs would concentrate on national boundaries and critical nodes from a fresh look at the current situation. To make it workable revenue would be shared by providers according to a satisfactory allocative mechanism between parties.

Skyguide has advocated the scenario of generalising co-operation:

“Overambitious plans will unavoidably lead to failures, possibly endangering not only individuals elements of the Single European Sky, but the concept as a whole.

….. The key to a successful FAB is related to the process applied for the design of the concept. Work must begin with an operational focus, with the view of defining the most technically sensible solution.

…. As explained above, the traditional way of organising ANS has been to build sectors closely following national boundaries. Such an approach will unavoidably result in an inefficient ATC system, in particular where crossing points are located close to sectors boundaries, depriving Air Traffic Controllers of the required distance to anticipate conflict resolution actions. The remedy in an airspace structure based upon political borders is to distort the natural flow of air traffic in such a way as to move crossing points away from the limits of controlled sectors. Airspace users are penalised because the unnecessary longer distances to fly.
The most logical first step in the design of FAB would be to start with a blank sheet of paper and to draw natural flows of traffic passing through a given area with reference whatsoever to national boundaries. From that process, the broad contours of a logical operational envelope will emerge, which will become the outside limits of a FAB."

(Francis Schubert, Corporate Secretary, Skyguide (2002) : “How to build a Functional Block of Airspace”, pp.4-5

As a first step, such co-operative mechanism could apply to FABs upper airspace. It would emphasise the importance of a full respect of national sovereignty with practical and realistic solutions. Later could be implemented more radical changes.

2. Regional European centres

Another approach is to consider airspace blocks from an ACC perspective. A control centre is set up to handle a European regional airspace block under multilateral agreements.

Three examples of European regional en-route centres provide for examples: Maastricht, CEATS and NUAC

Maastricht UAC

The Maastricht UAC illustrates an evolving development of the regional FAB concept.

At start in 1964 Belgium was the first Member State to delegate the en-route control of its upper airspace –above FL195- to Eurocontrol, to begin with at Brussels National airport and later in 1972 at the Maastricht Centre. Two years later, the Centre was entrusted control over the Northern German upper airspace –above FL245. In 1986, the Netherlands agreed to delegate to Maastricht provision of service for its upper airspace –above FL300. In 1993, the Centre was given the responsibility for en-route control of traffic flows above FL245 with a reorganisation of the Belgium upper and lower airspace. In addition the Maastricht Centre hosts a DFS military control unit.

Dealing with complex flows –ascending and descending phases, Maastricht has evolved towards a more upper airspace control centre but without having reached the flight level 285or 295 separation which might be a mark for qualifying for FABs.

The organisation tends also to reproduce national boundaries. Maastricht is divided up into the Hanover sector group, the Brussels sector group, the Delta-Costal sector group. In other words, control carries on being based on national consideration and revenues are split in proportion to traffic handled nationally –Luxembourg (1.06%) ; Belgium (34.39%) ; Germany (43.78%) ; The Netherlands (20.77%) (see Maastricht report 2001).

In short Maastricht –except for German adhesion- materialises the sensible combination of airspace portions that are too small to be efficiently run on a strict national basis. It is a transnational arrangement resulting from a ‘Minimum Efficient Size’ rationale rather than an attempt of creating a particular centre dedicated to manage an enlarged airspace block and/or specialising in high level flights service provision.
Central European Air Traffic Services UAC

CEATS has been made official by the signature of a multilateral agreement on 27 June 1997. It a a new common Upper Area Control Centre which covers a large part of the East European airspace: Austria, Bosnia and Herzegovina, Croatia, Czech Republic, Hungary, Italy (the northern part which consists of the sectors of Padova ACC), Slovakia and Slovenia. The regional airspace block is defined vertically above FL285/FL290, which in itself makes it coherent with a Transeuropean network, and management of overflights.

Eurocontrol stresses the expected benefits from CEATS and details the technical tools to achieve that end:

“to enable an increase in capacity and a decrease in the cost of services per unit while maintaining the flight safety by:
- uniform airspace procedures
- optimal sectorisation regardless to national border
- direct routings
- uniform and cost recovery implementation of new technologies and concepts
- sharing of resources.”

(CEATS operational concept document, 2002)

CEATS is scheduled to be operational by 2007-2010. Rather than a ‘big bang’ approach with duplication of investment and sudden switch to the new Centre, a step by step approach has been preferred:

“the migration from the current situation to the target situation will be through several stages where the current centres are gradually transformed to a virtual centre. Once this is achieved, it should be a simple matter of relocating resources to rationalise the number of centres in the area. The virtual centre involves the gradual harmonisation and where possible, integration or unification of:
- regulation, including licensing and certification;
- airspace management, including intra-centre, inter-centre and civil/military co-ordination;
- systems, including surveillance data processing, flight data processing systems and HMI;
- human resources management, including training and working conditions”

(CEATS presentation background, 2002)

The regional Easter European FAB has been phased in as follows:

CEATS Strategy Planning and Development Planning (CSPDU), Prague, November 1999. It is in charge of developing a co-ordination strategy, budget and control,
CEATS Research, Development and Simulation Centre (CRDS), Budapest.
CEATS Upper Control Centre (CUAC), Vienna, 2007-2010. At present, 7 ACCs about 500 controllers provide service for the CEATS FAB in 1998, they handled 1 million arrivals/departures and over 1.6 million overflights. CUAC will centralise provision of services and ‘optimise the use of resources, in order to reduce the unit cost’. 

GIVING SUBSTANCE TO EUROPEAN FUNCTIONAL AIRSPACE BLOCKS
The creation of the CEATS FAB relates to the provision and operation of Air Traffic Services and facilities by Eurocontrol. The agreement reinforces the role of Eurocontrol as ANSP. Eurocontrol will manage the CEATS Centre, which will get a separate budget. As an ANSP, Eurocontrol will have freedom to take out insurance to cover all risks connected to operations and liabilities –revenues, losses, damages.

The national contracting parties agree sharing essential facilities –radar, telecommunications, and flow control facility- for operations. They -as Eurocontrol- have after a four years period from the date of the agreement entering into force the possibility to express their intention to withdraw. It will then be effective after six years from the date of notification.

Different to Maastricht, the CEATS initiative makes FAB a tool for ANSPs and ACCs restructuring. In that respect, the Eastern European FAB crosses boundaries of seven ANSPs and eight national boundaries. Such process is timetabled on a five to seven years period before completion. This time length raises the issue the virtual centre in progress –i.e. the convergence process- and its adjustment to new technologies. With regard to restructuring assets, should a stepwise approach be better than a big bang approach?

NUAC

The NUAC project corresponds to the creation of a quasi European Nordic regional FAB, even if it does comply with the European FIR principle. It covers the upper airspace of Denmark, Finland, Norway, and Sweden.

There are particular characteristics attached to the Nordic FAB project that have probably made it easier to get commitment.

In the first place, one Nordic Airline Company dominates over the Nordic airspace. SAS is the first buyer of ATS in Sweden (44%), in Norway (42%), in Denmark (35%). SAS has hubs in Copenhagen and Stockholm, and the main airline company at Oslo. Therefore, there is overall balance between the monopoly power of the ANSPs, the suppliers, and the purchasing power of the main user of service, the buyer. Under the circumstances, the emergence of a collaborative environment between suppliers and buyer is more likely. The situation is unique in Europe.

A second characteristic is the civil-military interface. The Nordic region has airspace availability for making the military issue less complex when mapping the FAB. For example, in the case of Sweden, the drawing of routes and sectors dedicated to the military has been decided in the less dense civil traffic areas. Besides, in Sweden, civil and the military have been subject to integration –quite similar to Switzerland and Germany. In 1966, they were two separate ANSPs. It took about ten years to integrate both systems with operational units in 1978. The governing principle has been a clear division of responsibilities. The Luftfartverket (LFV), the Swedish Civil Aviation Administration, is responsible for peace time manning of all ATS units. The Swedish Armed Forces (SAF) will take over at times of tension or war, managing the LFV staff. Formal agreements between LFV and SAF have been signed. They detail the co-ordination decision-making mechanism, the sharing of costs and financing of investments. The staffing of LFV numbers 1200, 20% of controllers working at military airports, all controllers being in capacity to handle both civil and military traffic. The military itself makes use of civil airports. Hence controllers are used to controlling military flights. Also, as in other countries, the military have reserved training airspace blocks but clearance is given on the basis of meeting civil needs.
The third characteristic of the NUAC experiment is the nature of the restructuring process. The NUAC project is not so much the instrument for change as the consequence of the need for change. Sweden has given the impetus. In 1998, new direct routes were introduced which have received the support of politicians. Attempts to think how to increase and better manage capacity were made. So far Sweden has had three ACCs, Malmö, Stockholm and Sundsvall, each in charge of a FIR. Different options were debated so as to determine whether one or two Centres would be most appropriate. Apparently, from interviews at the LFV, the choice of two centres has rather been made on political than technical grounds. NUAC is itself in line with the Single European Sky perspective. It introduces separation between lower and upper airspace at FL285, and it promotes restructuring. It leads to a two centres option, one in Malmö for en-route upper airspace control, the other one in Stockholm for lower airspace. The efficiency gains of the operation seem not so much lying in less costly co-ordination or better direct routing but in re-sectorisation at the borders in the North as in the South of the Nordic airspace. Sweden with Denmark are leading the NUAC initiative. It is phased that the upper Swedish airspace will first be separate and service provision restructured with two ACCs in 2004. Then Denmark will join in and subsequently Norway and Finland, NUAC being scheduled to be operational in year 2006.

The fourth characteristic is that NUAC does not intend to reproduce the Maastricht organisation with respective nationals controlling national airspace. The aim is to create a transnational management of the upper airspace Nordic Region, revenues being allocated to a likely NUAC private entity of which member states would be shareholders.

Representatives at the LFV insist on two basic processes and overcoming one hurdle to a successful transnational FAB restructuring: the involvement of all parties and in particular the controllers; a sustained political will and commitment; the hurdle being the regulatory framework. The predicament is to see NUAC getting bogged down in complying with different national regulatory frameworks. Even if a joint regional regulatory Committee can be studied, the idea of a regional regulator might be more appropriate.

3. Drawing FABs from mathematical and statistical algorithms

Mathematical and statistical algorithms are used to optimising airspace design and drawing FABs. Work currently carried out at the Eurocontrol Experimental Centre on HADES (airspace design) and COCA (complexity indicators) helps drawing FABs from such perspective.

Under the HADES approach, a FAB is considered an optimised envelope where continuity of airspace and routes are required. The starting point is the demand side. Airline traffic flows with minima of traffic between city pairs are computed. Then, an optimised network of routes is drawn which seeks the maximum use of airspace. Constraints on military areas, Air Traffic Control Centres can be included in the modelling. The sectorisation outcome stems from routes and traffic flows.
Sectorisation is based on the creation of airspace volume units. The frontiers of the airspace units are drawn according to city pairs and crossing points. Then they are assembled into sectors so as to maximise a fitness function, which takes into account workload control, and complexity indicators. The function allows for a sector not to exceed a particular workload threshold and ensure a minimum flying distance in it. The last step consists of going from sectors to coherent FABs and European ACCs taking account of reactionary impacts between sectors.

Such mathematical algorithm does not draw sectors, FABs, from the existing situation. In this regard, it is easy to illustrate that the outcome of the process does not match the division of the European airspace along the existing national boundaries, even if the results can be subject to debate as the FABs frontiers depends very much on parameters values.

The algorithm can also be used in different configurations. It can apply to an existing set of routes and network and/or to existing sectorisation.

The interest of the abstract mathematical approach is to propose a number of coherent FABs from an optimised airspace design perspective. The results of simulation can then be compared to practical FABs options or else, from existing airspace design. From that interaction FABs can be drawn and might prove a power tool for discussing ANSPs FABs proposals.

4. Drawing FABs from an economic perspective

From an economic perspective FABs are tools for service provision restructuring. FABs are looked at as economic entities to which are attached revenues and management of assets. They are mapped so as to maximise economic efficiency –maximising economies of scale, minimising the costs of co-ordination, rationalising assets.

For a given airspace block, service provision has cost function that varies according to the level, the density and complexity of traffic. If cost-related a charging mechanism shall allow more revenues to complex areas where control is made more difficult and requires additional manning. Besides congested areas where delays are high shall be the focus of attention as they raise the issue of quality of service. Investment shall therefore be allocated to improve level and quality of service.

A starting point is categorising airspace with the help of economic related indicators on complexity, level of service, delays, and revenues. Large airspace portions can then be drawn congruent with the economic indicators.

For example, and although of limitation as FABs are only thought as clusters of countries, economic study illustrates that a single charging mechanism including a financial compensation to airline companies when they experience delays could apply uniformly to group of countries:
The data and econometric analysis suggest that such outcome (i.e. a new unit rate profile consistent with European uniform financial compensation on delays) could have been achieved by grouping countries into three clusters (i.e. economic FABs): small national airspace portions at crossroads of most frequently European flown routes (The Benelux and Switzerland); peripheral countries (Nordic countries, Ireland, Portugal and Austria); large European core countries (France, Germany, Italy, Spain, the UK)

(Hervé Dumez & Alain Jeunemaître, “Introducing financial compensation to airline companies for lack of capacity provision”, Nextor, The Aspen Institute, 19/20 March 2002

Hence, instead of national charging mechanism, remuneration for provision of service can be based on transfrontier airspace blocks. The overriding principle is to make charges coherent with complexity in service provision and search for increases in capacity and efficiency gains. These transfrontier airspace blocks define FABs.

Instead of airspace nation states, the economic perspective can apply to sectors. The uniform charging mechanism applies to cluster of sectors, which are comparable from an economic perspective. These clusters are economic FABs, but the latter are no longer in the limits of an airspace continuum.

5. The future of FABs

The creation of FABs is a dynamic process. FABs are currently studied and will be drawn from existing available technology, taking on board future equipment developments. It pictures an evolutionary model, which seeks safety and efficiency gains by reproducing the traditional vision of service provision. Based on experiments in progress (CEATS, NUAC) the evolutionary model is likely to necessitate at least several years to completion.

A key issue is to consider the evolutionary European strategy in the light of a complete rethink of service provision. In particular what might be the impact on FABs of the technological quantum jump proposed by Boeing and to a certain extent EADS?

Although not completely new the approach is voluntarily revolutionary as it introduces a radical new vision. The vision is based on satellite communications and positioning. It contends a move of Air Traffic Control from ground facilities to aircraft cockpit:

Aircraft-the synthesis of a variety of informations about an airplane's position, altitude, speed, and intended flight path into a unified, easy-to-interpreted graphical representation. Trajectory-based applications let users confidently predict where an airplane will be at some future time.

Common Information Network-a central airspace information resource that links system users and operators to real-time information about aircraft trajectories, weather, air traffic flow, and other air traffic system conditions.

Redesigned airspace-replacement of the complex, outmoded system of control sectors and segregated flow zones with a simpler, more open, managed-flow configuration.
The proposed concept envisions a redesign of the airspace. En-route airspace will not be divided and subdivided into sectors in response to air traffic volume fluctuations. Individual air traffic managers will be able to handle more aircraft and larger volumes of airspace reducing at once the proliferation of sectors, control sector radio frequencies, and the respective routine of handoffs as airplanes cross from one sector to another. At and around airports, the need for expansive controlled airspace will be minimised, and fly-through routes will be reserved for general aviation.

Extensive changes to airspace structures, airspace management, and procedure definition will be needed to achieve the safety and capacity of this phase. Fundamental changes to the air traffic controller’s job are envisioned – a transformation from air traffic controller to air traffic manager. Even the separation assurance function is envisioned as one of management, not control.

Boeing Air Traffic Management (2002): Revolutionary concepts that enable air traffic growth while cutting delays

Thus different visions about ATM future are competing. The Boeing one is quite compelling as has political and financial strength and is based on process (the Working Team Together group) which ensure co-operation between stakeholders (airline companies, ATM industry, etc.)2. By contrast, dealing with the objective of restructuring and improving efficiency, FABs seems so far to accommodate with an evolutionary perspective. What is unclear is to what extent the concept will prove able to adjust to radical technological shift such as advocated by Boeing. Not only, the boundaries of FABs but the vertical separation of airspace between lower and upper would be changed. Here the concern is the lost of investment and efforts because sticking to outdated ATM improvement answers.

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2 Hervé Dumez & Alain Jeunemaitre ‘Revolutionary versus evolutionary strategies: the future of ATM service provision from a supply chain perspective’, EEC Note N° 12/02 /CRG-Ecole polytechnique, September 2002
Section 3. Implementation processes

Section 1 and 2 have reviewed the definitions, experiments and perspectives in relation to FABs. The following section discusses the issue of implementation. A three-step analysis is proposed. Rather than finding outcomes the analysis attempts to develop viewpoints that could be worth considering before mapping FABs.

In the first instance, FABs are looked at in relation to the objectives of reducing fragmentation, restructuring airspace and service provision. The experiments and perspectives are gauged according to their likely consequences on the different services (optimisation of Airspace design, of ATFM, of Air Traffic Control operations). The consequences have been defined as integrative efficiency. It underlines the fact that optimising services can necessitate a more or less integrative approach between providers and that the end result might be more or less efficiency.

In the second place, as FABs’ may require lower or greater involvement from ANSPs, national and European institutions, the issue is about how realistic can be the implementation. Hence workability shall be considered in regard to technology certainty, political feasibility, economic efficiency.

Finally, the definition of an operational process is addressed. How to set it into motion is the focus of the final part of the section. It discusses centralisation versus de-centralisation, bottom-up versus top-down approach.

1. FABs and the integrative efficiency

The integrative efficiency is given by service according to the level of integration that the experiments and perspectives necessitate.

The main perspectives to create FABs reads as follows: the co-operative CHIEF + model; the creation of European UAC such as NUAC; the drawing of FABs from a blank sheet taking into account considerations on traffic flows, routes, complexity; the drawing of FABs from an economic perspective; the revolutionary perspective.

The following table summarises likely outcomes of different perspectives. For example, the CHIEF+ co-operation project does not require a high degree of integration. Neighbour providers at cross-border locations can remodel airspace design. From that remodelling ATC operations can be handled by joint venture business types or consortium. At the other extreme, the revolutionary approach based on satellite and new ground facilities would require the higher degree of integration. It would mean thinking the European future in relationship with the US, new practices in considering flow management and presumably the creation of a new supranational entity to manage en-route services.
Table 1: Integrative efficiency on FABs

<table>
<thead>
<tr>
<th>CHIEF+</th>
<th>Airspace Design</th>
<th>ATFM</th>
<th>ATC</th>
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<tbody>
<tr>
<td>Optimisation of</td>
<td></td>
<td>Local co-ordination</td>
<td>Consortium</td>
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<tr>
<td>Sectors at the borders</td>
<td></td>
<td></td>
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</tbody>
</table>

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<thead>
<tr>
<th>NUAC/CEATS</th>
<th>Group of countries</th>
<th>Regional</th>
<th>Creation of European</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redefinition lower/upper airspace</td>
<td></td>
<td>centralisation</td>
<td>regional centres</td>
</tr>
<tr>
<td>Re-sectorisation</td>
<td></td>
<td></td>
<td>Assets restructuring</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Algorithms HADES/COCA</th>
<th>European Airspace design</th>
<th>Centralisation</th>
<th>ACCs restructuring through re-allocation</th>
</tr>
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<td></td>
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<table>
<thead>
<tr>
<th>Economic Clustering</th>
<th>European Airspace design without continuum</th>
<th>Economics of ATFM centrally managed</th>
<th>European financial incentive framework</th>
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<td></td>
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</table>

<table>
<thead>
<tr>
<th>Revolutionary</th>
<th>Europe and US</th>
<th>Trajectory analysis</th>
<th>New commercial entity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Introduction of new tools</td>
<td></td>
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</table>

But the table says probably a bit more. To begin with perspectives are not exclusive even if looked at in isolation. For example, a mix between the algorithm an economic perspective can be thought of: the optimisation of the sectorisation from a traffic flow perspective will result in FABs. Each FAB will then be considered as the summation of sectors that belongs to defined economic clusters. Each charging regime on FABs would then adjust accordingly.

The integration process can also be uneven when dealing with services. For example, a possibility is to have Airspace designed defined from a European perspective. But it would not necessarily entail a particular level of integration of service providers. The providers could just adapt their operations to new routes and airspace corridors. On the other hand they can also merge several of their ACCs into one creating by then a high degree of integration.

The issue is therefore to what extent integration at the European level to optimising services will bring about the expected efficiency gains and at what cost: should FABs in the first place deal with particular nodes in the ATM network or should the starting point be more ambitious? Can airspace design be run independently with national and European initiatives at the same time? How to take into account reactionary effects in the network? By the same token, should charging regimes be differentiated according to FABs? Can FABs be managed and run independently?
2. Workability of FABs

Implementing FABs raise inevitably the workability issue. Of course the more ambitious and far reaching are the plans the more the uncertainty of the outcome. Here workability of FABs is assessed considering the technology, political and economics aspects.

<table>
<thead>
<tr>
<th></th>
<th>Technology</th>
<th>Politics</th>
<th>Economics</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHIEF+</td>
<td>Known</td>
<td>Increase in national co-operation</td>
<td>Sharing revenues</td>
</tr>
<tr>
<td>NUAC/CEATS</td>
<td>Implementation of new technologies</td>
<td>Multinational or multilateral agreements under Eurocontrol</td>
<td>Financial autonomy Regional regulation</td>
</tr>
<tr>
<td>Algorithms</td>
<td>Known but robustness of simulation exercises</td>
<td>European mechanism</td>
<td>European management and regulation</td>
</tr>
<tr>
<td>Economic Clustering</td>
<td>Known but robustness of simulation exercises</td>
<td>European mechanism</td>
<td>European management and regulation</td>
</tr>
<tr>
<td>Revolutionary</td>
<td>Quantum jump leap Technology of the future</td>
<td>Political strength</td>
<td>Financial resources Franchising</td>
</tr>
</tbody>
</table>

Table 2: Implementing FABs

The CHIEF + perspective –reinforcing national co-operation would not raise important issues of workability. It is rather a matter of political will to agree a binding framework in which co-operation is bound to develop. It would not necessarily entail reformatting institutions.

The creation of European Centres on the model of NUAC and CEATS is much more political. The member states will have to agree the closure of national centres. Presumably the ability to put forward a zero sum game structure (no losers, no winners) would prove necessary condition. On these grounds, the member states are not on an equal footing: quality of assets, size of the national airspace, importance of the military, etc. Compensation schemes would have to be studied. Finally, as the Nordic experiment recalls, the creation of a new centre cannot occur without the full participation of controllers and unions.
In the middle, of the spectrum, the workability of drawing and implementing FABs from scratch (mathematical algorithm, economic perspective) cannot be considered in isolation. They are tools of simulation. Although the results are sensible to parameters value they have the advantage of being independent from the political dimension. There workability lies rather in their ability to be reactive and provide with information for the decision making process.

As for the revolutionary it shall not be dismissed too rapidly. The technology exists and is in use in other transportation sectors (road, sea). It appears inevitable that Air Transport will sooner of later follow. But the strength of the new vision is that its proponents are key players (airplane producers) with important technology capabilities, political influence and financial resources. Besides, the initiative is co-operative as it associates the key stakeholders (ATM providers of ground facilities, airplane and satellite producers, airline companies). Would en-route upper airspace control be delegated to a supra national consortium?

3. Setting FABs into motion

The last step of the analysis consists of thinking possible paths to set FABs into motion. The characteristics that are emphasised are the choice of a level of centralisation and the choice of a method, bottom-up or top-down.

<table>
<thead>
<tr>
<th>Bottom-up</th>
<th>Top-down</th>
</tr>
</thead>
<tbody>
<tr>
<td>De-centralised</td>
<td>Supply restructuring through market forces</td>
</tr>
<tr>
<td>Centralised</td>
<td>Management of European regulatory contracts</td>
</tr>
</tbody>
</table>

*Table 3: setting up FABs*

*Fully de-centralised modus operandi*

It can be viewed as follows.

FABs are the end result of ANSPs business strategies. Freed from administrative constraints and separate from national regulators, the supply side restructures through alliances and mergers. European regional consortiums or providers emerge which control transfrontier airspace blocks. The optimisation of the ex ante mapping of FABs become secondary as efficiency gains stem from assets and management rationalisation. The de-centralised model can also be thinkable without full corporatisation of providers. Part of the negotiating parties can be the civil aviation administration.
National regulation and tendering

A still de-centralised approach would be to leave national regulators and administrations decide about delegation of service from joint bilateral or multilateral agreements defining FABs. They would jointly tender the delegation of service and select the most suitable proposal according to safety and efficiency gains. The mapping of FABs would then be driven by national motives in accordance with a European regulatory roof.

European regulation under contractual arrangements

A step further strengthening the constraints in the system would be the drawing at the European level of both FABs and binding standardised regulatory contracts based on performance tender to ANSPs. The contracts, which would be mandatory, would leave the national ANSPs and administrations enter into negotiation to make proposals on FABs.

Euro Air Traffic Services

Finally, a fully centralised approach would be to make the national providers join a unique commercial entity which starting with the management of cross-border FABs will gradually gain autonomy, concentrate the management of airspace design and ATC operations in a single European entity, FABs being a tool to that end.