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European and USA Operational Concepts for 2000-2010: A Framework for Comparison

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Abstract

The last couple of years have seen major efforts to think strategically about future Air Traffic Management (ATM) concepts for the next 15-20 years, both within Europe and in the USA. Within Europe this effort has focussed on the European Air Traffic Management System (EATMS) and more recently, the ATM Strategy for 2000+ initiative. In the USA, ATM concept thinking has led to the goal of 'free flight' and a future concept of operations for the National Airspace System.

A comparison of these developments is now appropriate since it will:

- identify areas for collaboration,
- enable genuine differences to be understood (eg those deriving from different traffic conditions),
- identify commonalities which might help reduce the proliferation of equipment requirements to the benefit of ATM service providers and airlines.

Eurocontrol and the FAA have been working together over the last year in order to carry out this comparison of operational concepts. This paper presents a framework for analysing ATM concepts. It will facilitate the identification of genuine differences between the European and US air traffic systems and enable the underlying reasons for the differences to be understood.

1 Introduction

The last couple of years have seen major efforts to think strategically about future Air Traffic Management (ATM) concepts for the next 15-20 years, both within Europe and in the USA. Within Europe this effort has focussed on the European Air Traffic Management System (EATMS) initiative and, most recently, on the European Civil Aviation Conference (ECAC) ATM Strategy for 2000+. In the USA, the focus of concept thinking has been the Free Flight initiative.

Collaborative effort between Europe and the USA in air traffic operational concepts is being undertaken as part of Action Plan 2 of the FAA/Eurocontrol Collaboration in R&D which was signed in February 1997. The objectives of Action Plan 2 are:

- To contribute to the development of a global perspective on aviation services by providing insight into the various current and future operational concepts in existence for European and US environments.

- To normalise the vocabulary of operational concepts by identifying similarities and differences, and comparing and contrasting the differences in relation to the external environmental constraints - city pair locations, national boundaries, weather, etc.

- To highlight, and in turn mitigate, the associated risk of the communities not having fully compatible solutions by identifying the dissimilarities in context and requirements within the operational concepts.

- To identify areas for co-operative development and develop a methodology for tracking and resolving issues and changes in operational concepts.

It is important that comparisons of European and USA operational concepts take place within an appropriate analysis framework. A framework provides a means of structuring the comparison and of ensuring that it is meaningful. This paper presents such a framework.

2 The ATM Environment

In comparing European and USA operational concepts, it is important to compare like-with-like. This means that differences in the ATM environment, which condition the circumstances in which aircraft fly and ATM has to operate, should be made explicit and that the comparison should focus on geographic areas which are as similar as possible from the ATM point of view.

Some of the key environmental differences are listed in Table 1.

Table 1: Differences affecting European and US ATM Systems

Europe	**USA**
Political	
• Heterogeneous - many sovereign states, different cultures and languages	• Homogeneous - one nation with a single culture and language
Market	
• Deregulated but effects small to date • Funding through route charges • Separate arrangements for airport ATC charges	• Fully deregulated • Funding through ticket tax, fuel tax and general fund
Weather	
• CAT II/III operations more frequent	• Severe weather phenomena more frequent
Traffic	
• Non-stop origin-destination routes • GA less sizeable	• Hub and spoke route networks • GA more sizeable
ATM System	
• Systems owned and operated at national level • Wide range of airport owners and operators	• Federal government owns and operates system • Airports largely owned and operated by government bodies

In order to provide, as far as possible, a like-for-like comparison, it was decided to compare the European core area[1] with a triangular area in the Eastern USA bounded by Boston, Chicago, and Miami. The areas are shown in Figure 1. They were selected as being similar from the ATM perspective, namely:

Both areas of high traffic density: this affects the complexity of the ATM task and is likely to have implications for airspace structuring and systemisation.

Similar route lengths: which governs:

- the flight profile in terms of fraction of flight time in climb, cruise and descent,
- the time available, and hence the scope, for applying measures such as speed control,
- the criteria used to assess ATM performance, for example punctuality is likely to be more important for short haul flights than optimal fuel profiles.

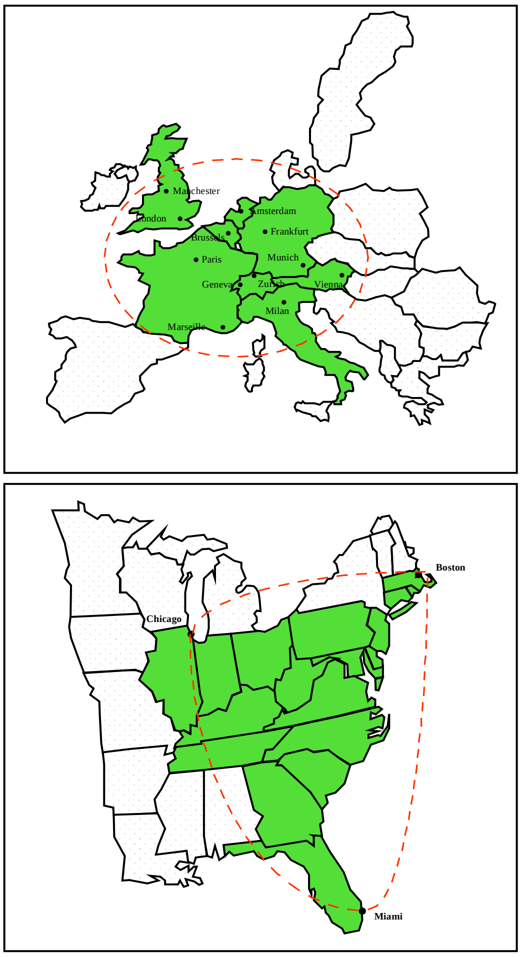
A high fraction of origin-destination pairs in USA: to be comparable with Europe, which does not have a hub-and-spoke route network in the same way as in the US.

Inclusion of slot constrained airports: the European core area contains a number of slot constrained airports, which have implications for air traffic flow management, traffic management and queueing. Hence slot constrained airports were needed in the US area to ensure a like-for-like comparison.

Inclusion of military areas: some future concepts involve the use of areas of airspace which have to date been permanently reserved for military use. Hence such areas needed to be included for both Europe and the USA.

[1] Defined as the area covered by the following ATC centres: Amsterdam, Brussels, Dusseldorf, Frankfurt, Geneva, Karlsruhe, London, Maastricht, Manchester, Marseille, Milano, Munich, Paris, Rheims, Vienna, Zurich.

Figure 1: Approximate Areas for Comparison under Action Plan 2

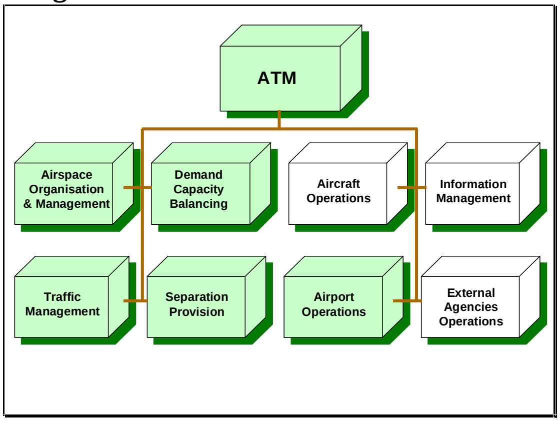


3 A Common ATM Concept Model

Since some proposed changes represent fundamental differences to current ATM methods, it is essential to have a common understanding of the fundamental ATM processes, ie the essence of “what ATM has to do” rather than “how it does it”. This implies a common model of ATM that defines a set of ATM component processes and ensures a common vocabulary. The Invariant Process Model developed within Europe is shown in Figure 2 and has been adopted, with some modification, for the Action Plan 2 work.

The aim was that this model should be simple and as independent as possible from specific implementations. This allows various concepts to be accommodated within the model and compared.

Figure 2: ATM Invariant Process Model



The following five core ATM processes, denoted by shaded boxes in Figure 2, are identified:

Airspace Organisation and Management: covers the structure, division and categorisation of airspace, and the airspace management rules which apply. It segregates different classes of aircraft users and airspace environments (by airspace boundaries and rules) and separates aircraft in the same type of airspace from each other (by routes and routeings).

Demand Capacity Balancing (DCB): is the process of adapting air traffic demand to available airport and airspace capacity and reciprocally adapting capacity to demand when and where possible. The process is necessary to avoid overloading the airspace or airports which could have safety implications. DCB acts progressively from a strategic level many months ahead when flights and services are scheduled to the tactical level on the day of operations. Flow management is a key DCB process. Within Europe it is carried out through the Central Flow Management Unit and in the USA through the Ground Delay Programme.

Traffic Management - Sequencing and Spacing is the preferred US terminology: Here traffic management denotes the configuration and management of the flow of traffic through choke points (eg through the use of metering techniques). It includes the provision of queues both on the ground and in the air, the location of queueing points across the ATM network and their management in real time. As a process, traffic management operates on individual flights and is closely related to, and sometimes indistinguishable from, the separation provision process.

Separation Provision: covers both separation per se and expedition in the sense of issuing clearances that allow the aircraft to progress along its flight plan in a conflict free manner. The fundamental principle is to apply positive separation between aircraft. Thus separation provision is characterised by preserving minimum safe separation standards between aircraft, rather than being a collision avoidance process by which aircraft simply miss each other.

Airport Operations: provides traffic management and separation provision on or near the ground and makes the most efficient use of available airport resources.

Aircraft Operations, Information Management and External Agencies Operations are essential to the functioning of the overall concept, but they are not central to the development of the main concept characteristics; hence their exclusion from the set of core processes.

4 The Network View

4.1 Pressures for change

It is crucial to understand the drivers for change in ATM concepts. The three basic performance attributes of the ATM service are safety, capacity and cost. In both Europe and the USA air traffic is predicted to approximately double by 2015.

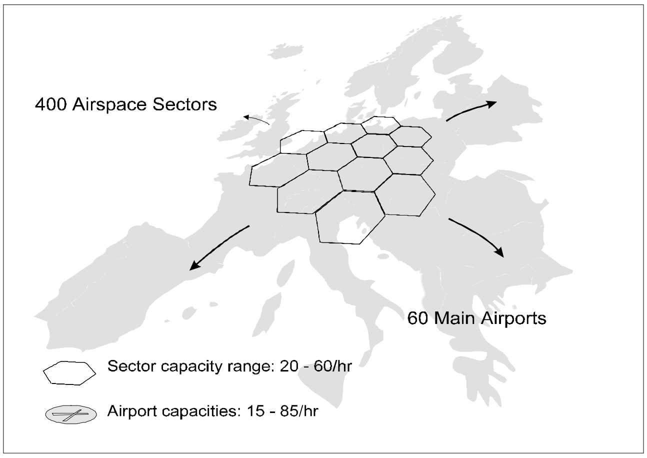
Whilst safety remains paramount, particularly in the face of increasing traffic densities, and cost is obviously a very important factor, it is provision of sufficient capacity to meet the predicted demand that is the main driver for change on both sides of the Atlantic.

Capacity manifests itself through a number of factors which can be traded-off. They include the number of flights in the system, delay, flexibility and flight efficiency. Within Europe the emphasis has focussed on containing delay; in the US the requirement is generally expressed as a combination of greater throughput coupled with greater flexibility and efficiency in flight.

4.2 A Network View

The focus on capacity makes it essential to think about the ATM service as a network of airports and airspace sectors. This is illustrated, for Europe, in Figure 3. Capacity improvements must be planned with a view to overall network capacity. Within Europe, the Eurocontrol Organisation is best placed to hold the overall network view.

Figure 3: The European ATM System as a Network



4.3 Expanding Network Capacity

Expanding the capacity of the ATM network means increasing airspace capacity and exploiting airport capacity to the maximum. Future operational concepts offer the likely means of doing so. Figure 4 groups the measures for increasing capacity under four headings that derive from a network perspective. One of these relates to exploiting available airport capacity, and the other three to exploiting and increasing airspace capacity. It is possible to accommodate all ideas for increasing capacity within this framework.

Airspace and Sectors: Additional airspace capacity might be obtained by using the finite volume of airspace more efficiently. Flexible use of airspace initiatives can free up additional airspace to users. Reduced separation standards - where demonstrably safe - will reduce the volume, or “bubble”, of airspace needed to be allocated to each aircraft. Continuing developments to routes and sectors can provide additional capacity by minimising controller workload and allocating it to a greater number of controllers.

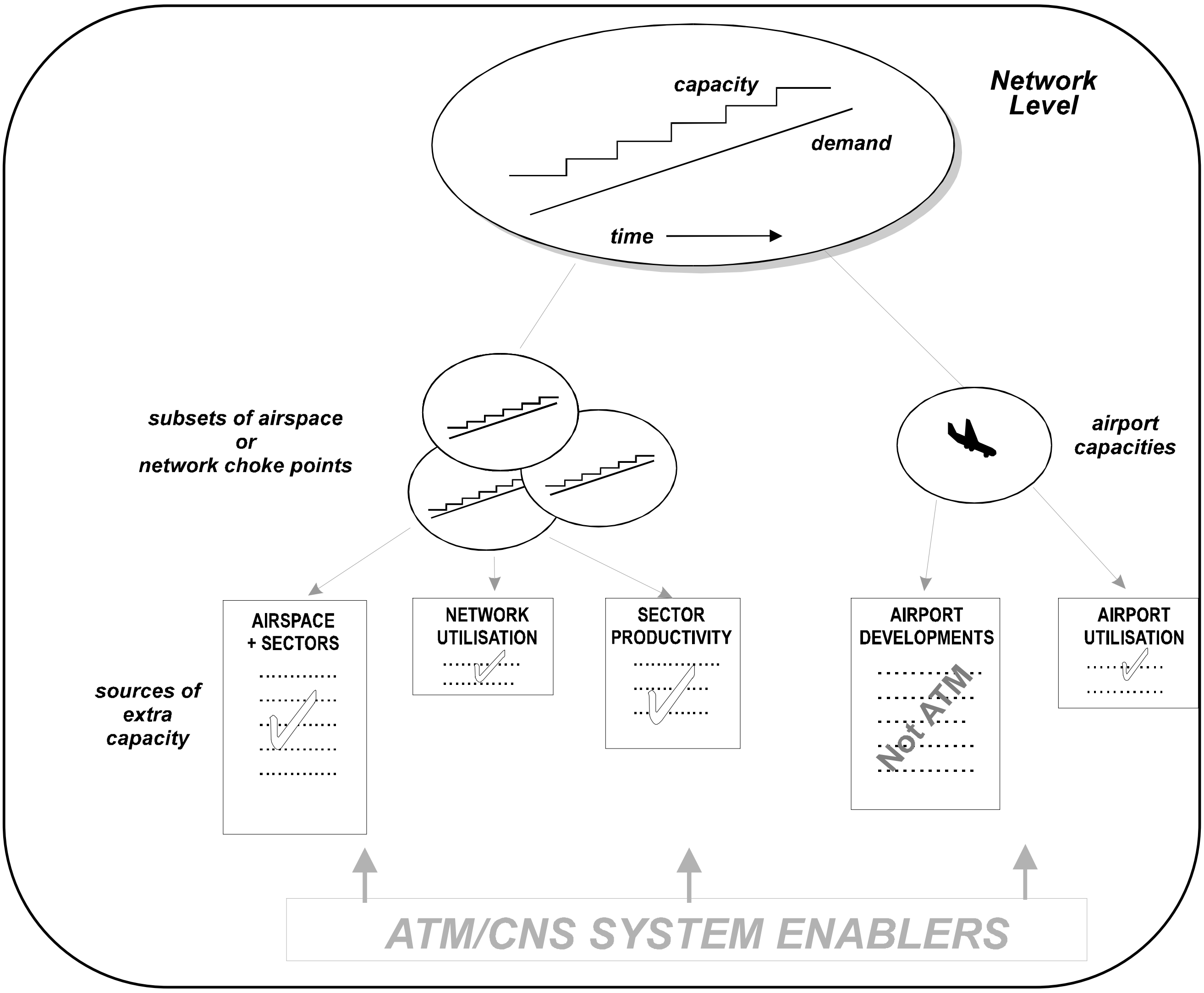
Network Utilisation: The intrinsic capacity of the current network can be used more efficiently through improved slot allocation procedures and more flexible re-routeing processes, etc. Traffic flows can be smoothed to avoid bunching and to optimise queueing across the network. Integrated, or collaborative, scheduling processes - that take user preferences into account - could optimise the distribution of demand across the available capacity.

Sector Productivity: Individual sectors could process more aircraft if controller workload could be reduced. The main avenue for doing so is the provision of computer assistance for specific controller tasks - eg conflict detection, controller prompts, monitoring - can help. Transferring some separation responsibilities to the cockpit may also contribute to reducing workload. In the longer term clearances of 20 to 30 minutes offer the prospect of markedly reducing much of today’s tactical workload.

Airport Utilisation: Physical developments at airports (additional stands, taxiways, runways, etc) that increase capacity are outside the scope of ATM. However, the available airport capacities can be exploited to the maximum if aircraft are in the optimal sequence at the minimum spacing. Computer tools can assist this process, particularly in multi-runway and cross-runway situations. In addition, the loss of runway capacity in low visibility can be minimised through new operating methods and systems/technology for cockpit and ATC alike.

CNS/ATM System Enablers: The above methods for improving network capacity will be applied at different times and in different places across the ATM network. Major improvements will need to be grouped into a limited number of change steps that provide the necessary increases in capacity, each change step being “enabled” by having the necessary systems infrastructure in place. The framework can thus help in identifying the full range of Communications, Navigation and Surveillance (CNS), ATM and Avionics systems and capabilities needed to underpin the evolving ATM concept.

Figure 4: Provision of Network Capacity



5 The Framework

The main elements of the framework then become:

- Selection of geographic areas which are similar from an ATM point of view, to ensure a like-with-like comparison.

- Definition of a common model of ATM - the Invariant Process Model - that defines a set of ATM processes and ensures a common vocabulary.

- Statements of methods and key changes in method foreseen for each invariant process at five year periods - 2000, 2005, 2010 and 2015.

- The expected impact of change to be expressed as a network performance plan capacity for each generic network element, ie typical sector capacities, airport utilisation levels, etc. This will include the development of metrics and clear definition of a baseline against which changes are to be assessed.

Whilst long term visions are certainly necessary, the ATM system has to evolve in a step-wise fashion. Hence each change step must be an evolutionary change that is achievable from the previous state of the ATM system, and provide a platform for further developments. Expressing future concepts in five year change steps brings realism to the process by making transitionary thinking an integral part of the concept formulation.

What the framework brings to the discussion of concepts is objectivity, and driving from a service perspective it keeps the focus on pragmatic solutions.

6 Next Steps

The next steps are:

- Work to identify metrics to compare the European and US systems, which is already underway.

- The development of capacity enhancement plans for 2005, 2010, 2015 based on suitable combinations of concept elements.

- One important area where greater insight is required is the so called “gate-to-gate” approach to ATM. Essentially, this covers the overall interaction of demand capacity balancing, traffic management and queueing, and airport operations. Work is needed to establish how and why the current European and US concepts differ and exactly what “gate-to-gate” means in terms of the core ATM processes, and to identify the benefits that might be expected.

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