

**NAVIGATION STRATEGY
FOR ECAC**

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Abstract

This document provides a harmonised and integrated strategic framework for the development of navigation applications for ECAC Member States, to allow a cost-effective, customer oriented evolution of the European Air Navigation Systems during the period 2000-2015. The evolution of the air navigation systems is described in terms of performance, functionality and corresponding infrastructure, taking due account of the principle of global interoperability.

This Navigation Strategy supports the operational developments proposed by the ATM 2000+ Strategy and is in line with the implementation of the ICAO Global Air Navigation Plan for CNS/ATM systems in ECAC.

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The following table identifies all management authorities who have successively approved the present issue of this document.

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EXECUTIVE SUMMARY

- i. The growth in air transport seen in the last two decades, and the forecasts indicating that air traffic movements in Europe will more than double by 2015, compared with those for 1997, maintain a continued pressure to upgrade the capacity of the overall European ATM system, to alleviate congestion and delays.
- ii. The existing Air Navigation System and its sub-systems suffer from shortcomings in technical, operational and economic aspects. Despite the success of EUROCONTROL EATCHIP, and the measures already in hand to provide further improvements, the current system is unlikely to be able to cope with traffic increases of the predicted magnitude. New advanced systems and concepts can offer potential improvements in terms of safety, efficiency and/or economy of flight, provided that their implementation is based on a fully co-ordinated, harmonised, evolutionary and flexible planning process.
- iii. This Navigation Strategy has been developed to answer to this need. The users requirements have been the main driver in its development. The main objective of this Air Navigation Strategy is to provide a harmonised and integrated common framework which will allow a cost-effective, customer oriented evolution of the European Air Navigation Systems during the period 2000-2015. The evolution of the air navigation systems is described in terms of performance, functionality and corresponding infrastructure, taking due account of the principle of global interoperability.
- iv. The Navigation Strategy supports the operational developments proposed by the ATM 2000+ Strategy towards the implementation of a uniform European Air Traffic Management system. It is in line with the implementation of the ICAO Global Air Navigation Plan for CNS/ATM systems in ECAC.
- v. The time horizon of this Navigation Strategy is split into three phases: short-term (2000-2005), medium-term (2005-2010) and long-term (2010-2015 and beyond), and it is in line with other EUROCONTROL strategies.
- vi. The main strategic streams described in this Navigation Strategy are aimed at:
 - achieving a total RNAV environment with defined RNP values for all operations ECAC-wide;
 - facilitating the implementation of the 'free routes' concept;
 - supporting the continued operations of aircraft with lower capabilities as long as operationally feasible;
 - implementing 4D RNAV operations, to support the transition to a full gate to gate management of flight by 2015 ;
 - supporting the continued operations of State aircraft, in line with the principles of the overall ATM 2000+ Strategy;
 - providing positioning and navigation data at the required performance levels to support the various applications in the ATM/CNS environment.
 - a judicious deployment of the space-based infrastructure and a rationalisation of supporting ground-based infrastructure for all phases of flight, ensuring the transition to GNSS, in line with ICAO recommendations.
- vii. Advances in Navigation functionality will enable improvements in airspace design (structure, sectorisation, associated route network, applicable route spacing, separation minima and responsibilities, etc.), and will allow for a high degree of flexibility for aircraft operations and for the navigational equipment used. Ultimately, all these elements, together with appropriate ATM tools will enable operators to conduct their flights in accordance with their preferred trajectories, dynamically adjusted, in an optimum and cost-efficient manner.
- viii. This Navigation Strategy recognises the emergence of satellite technology and its future role in the global navigation environment. However, it is expected (based on current knowledge) that the rate of technological development of the system and the time needed for the resolution of institutional limitations will result in the need for a ground-based back-up system for GNSS for the foreseeable future for all phases of flight.

- ix. The feasibility of some options is still surrounded by many uncertainties and requires additional study (safety, R&D, CBA). Since all phases of flight are interrelated, constraints solved in one phase will not necessarily deliver the entire expected benefits, because of unsolved (or newly-generated) constraints for the other phases. CBAs will help to avoid the development of purely technology-driven solutions.
- x. This Navigation Strategy aims to achieve a harmonised evolution of the overall Navigation System. In the framework of this strategy States may give preference to one implementation option or another in order to reflect sub-regional and local differences and to provide tangible and early benefits to the users. The availability of benefits will encourage the agreement and commitment of the users to the implementation plans. Furthermore, it will help the smooth transition to new systems and will minimise the period when support of both existing and new functionality will be necessary.

1. FOREWORD

1.1 About the Document

- 1.1.1 This document constitutes the EUROCONTROL Navigation Strategy for the European Civil Aviation Conference (ECAC) airspace. It describes the future evolution of the ECAC navigation environment as a component of the European Air Traffic Management system .
- 1.1.2 This Navigation Strategy identifies general principles and future actions to provide a harmonised and integrated framework for air navigation planning for the entire ECAC airspace. It describes available and potential air navigation applications and means of supporting these applications, in terms of required performance, functionalities, and enabling infrastructure.
- 1.1.3 This Navigation Strategy is a living document, which will be reviewed periodically, to ensure that the rationale for the next step forward remains valid in the light of the progress made, and to reflect the actual changes which take place in aviation. It is anticipated that the strategic steps defined in this document will be included in the final version of the ATM 2000+ Strategy.

1.2 Responsible Body and Acknowledgements

- 1.2.1 This document has been developed by the EUROCONTROL Airspace and Navigation Team (ANT). It is expected that this strategy will be endorsed in accordance with the EUROCONTROL EATCHIP procedures.
- 1.2.2 The EUROCONTROL Agency wishes to acknowledge the valuable assistance received from Member States, the International Civil Aviation Organisation (ICAO), ICAO All Weather Operations Group (AWOG), the European Commission, the Supreme Headquarters of Allied Powers Europe (SHAPE), the International Air Transport Association (IATA), the Association of European Airlines (AEA), and the International Council of Aircraft Owner and Pilot Associations (IAOPA), in preparing this strategy.

1.3 Structure of the Document

Executive Summary - gives a management overview of the content and main issues of the strategy.

Foreword - describes the purpose of the document, its ownership and its structure.

Introduction - provides the context necessary in order to understand the contents of the strategy.

Requirements - describes the operational requirements of the different users, on the basis of which the strategic steps will be defined.

Strategic Actions - provides a graphical and a tabular representation of the 'roadmap' of change, the main components and action items of the strategy.

Annexes - provide additional background information (rationale for the strategic actions, a list of references, abbreviations, etc).

2. INTRODUCTION

2.1 Need for a Navigation Strategy

- 2.1.1 The phenomenal growth in air transport industry seen in the last two decades is expected to gather still more pace, with forecasts indicating that air traffic movements in Europe will more than double by 2015, compared with those for 1997. These extra movements are likely to create extra congestion and delays, and mean that there is an ever-growing pressure to upgrade the capacity of the overall system.
- 2.1.2 Air transport industry is supported by an aviation community which encompasses a wide range of stakeholders: aircraft operators, service providers, avionics and infrastructure manufacturers. Each of these user groups have diverse, specific and sometimes conflicting needs and expectations. Trade-offs between conflicting requirements will be necessary.
- 2.1.3 New systems and concepts emerging as technology advances, offer potential improvements in terms of safety, efficiency and/or economy of flight. Emerging technologies can support a variety of systems designs and implementation options, some of them still immature.
- 2.1.4 The existing Air Navigation System and its sub-systems suffer from shortcomings in technical, operational and economic aspects. Despite the improvements achieved through EATCHIP, and the measures already in hand to provide further improvements, the current system is unlikely to be able to cope with traffic increases of the predicted magnitude. However, new advanced systems and concepts can offer potential improvements in terms of safety, efficiency and/or economy of flight.
- 2.1.5 This Navigation Strategy has been developed to deal with these various aspects. It is based on expressed operational requirements, taking a gate-to-gate approach, recognises the large variety of aircraft with different capabilities seeking to operate to optimum performance by exploiting the benefits of new and/or rationalised existing systems as early as possible.

2.2 Scope

- 2.2.1 This Navigation Strategy delivers a set of general principles necessary to provide a harmonised and integrated common strategic framework for air navigation planning for the entire ECAC airspace. The strategy describes available and potential air navigation applications and means of supporting these applications, in terms of required performance, functionality and enabling infrastructure. It focuses on increased safety, flexibility, cost-effectiveness, operational efficiency and global interoperability issues. It indicates the way to reach the best choice in terms of safety and cost-effectiveness
- 2.2.2 This Navigation Strategy addresses General Air Traffic (GAT) operations under ICAO Instrument Flight Rules (IFR) within ECAC airspace. This includes the en-route, terminal area, approach and landing phases of flight as well as ground operations and procedures.
- 2.2.3 The evolution of the ECAC air navigation infrastructure will follow closely this strategy. This may affect non-IFR operations, which have traditionally taken advantage of the infrastructure provided for GAT IFR operations, so that continued non-IFR operations in the future European air navigation environment may require enhanced aircraft capability.
- 2.2.4 This Navigation Strategy recognises that military users of the ECAC airspace carry out operations which may not comply with ICAO IFR or individual national aviation rules or procedures for GAT. However, their unrestricted access to the entire airspace will continue to be provided.
- 2.2.5 The time horizon of this strategy is split into three phases: short-term (2000-2005), medium-term (2005-2010) and long-term (2010-2015 and beyond), and is in line with other EUROCONTROL strategies (see § 2.3.3.).

2.3 Objective

2.3.1 The main objective of this Navigation Strategy is to provide a harmonised and integrated common framework which will allow a cost-effective, customer oriented evolution of the European air navigation systems during the period 2000-2015. The evolution of the air navigation systems is described in terms of performance, functionality and corresponding infrastructure, taking due account of the principle of global interoperability.

2.3.2 This Navigation Strategy aims, therefore, to provide the basis (NOT a plan for implementation) for:

- the development of ECAC air navigation applications and supporting infrastructure;
- the rationalisation, integration and harmonisation of existing and new air navigation systems.

2.3.3 This Navigation Strategy aims to achieve a harmonised evolution of the air navigation system, to support the operational developments proposed by the EUROCONTROL ATM 2000+ Strategy towards the implementation of a uniform future European Air Traffic Management system. It also supports as far as practicable the implementation of the ICAO Global Air Navigation Plan for CNS/ATM systems in ECAC. The relationship between these elements is shown in Fig.1.

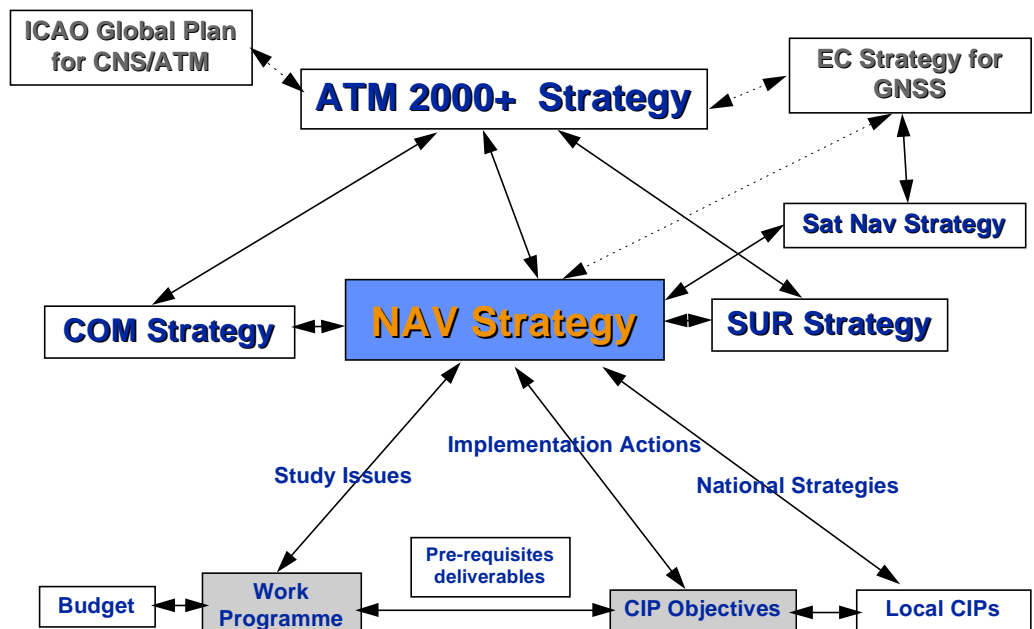


Fig.1 Relationships

2.4 Principles

2.4.1 The following general principles have governed the development of this Navigation Strategy:

- to identify and evolve from the needs and priorities of both users and providers of the navigation systems and/or services;
- to take due account of institutional arrangements and legal regulations;
- to accommodate geographical differences in capabilities, performance requirements, and in the existing and required infrastructure;
- to enable coherent development plans to be made, both within ECAC and with neighbouring regions.

2.4.2 The strategy must remain sensitive to the evolution and continued recognition of the needs and priorities of both users and providers of the navigation systems and/or services and the

consequences and benefits of the available system options, as they emerge during the period

- 2.4.3 In the framework of this strategy States may give preference to one implementation option or another in order to reflect sub-regional and local differences. They have to be developed in a continuous consultation with the users and to provide them tangible and early benefits. The availability of benefits will encourage the agreement and commitment of the users. Furthermore, it will help the smooth transition to new systems and minimise the period when support of both existing and new functionality will be necessary, with consequential reduction in supporting costs.

2.5 Working Methodology

2.5.1 The following diagram (Fig.2) illustrates the methodology used to derive this Navigation Strategy, taking into consideration:

- aircraft operators' requirements;
- known European and global policies and plans for Air Navigation Systems;
- infrastructure and services in use, being introduced and/or planned for introduction.

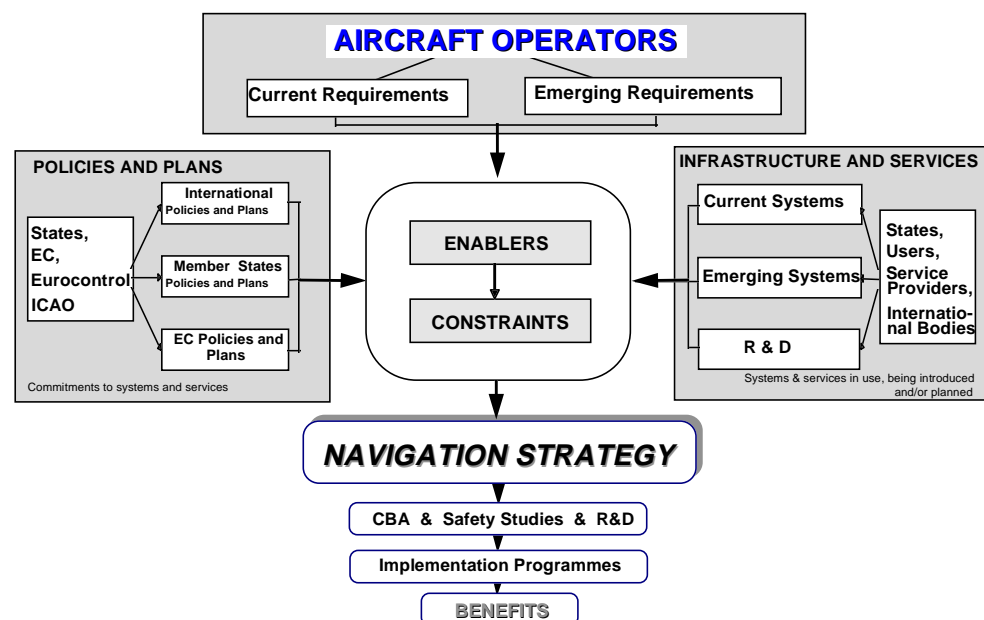


Fig.2 Working Methodology

2.5.2 This Navigation Strategy has considered the aircraft operators' expressed requirements the main driver for operational improvements in the European Air Navigation System. Due to the wide range of aircraft operator groups, having diverse, specific and sometimes conflicting needs and expectations, trade-offs between conflicting requirements have been necessary.

2.5.3 The policies and plans developed by the Member States and by various international bodies (e.g. EUROCONTROL, the European Commission, ICAO, etc.) reflect their current commitments to deliver certain services and/or systems. These plans are not necessarily co-ordinated at a regional level in respect of their implementation, impact or interoperability.

2.5.4 Various potential operational improvements were examined, together with the consequences of pursuing particular options. Thorough analysis identified enablers (e.g. new technologies) and/or constraints (e.g. costs or timescale limitations) which would affect expressed requirements.

2.5.5 The feasibility of some options is still surrounded by many uncertainties and requires additional study (safety, R&D, CBAs). Since all phases of flight are interrelated, constraints

solved in one phase will not necessarily deliver the entire expected benefits, because of unsolved (or newly-generated) constraints for the other phases. CBAs will help to avoid the development of purely technology-driven solutions.

3. REQUIREMENTS

3.1 Users Requirements

Users

- 3.1.1 In the context of this Navigation Strategy the aviation users community encompasses a wide range of interest groups including aircraft operators, airport operators and Air Traffic Services Organisations (ATSOs) (ref.[11]).
- 3.1.2 Aircraft operators are the prime users of the Air Navigation System. They encompass commercial air transport (passenger and cargo), State aircraft, business and general aviation, aerial work.
- 3.1.3 Airport operators are the managers of airport operations. Airports are operated as (commercial) businesses providing services to passengers and airspace users. Their requirements are addressed here in the context of operations on the runway (e.g. runway guidance for take off or landing and SMGCS).
- 3.1.4 Air Traffic Services Organisations (ATSO) refer to the providers of national and sub-regional air traffic services (ATS), aeronautical information services (AIS), and airspace management (ASM).

Aircraft Operators Requirements

- 3.1.5 This Navigation Strategy has considered aircraft operators' expressed requirements as the main driver in its development. These requirements have been determined either through direct input from users organisations or from other sources [ref. 4 and 14].
- 3.1.6 The aviation users' community requirement is for a Strategy that takes into account their various needs and develops plans accommodating the large variety of capabilities and functionality. However, trade-offs between conflicting requirements are inevitable and finding the best compromise is a delicate and difficult exercise which will clearly not always satisfy all interests.
- 3.1.7 A further requirement is that future gate-to-gate air traffic and navigation services are provided in a seamless, globally interoperable air navigation systems environment. The aims are for minimum performance requirements, the ability to plan and operate flights with maximum flexibility, efficiency and cost-effectiveness, based on common procedures applied uniformly throughout ECAC and with no degradation in safety.
- 3.1.8 The users also require optimum use of the available additional capacity and shorter routes . Applications such as closely spaced routes and parallel approaches and departures are some of the means by which these requirements may be fulfilled. The application of the ICAO RNP concept is required for all phases of flight, allowing for a high degree of flexibility for aircraft operations and for the navigational equipment used.
- 3.1.9 More specifically, users have stated the following requirements (through direct input or ref.[4]):
- to support the ATM 2000+ Strategy and the Target Operational Concept;
 - to exploit the full benefits of B-RNAV implementation both en-route and in TMA;
 - to continue the optimisation of the ECAC airspace structure based on operational requirements;
 - to implement RVSM and free routes, in order to increase airspace capacity and, along with RNAV to improve user preferred trajectories in all phases of flight;
 - to investigate the benefits of RNP 1 (or better) RNAV application;
 - to take advantage of advanced navigation capability of modern aircraft and to examine the potential to implement 4D RNAV;
 - to maximise the freedom of movement by exploiting new technological opportunities;
 - to accommodate a wide variety of capabilities and to provide differing levels of service

- according to the users' business needs;
 - to provide real-time or near real-time aeronautical information of sufficient quality (accuracy, integrity) to support the required application;
 - to facilitate the implementation of advanced ground-based data processing systems and air-ground integration;
 - to reduce infrastructure costs and improve ATM productivity;
 - to increase user involvement in real-time decision-making for flexibility increase and to keep aircraft operators as the final decision-makers for the conduct of flight;
 - to develop sound and transparent business cases at each stage of decision-making;
 - to avoid making new equipment mandatory, without prior consultation and co-ordination with the users;
 - to facilitate the redistribution of responsibilities between aircraft and ATC.
- 3.1.10 The IATA CNS/ATM User Driven Plan identifies the "free flight" concept as having an important potential for implementation in the European region [ref.4]. Its application is foreseen in line with the ATM 2000+ Strategy [ref.1]. The Plan identifies the "Free Flight" Concept as being a future world-wide concept that must have similar features on both sides of the Atlantic Ocean and world-wide. An initial step towards "Free Flight" is the implementation of the Free Routes Airspace followed, later on, by a transfer of separation responsibility from ground to air, where and when safe to do.
- 3.1.11 The military aviation authorities will continue efforts to make military aircraft, and in particular military transport aircraft, compliant with civil aviation requirements for the conduct of GAT operations. However it must be foreseen that a great number of aircraft cannot or cannot completely be equipped to the required standard. Nevertheless these aircraft may be required to operate as GAT in the performance of their tasks. Procedures to accommodate these flights without compliance to the civil air navigation equipment requirements are to be established and infrastructure support for the conduct of such flights is to be maintained.
- 3.1.12 General Aviation and Air Work consists of many varieties of aircraft and capabilities. It is foreseen that a great number of aircraft cannot or cannot completely be equipped to a required standard on the basis of currently available equipment. Procedures to accommodate these flights may be required or infrastructure support for the conduct of such flights may have to be maintained as long as operationally feasible.

3.2 ATM Requirements

- 3.2.1 The future European Air Traffic Management system [ref.1,2] will have to provide adequate solutions to determine the optimum ways in which the ECAC airspace could be used. These solutions will require appropriate support and evolution of the Air Navigation Systems as well as of the Communications and Surveillance systems. These systems are considered enablers to ATM. Their functions become increasingly interdependent and require a higher and more predictable quality of service.
- 3.2.2 The future European ATM environment will require improved navigation accuracy, and more reliable navigation systems. The navigation infrastructure must be capable of providing, ECAC-wide, accurate, reliable, seamless and gate-to-gate position determination.
- 3.2.3 The ECAC area is not uniform in terms of ATM complexity and this may result in different and changing requirements on air navigation systems. The degree of complexity is dependent on current and expected capacity requirements and on supporting technology.
- 3.2.4 The required improvements in the Navigation function will enable improvements in airspace design (structure, sectorisation, associated route network, applicable route spacing, separation minima and responsibilities, etc.). Ultimately, all these elements, together with appropriate ATM tools will enable operators to conduct their flights in accordance with their preferred trajectories, dynamically adjusted, in an optimum and cost-efficient manner.

3.3 Communications Dependencies

- 3.3.1 The technological developments of modern air navigation systems and their evolution towards the future European ATM system create a specific requirement for data link. The Communications function will allow the routine exchange of necessary information between air-ground and ground-ground elements of integrated Navigation and Surveillance systems.
- 3.3.2 Emerging ground- or satellite-based augmentation systems for satellite navigation require specific communication links among their various components. Air-to-air data link is another service required from the Communications domain, to serve the navigation, the surveillance and the aeronautical information services functions.

3.4 Surveillance Dependencies

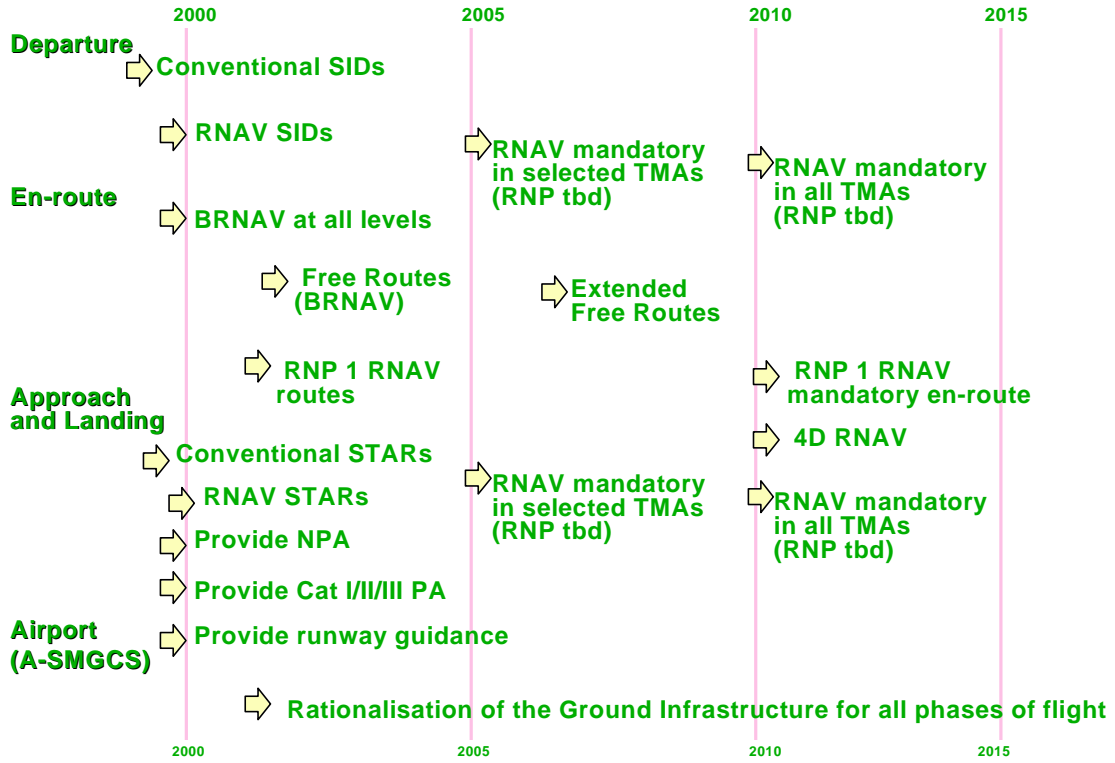
- 3.4.1 The application of the ADS concept in the future air navigation environment supported by a “sole means” of GNSS derived position will require the availability of high quality navigation data from aircraft systems for all phases of flight. Until then ADS will continue to be supported by a ground based surveillance function which can provide independent verification of the position information provided in the ADS messages. The EUROCONTROL Surveillance Strategy [ref.13] indicates that in the period up to 2015, a “sole means” ADS surveillance implementation is not expected.

3.5 Aeronautical Information Services Dependencies

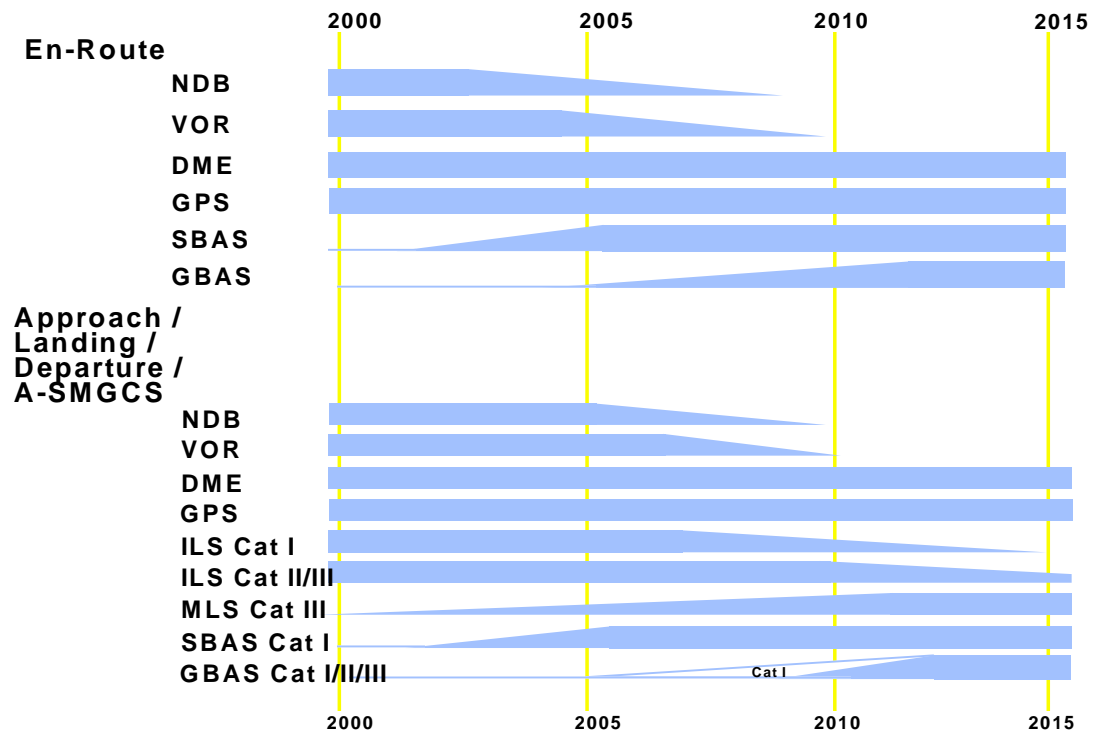
- 3.5.1 The role and importance of aeronautical information/data and charts systems has changed significantly with the implementation of RNAV and RNP concepts. AIS has become a crucial and critical enabler for the implementation of the future European ATM system. The global requirement for precise navigation capability will require high quality (accuracy, resolution and integrity) aeronautical databases. The integrity values are required to be raised from the current value of 10^{-3} to 10^{-8} (ICAO Annex 15) to enable the implementation of CNS/ATM. Moreover, it is anticipated that an integrity value for aeronautical co-ordinate data of 10^{-9} will be required to support $RNP \leq 1$ procedures in the terminal area.
- 3.5.2 For the safe performance of operations the coordinate data has to be published in the a common geodetic reference system (WGS-84) as of 1 January 1998. For future developments it is essential that electronic storage, provision, update and interrogation of aeronautical databases and charts (including terrain and obstacle information) are implemented. Global standardisation of the communication and display of these data are necessary. These improvements will allow on-line, real time, high quality aeronautical information to the users.
- 3.5.3 The strategic actions required to achieve these performance requirements are addressed by the EUROCONTROL AIS Strategy.

4. STRATEGIC ACTIONS

4.1 Roadmap for Strategic Actions



4.1.1 Rationalisation of the Ground Infrastructure



4.2 Summary of Strategic Actions

4.2.1 Departure Phase (Initial Departure and SIDs)

Strategic Steps - 2000-2005	RNP	Systems
1. Provision and maintenance of take-off guidance at airports (§ 5.1)	TBD (§ 5.1.6)	ILS Cat.III (maintain as long as possible) MLS (initial use; replaces ILS Cat.III where appropriate) INS/IRS + update MMR (initial use)
2. Provision and maintenance of RNAV SIDs (§ 5.2)	RNP-5 accuracy (B-RNAV)	DME/DME; VOR/DME; (comprehensive coverage at low levels is required) INS/IRS+ update; GPS+RAIM (+conventional back-up); SBAS GBAS (expected introduction towards the end of the period)
3. Provision and maintenance of conventional SIDs (§ 5.3)		NDB; VOR; DME; INS/IRS+ update.
4. Rationalisation of ground infrastructure (§ 5.15)		NDB (rationalisation) VOR (initial rationalisation) DME (improved coverage)
Strategic Steps - 2005-2010		
1. Provision and maintenance of take-off guidance at airports (§ 5.1)	TBD (§ 5.1.6)	ILS Cat.III (maintain as long as possible) MLS (increased use; replaces ILS Cat.III where appropriate) INS/IRS + update GBAS MMR (increased use)
2. Provision and maintenance of RNAV SIDs ; and Mandate of RNAV in selected TMAs (§ 5.2)	TBD (likely RNP≤1) (§ 5.2.6)	DME/DME VOR/DME; (comprehensive coverage at low levels is required); INS/IRS + update; GPS+RAIM (+conventional back-up); SBAS; GBAS (expected availability)
3. Provision and maintenance of conventional SIDs (§ 5.3)		NDB; VOR; DME; INS/IRS+ update
4. Rationalisation of ground infrastructure (§ 5.15)		NDB (withdrawal before 2010); VOR (withdrawal by 2010); DME infrastructure improved
Strategic Steps - 2010-2015		
1. Provision and maintenance of take-off guidance at airports (§ 5.1)	TBD (§ 5.1.6)	ILS Cat.III (reduced use) MLS (continued use; replaces ILS Cat.III where appropriate; cannot evaluate ratio of replacement); INS/IRS + update GBAS (may detract from deployment of MLS at new locations) MMR (widespread use; with upgrades as required)
2. Mandate of RNAV in all TMAs (§ 5.2)	TBD (likely RNP≤1) (§ 5.2.6,9)	DME/DME; INS/IRS + update; GBAS; SBAS; RNAV MASPS avionics

3. Implementation of 4D RNAV operations (§ 5.9)	TBD (§ 5.9)	advanced aircraft systems capable of 4D RNAV (MASPS); ATC tools: integrated arrival/ departure managers, datalink
4. Rationalisation of the ground infrastructure (§ 5.15)		VOR (withdrawal by 2010) DME infrastructure maintained

4.2.2 En-Route

Strategic Steps - 2000-2005	RNP	Systems
1. Requirement for B-RNAV at all flight levels en-route (§ 5.4)	RNP-5 accuracy	VOR/DME; DME/DME; (to provide adequate infrastructure and to rationalise as appropriate) INS/IRS + update GPS+RAIM (+conventional back-up) SBAS; GBAS (expected introduction towards the end of the period)
2. Implementation of RVSM (§ 5.5)		RVSM MASPS compliant altimetry systems
3. Implementation of free routes (§ 5.6)	RNP-5 accuracy (B-RNAV)	as for B-RNAV (1) above; (comprehensive coverage is required); adequate ATC tools
4. Continue to support operations of aircraft with lower capability (§ 5.7)	RNP- 5 accuracy (B-RNAV)	NDB; VOR DME
5. Implementation of dedicated RNP-1 RNAV routes on an opportunity basis (§ 5.8.2)	RNP-1 accuracy	DME/DME (comprehensive coverage required) INS/IRS + update; GPS+RAIM (+conventional back-up); SBAS (expected introduction towards the end of the period); GBAS; adequate database integrity
6. Rationalisation of the ground infrastructure (§ 5.15)		NDB (rationalisation) VOR (rationalisation) DME (comprehensive coverage)
Strategic Steps - 2005-2010		
1. Extended implementation of free routes (§ 5.6)	RNP 5 accuracy	as for B-RNAV (1) above; GNSS; adequate ATC tools
2. More widespread introduction of RNP-1 RNAV routes (§ 5.8.2)	RNP-1 accuracy	DME/DME; INS/IRS+ update; GNSS
3. Continue to support operations of aircraft with lower capability (§ 5.7)	RNP 5 accuracy	VOR/DME, INS/IRS+ update; GPS+RAIM (+ conventional back-up)
4. Rationalisation of ground based infrastructure (§ 5.15)		NDB (withdrawn before 2010) VOR (withdrawn by 2010) DME (comprehensive coverage)
Strategic Steps - 2010-2015		
1. Mandate of RNP-1 RNAV operations (§ 5.8)	RNP-1	RNAV MASPS avionics DME/DME (comprehensive coverage); INS/IRS+ update; GNSS (National Authorities may retain a VOR infrastructure for domestic/State flights, but ECAC wide VOR no further required)
2. Extended implementation of	TBD (§ 5.6)	as above

free routes (§ 5.6, § 5.9)		
3. Implementation of 4D RNAV operations (§ 5.9)	TBD (§ 5.9)	DME/DME (comprehensive coverage) INS/IRS+ update; GNSS advanced aircraft systems capable of 4D navigation (4D RNAV MASPS) ATC tools: integrated arrival/ departure managers, datalink

4.2.3 STARs , Approach and landing

Strategic Steps - 2000-2005	RNP	Systems
1. Selective provision and maintenance of RNAV STARs and holding procedures (§ 5.10)	TBD (likely RNP _{≤1}) (§ 5.10)	DME/DME; VOR/DME; (comprehensive coverage at low levels is required) INS/IRS+ update; GPS+RAIM (+conventional back-up); SBAS (expected introduction by the end of the period) GBAS (expected introduction by the end of the period)
2. Provision and maintenance of conventional STARs and holding procedures (§ 5.11)		VOR, NDB; DME; INS/IRS + update;
3. Provision and maintenance of NPA capability at airports (§ 5.12)	TBD (§ 5.12.2)	NDB; VOR; GPS+RAIM (+conventional back-up); SBAS (expected introduction by the end of period)
4. Provision and maintenance of Cat I Capability at airports (§ 5.12)	TBD (§ 5.12.2)	ILS Cat.I (continue wide spread use/ maintain service level as long as possible); SBAS (expected introduction by the end of the period) GBAS (expected introduction by the end of the period) MMR
5. Provision and maintenance of Cat II/III Capability at airports (Cat.III including roll-out guidance) (§ 5.13)	TBD (§ 5.12.2)	ILS Cat.II/III (continue wide spread use/ maintain service level as long as possible); MLS (initial introduction to replace ILS Cat II/III); MMR
6. Provision and maintenance of runway guidance for precision approaches (§ 5.14)	TBD (§ 5.14)	reduced use/availability of marker beacons, as far as feasible through the use of DME, relation with requirement for locators (NDBs)
7. Rationalisation of ground based infrastructure (§ 5.15)		NDB (rationalisation) VOR (initial rationalisation) DME (comprehensive coverage)
Strategic Steps - 2005-2010		
1. Provision and maintenance of RNAV STARs and holding procedures; and Mandate of RNAV in selected TMAs (§ 5.10)	TBD (likely RNP _{≤1}) (§ 5.1.6)	DME/DME; VOR/DME; INS/IRS + update; GPS + RAIM (+ conventional backup); SBAS (expected availability)
2. Provision and maintenance of conventional STARs and holding procedures (§ 5.11)		VOR, NDB, DME; INS/IRS+update
3. Provision and maintenance of	TBD	VOR; GPS + RAIM (+ conventional backup);

NPA capability at airports (§ 5.12)	(§ 5.12)	SBAS (expected availability); GBAS
4. Provision and maintenance of Cat I Capability at airports (§ 5.12)	TBD (§ 5.2.12)	ILS Cat.I (continued use/ maintain service level as long as possible); GBAS&SBAS (possible option to replace ILS Cat.I) MMR (increased use)
5. Provision and maintenance of Cat II/III Capability at airports (Cat.III including roll-out guidance) (§ 5.13)	TBD (§ 5.2.12)	ILS Cat.II/III (continued use/ maintain service level as long as possible); MLS (further use; replaces ILS CatII/III as appropriate; cannot evaluate ratio of replacement); GBAS (possible introduction, subject to constraints) MMR (increased use)
6. Rationalisation of ground based infrastructure (§ 5.15)		NDB (withdrawn before 2010) VOR (withdrawn by 2010) DME (comprehensive coverage)
Strategic Steps - 2010-2015		
1. Mandate of RNAV in all TMAs (§ 5.10)	TBD (likely RNP \leq 1) (§ 5.1.6)	DME (comprehensive coverage); INS/IRS + update; SBAS; GBAS: RNAV MASPS avionics
2. Provision and maintenance of NPAs at airports (§ 5.12)	TBD (§ 5.12.2)	SBAS ; GBAS
3. Provision and maintenance of Cat I Capability at airports (§ 5.12)	TBD (§ 5.12.2)	ILS (diminishing use/ maintain service level as long as possible); SBAS/GBAS (continued introduction to replace ILS Cat.I when appropriate; cannot evaluate ratio of replacement) MMR (widespread use; with upgrades as required)
4. Provision and maintenance of Cat II/III Capability at airports (Cat.III including roll-out guidance) (§ 5.13)	TBD (§ 5.12.2)	ILS (diminished use/ maintain service level as long as possible); MLS (further introduction to replace ILS Cat II/III); GBAS (further introduction to replace ILS Cat II/III) (cannot evaluate ratio of ILS replacement by MLS or GBAS) MMR (widespread use with upgrades as required)

4.2.4 Navigation requirements on airport surface, in support of Advanced Surface Movement Guidance and Control Systems (A-SMGCS).

4.2.4.1 Much attention is currently paid within ICAO international working bodies to the development of the concept of Advanced Surface Movement Guidance and Control Systems (A-SMGCS). These systems are seen as an important factor to increase the capacity and efficiency at airports and an integral part of the gate-to-gate strategies.

4.2.4.2 Requirements for navigation at and around airports in relation to A-SMGCS are currently under evaluation, following the extension of the EUROCONTROL convention to include airport operations. An apparent relationship exists between A-SMGCS and the runway guidance function (§ 5.14), as well as many relationships with domains other than Navigation (e.g. Surveillance). Studies are underway (in EUROCONTROL as well as in some European States) and their

results, when available, will in future be considered in this Navigation Strategy (§ 5.16).

5. ANNEXE 1 - STRATEGIC ACTIONS

Departure Phase (Initial Departure and SID)

5.1 Provision of take-off guidance

Objective: to support continued operations in low visibility conditions.

Rationale:

5.1.1 With the increased demand for optimised runway utilisation, ATS providers and aircraft operators require lower take-off minima, which can potentially improve/maintain the runway capacity for operations in low visibility conditions.

5.1.2 Runway guidance is provided on Cat III Precision Approach runways (§ 5.13-14)

Enablers:

5.1.3 Runway guidance is currently provided on Cat III Precision Approach runways by ICAO standardised non-visual systems to approach and landing, i.e. ILS and MLS. These can also be used for departure operations (ICAO Annex 10). Considerations with respect to these operations (§ 5.13) apply.

5.1.4 Runway guidance can also be provided by INS or IRS with update on the runway prior to departure. However, the costs of this equipment are still high. It is expected that GBAS, as required for Cat III operations, thus providing runway guidance, may be available in the timeframe covered by this Strategy. Initially, it may not be an ECAC-wide acceptable system to replace totally ILS Cat III, but this is expected to happen towards 2010 - 2015.

5.1.5 Full benefits from this strategic action can be achieved with the integration of arrival/departure managers and better information management, which are expected to increase the throughput of aircraft on airports and in terminal airspace (§ 5.1.8, 5.10.8).

Constraints:

5.1.6 The RNP concept for departure operations is under development by the ICAO OCP and RGCSP (see also § 5.2.6, 5.14). It will be incorporated in either the ICAO RNP Manual Document [ref.20] or a separate manual will be produced. The required material is expected to be ready in the 2000-2005 timeframe.

5.1.7 The availability of high quality aeronautical data is critical to the successful development of Cat III systems. However, the required enhanced AIS data integrity is not expected to be widely available before the timeframe 2005-2010.

5.1.8 The reduction of take-off minima will have implications for ATC, which must be considered fully. Integrated AMAN/DMAN systems are expected to be widely available at the busier airports by 2008 (§ 5.10.8).

5.2 Provision and Maintenance of RNAV SIDs

Objective: to support the ATM 2000+ Strategy for TMA reorganisation, in order to give increased capacity, flexibility and efficiency of operations

Rationale:

5.2.1 While physical extensions to airports, especially additional runways, may take 15-20 years, changes to TMAs may be made much quicker. The proposed TMA reorganisation is based on current systems and on the application of RNAV, without major technological changes/advances.

5.2.2 RNAV SIDs will be introduced in ECAC as follows:

- in the period up to 2005, providing new or overlay RNAV SIDs for the use of appropriately equipped aircraft;
- between 2005-2010, mandating RNAV SIDs in selected TMAs;

- post 2010 mandating RNAV SIDs in all TMAs.

Enablers:

5.2.3 The implementation of RNAV procedures is supported by aircraft operators (§3.1.9).

5.2.4 Initial trials have shown that RNAV SIDs may bring cost savings in terms of fuel reductions through reduced track length and more consistent performance. Environmental benefits, through appreciable noise and emission reduction, are also achievable.

5.2.5 The standardisation of RNAV procedures has started through the B-RNAV programme and guidance material to support RNAV operations in TMA is under development by TARA. This material addresses operational and functional requirements as well as other related elements and is developed in accordance with the different PANS Ops criteria applicable to VOR/DME, DME/DME and GPS procedures.

5.2.6 The application of the RNP concept to departure is considered a main enabler for increased efficiency of initial departure operations (see also § 5.14). The introduction of a total RNAV environment with defined RNP values for all operations within terminal airspace could support optimum use of the available navigation aids. ICAO OCP and RGCSF are studying the appropriate values for TMA operations. RNP requirement is primarily determined by obstacle clearance criteria. RNP<5 is required to provide the necessary accuracy immediately after take-off and this is expected to be achieved with suitable operational procedures (e.g. position update on runway). Lateral accuracy is not seen at present as a limiting factor for RNAV departure procedures

5.2.7 Increased use of RNAV in TMA will be encouraged throughout the entire period from 2000 to 2010, in order to allow benefits to capable aircraft. Evidence of achievement of these benefits may provide an incentive for re-equipment by other aircraft operators.

5.2.8 By 2010, the evolution of navigation systems capabilities and supporting infrastructure are expected to reach an RNP 1 RNAV baseline. Expected widespread use of RNAV SIDs and the availability of RNAV equipment capable of RNP=1 performance in order to satisfy approach and landing criteria (§ 5.10) may support a decision to mandate RNP 1 RNAV SIDs in all ECAC TMAs. Most lower capability aircraft will have been either removed from operations or upgraded by that time.

5.2.9 The forecast traffic growth and the increase in en-route capacity are expected to require increased performance post 2005, in particular in the very high density areas of ECAC. In consequence, timing accuracy becomes important, e.g. for efficient approach sequencing. The expected accuracy requirements are in the order of e.g. +/- 30secs at the entry to TMA, ±5 seconds at the approach gate. This would equate to RNP<1. Such performance can be achieved with DME based RNAV systems, GNSS or INS or IRS with update.

Constraints:

5.2.10 The early benefit estimations (§5.2.4) have to be confirmed.

5.2.11 The present policy within the B-RNAV programme (2000-2005) is merely to facilitate RNAV in TMA whilst requiring RNAV on designated feeder routes. Due to the significant differences between high and low density TMAs, it is therefore important that a CBA is performed, prior to setting up a mandatory requirement for RNAV in TMA.

5.2.12 The cost benefit for RNAV must be demonstrated either by the reduction in infrastructure costs or the ability to make use of RNAV to effectively increase capacity/economy and/or reduce the environmental impact of operations.

5.2.13 The ICAO requirement to provide 7 years' advance notice of change in requirements may prevent the mandatory use of RNAV in the TMA in the first timescale of this strategy (2000-2005). Conventional SIDs based on VOR/DME and NDB will continue to be provided at least until 2006-7 (§ 5.3). This impacts upon the navigation infrastructure which must continue to support both conventional and RNAV procedures. The total removal of NDBs, which is an objective of many service providers, would require additional capability from on-board equipment, which cannot be mandated within this timeframe.

5.2.14 A mandate for RNP 1 RNAV operations by 2006-2007 may be agreed with appropriate co-ordination and support from users and the appropriate (7 years) advance notice. This would require a decision to be made by 1999-2000 at the latest.

5.2.15 The ICAO manual on RNP values applicable to all phases of flight, which could support the introduction of a total RNAV environment, is under development and it is expected to be available before 2005.

5.2.16 A mandatory requirement for RNP 1 operations would imply a comprehensive DME coverage at lower flight levels and RNAV MASPS-compliant avionics.

5.2.17 The present level of integrity associated with aeronautical data published by AIS is insufficient to support RNP 1 operations. Another issue is the present lack of consistent interpretation of the text associated with conventional and RNAV TMA procedures and their translation for use in the navigation databases.

5.3 Provision and Maintenance of Conventional SIDs

Objective: to support continued TMA operations of aircraft with lower capability

Rationale:

5.3.1 The requirement of the users is for a Strategy that takes into account all their various and contradictory needs and develops actions acceptable for all categories of users.

Enablers:

5.3.2 Conventional SIDs based on VOR/DME and NDB will continue to be provided until at least 2006-7 (§ 5.2.13).

5.3.3 These navigation aids will be also required to support en-route operations (§ 5.4, § 5.7) and conventional STARs and holding procedures (§ 5.11).

5.3.4 ICAO SARPs for VOR, DME and NDB ground beacons are available, as are certification and operational approval standards for the corresponding airborne equipment.

5.3.5 ICAO PANS Ops are available for VOR/DME, DME/DME and GPS based procedures.

Constraints:

5.3.6 The use of RNAV in TMA may be mandated in selected TMAs, based on local requirements. This will limit the area of operations of lower capability aircraft (§ 5.2.2).

5.3.7 National rationalisation plans for conventional infrastructure (i.e. VOR and NDB), enabled by the increased use of RNAV, will further impact the operations of non-RNAV aircraft or lower capability B-RNAV aircraft.

5.3.8 Aircraft with lower capabilities will not be able to operate in an RNP 1 RNAV environment. These aircraft will either be removed from operations or their non-compliant avionics will require upgrading or be replaced. Procedures for accommodating State aircraft with lower capabilities have to be developed.

En-Route Phase

5.4 Requirement for B-RNAV at All En-Route Flight Levels

Objective: to support a new route structure in order to increase airspace capacity

Rationale:

5.4.1 RNAV has been preferred to the conventional method of navigation for the improved operational efficiency and the potential capacity gains that can be derived from its application. The implementation process needs to continue until full application of B-RNAV is achieved at all flight levels for en-route operations.

Enablers:

5.4.2 The design and implementation of the new route networks (e.g. ARN Version 3) rely on a complete RNAV environment in the ECAC en-route airspace. The new route structure is designed to make use of the RNAV and FUA concepts.

Constraints:

5.4.3 The major constraint in requiring B-RNAV at all flight levels is the provision of supporting infrastructure. Some gaps do exist in the DME coverage in limited areas of Europe at lower flight levels. The actions outlined in this strategy may help Member States to develop coherent plans (e.g. to deploy additional navigation aids) in order to fully support the implementation of B-RNAV.

5.5 Implementation of RVSM

Objective: to increase en-route airspace capacity by providing additional flight levels

Rationale:

5.5.1 The application of RVSM is considered the most cost-effective means of providing increased ECAC airspace capacity. RVSM will provide six additional flight levels for use in the highly congested airspace between FL 290 to FL 410 inclusive, which will provide the additional en-route capacity needed to support the demand over the next 8-10 years as well as giving the opportunity for achieving better flight profiles. RVSM is planned to be implemented in November 2001. The associated required RVSM height keeping performance may have its influence on risk assessments for separation minima in the horizontal plane (see "constraints").

Enablers:

5.5.2 The airspace users support almost unanimously the implementation of RVSM (§3.1.9). The RVSM CBA demonstrated a positive benefit-to-cost ratio over a wide range of assumptions regarding future developments within the European aviation environment.

5.5.3 Aircraft height keeping performance (including altimetry system accuracy) will have to meet specific RVSM criteria (MASPS-compliant altimetry and height-keeping systems), which may require re-equipage and/or fuselage treatment. Some changes will be required to ATC systems. A monitoring system to confirm RVSM height keeping performance will be applied to support a safe introduction of RVSM.

Constraints:

5.5.4 Due to the aircraft height keeping performance requirements which enable the safe operation in the RVSM airspace, the overall height keeping accuracy of aircraft flying in European airspace will increase. Safety assessments for horizontal separation minima, especially for (reduced) minimum route spacings, apply aircraft height keeping accuracy as one of the parameters which influences the horizontal risk. In general the risk models assume that the better the vertical accuracy, the higher the collision risk in the horizontal plane. Therefore, when considering the safety of separation minima on the basis of (improved) horizontal navigation performance (RNP), it will be necessary to take into account the effect of increased vertical accuracy, as brought about by RVSM requirements.

5.5.5 The introduction of RVSM and the resulting availability of more flight levels above FL290, may require re-sectorisation. This requirement has to be taken into account considering re-sectorisations in the context of route-structure changes. Therefore, the navigation infrastructure, as required to support en-route route structures and the associated airspace (sectorisation) structures, may need to take into account RVSM airspace requirements.

5.5.6 Other key elements in the implementation of RVSM relate to ATC issues (e.g. airspace requirements, ATC operational procedures, ATC system support, etc.), which are not covered by this Navigation Strategy.

5.6 Implementation of Free Routes

Objective: to support increased flexibility of en-route operations and to improve user preferred trajectories

Rationale:

5.6.1 The Free Routes concept allows aircraft with RNAV capability to plan flights between en-route points at the beginning/end of the Terminal Procedures (SIDs / STARs) or the entry/exit points to the Free Routes airspace. This concept is expected to contribute to the flexibility of en-route operations, to give capacity increases, and to allow fuel and time efficient operations with

the minimum of ATC constraints. It is expected to offer an increase in en-route capacity in the timeframe 2000-2006/8, by allowing aircraft to benefit from the improved on-board capabilities and by enabling selectable user operational preferences.

Enablers:

5.6.2 Initial studies and simulations (EUROCONTROL) have indicated a reduction of approximately 33% in conflicts in a Free Routes environment, primarily from the dispersion of tracks. This in turn could allow a greater proportion of aircraft to receive the requested flight level and a reduction in controller intervention. This may to some extent be reflected in increased sector capacity. If feasible, the two factors would significantly increase the effective system efficiency and capacity and would become an important step towards the future European ATM system.

5.6.3 The Free Routes Project is currently under development within EATCHIP. Its initial application from 2002 is based on B-RNAV capability. No additional airborne equipment fit will be required and the requirements for navigation infrastructure remain unchanged from this point of view.

Constraints:

5.6.4 The Free Routes Concept may address additional capacity increase which may be required in the time frame 2002-2006, after the RVSM implementation. The initial simulations (§ 5.6.3) retained the control function of the ground system, but with flexibility being offered to aircraft to follow their optimum profile. The studies underway have demonstrated the need for adequate controller support due to the complexity of the interaction between these "ideal" routings and the resulting spread of conflict points. The required enhancements in ATC tools are yet to be determined and are expected to be the most costly element of the implementation.

5.6.5 There will be a need for the controller tools to support the application of the Free Routes to specific parts of the airspace (e.g. higher FLs or areas with less dense traffic). An additional requirement for comprehensive navigation coverage with appropriate infrastructure may arise when the effective implementation area is defined (EATCHIP).

5.6.6 The feasibility of implementing free routings ECAC-wide in the timeframe 2005-2010 is under consideration within EATCHIP. Issues being addressed include the relative roles of ATC and aircraft systems for separation assurance, management of the converging traffic around the terminal airspace and the concentration of traffic likely to occur in the proximity of an active restricted area. The main areas of development required in such an environment may involve vertical and time profiles (4D RNAV) (§ 5.9). Some options studied under the EUROCONTROL PHARE programme using this concept demonstrated that RNAV and FMS, together with a ground-based ATC function, can play an important role in future developments.

5.6.7 The period to 2005 is likely to see only the very first stage of the 'free routes' implementation process, or more likely an experimental stage. The ability to use the navigation capability will increasingly require further development of ATS and airborne systems. It is expected that free routes operations will be gradually extended throughout the upper and lower airspace, as the support tools become available. However timescales are uncertain.

5.7 Continue to Support Operations of Aircraft with Lower Capability

Objective: to support continued en-route operations of aircraft with lower capability and State aircraft

Rationale:

5.7.1 This Strategy takes into account the needs of all categories of users and defines actions to address them (§ 3.1.6). State aircraft are exempted from the B-RNAV mandatory requirement and their operations need to be supported (§3.1.10).

5.7.2 The aircraft equipped with lower capability B-RNAV systems equally require support to continue their operations as long as feasible.

Enablers:

5.7.3 In line with international agreements, State aircraft have unrestricted access to the entire airspace and corresponding infrastructure support for their operations has to be maintained. After 2010, military GAT operations are expected to use advanced navigation systems, either self-

contained or satellite-based.

5.7.4 B-RNAV systems are expected to progressively reduce operations up to 2010 due to the evolution of the air navigation environment.

5.7.5 Due to the continued need to support conventional procedures in TMAs (§ 5.3, § 5.11), the rationalisation and/or withdrawal of conventional supporting infrastructure (mainly VOR and NDB) is not expected to be completed before 2010 (§ 5.7.8, § 5.15).

Constraints:

5.7.6 Throughout the period 2005-2010 the need to accommodate a reduced number of aircraft equipped with lower capability B-RNAV systems imposes restrictions on the majority of aircraft, which have higher RNAV capabilities, and delays the benefits to be derived from an RNAV environment with increased performance requirements (e.g. RNP 1). RNP 1 RNAV is expected to be mandated ECAC-wide from 2010 for all phases of flight (§ 5.8, 5.2.8, 5.10.2).

5.7.7 Some military GAT operations may still require conventional infrastructure support beyond 2010. On a national basis, authorities may decide to continue the provision of conventional services for military use.

5.7.8 For en-route operations, NDBs and VORs are expected to be completely withdrawn before or by 2010. VOR services may continue to be required at a limited number of airports to support TMA operations beyond 2010, but not ECAC wide (§ 5.3.11), and the system is expected to be completely withdrawn by 2014-2015. The further developments in GNSS may accelerate VOR withdrawal for all phases of flight.

5.8 Mandate of RNP-1 RNAV operations

Objective: to support additional capacity gains through the definition of closely-spaced parallel routes

Rationale:

5.8.1 RNP 1 RNAV is expected to enable a reduction in route spacing and separation criteria and consequently give increased system capacity .

Enablers:

5.8.2 It is possible to require this performance on a limited basis for dedicated routes between 2000-2010, where the need for additional capacity is stringent and no other means of providing additional capacity will bring benefits. In this timeframe RNP 1 operations can be performed with dual/multi DME RNAV systems. A comprehensive DME coverage is required and is expected to be available throughout the timeframe, due to the requirements to enhance coverage to support B-RNAV operations.

5.8.3 Global standards are available for RNP x RNAV systems [ref.16] (§ 6.3.2). They relate presently to plan navigation (2D RNAV) but work is underway to extend the standards to longitudinal and vertical (3D) requirements, as well as time (4D). It is expected that they will be available before 2005.

5.8.4 Rationalisation plans for ground navigation aids (VOR, NDB) will be from 2000 onwards on an opportunity basis (§ 5.2, § 5.10). The increase in RNP 1 and even RNP<1 RNAV-equipped aircraft, due to the more stringent demands of terminal airspace operations, will lead to the mandatory requirement for a (baseline) RNP 1 RNAV requirement en-route from 2010 onwards.

5.8.5 This will allow further rationalisation up to the total removal of VOR. Since the ability to revert to non-RNAV operations will no longer be available, the removal of VOR would imply a requirement for an increased quality of performance offered by RNAV. This could only be achieved if all aircraft satisfied the full RNP 1 RNAV MASPS. If this was necessary/required before 2005, it could imply considerable expense to operators for those aircraft which have to be retro-fitted. After 2010, however, it is expected that RNP 1 RNAV MASPS will be the common level of aircraft capability.

5.8.6 The DME infrastructure will continue until at least 2015, and will support RNP 1 RNAV operations adequately. Multi DME-based RNAV systems, INS/IRS with update, GNSS systems

will provide the required performance.

Constraints:

5.8.7 Before new avionics requirements are set it is important that the benefit arising from their implementation can be quantified and a positive CBA can be demonstrated. Existing RNAV systems have a continuity of service and integrity level significantly below that of VOR transmitter/receiver combinations. Indeed, many of the current RNAV and FMS equipment which meets RNP 1 cannot provide the required continuity of service and in many cases cannot meet the integrity requirements.

5.8.8 Further constraints in requiring more stringent RNP values are the present CFMU and ATC systems. These currently have no means of distinguishing between aircraft with mixed capabilities and this facility has to be provided if different requirements are imposed. Handling traffic with mixed capabilities will be a draw-back to implementing such a requirement, due to the possible decrease in capacity through increased controller workload as well as the need for costly enhancements or changes to ATC systems. Studies and simulations have demonstrated that potential capacity gains from a mixed capability environment are limited and could result in reduced ATC sector capacity.

5.9 Implementation of 4D RNAV Operations

Objective: to exploit the advanced navigation capability in four dimensions in order to maximise freedom of movement, efficiency and flexibility of operations

Rationale:

5.9.1 4D RNAV operations by capable aircraft may offer significant benefits and allow a redistribution of responsibilities between aircraft and ATC between 2010-2015, provided that adequate ATC tools are available.

Enablers:

5.9.2 Extending the capability of RNAV to accurate time control (4D RNAV) is expected to offer significant benefits when supported by suitable ATC tools. 4D-capable aircraft systems certified against 4D RNAV MASPS, could support such advanced operations. Global standards could be available in the proposed timeframe (2010-2015), and action is underway (EUROCAE/RTCA) to extend the existing 2D MASPS to 4D [ref.16].

5.9.3 The EUROCONTROL PHARE programme has demonstrated the feasibility of 4D operations. A follow-up project is focused on implementation issues, with the aim of achieving operational benefits by making best use of available technology (§5.10.3).

Constraints:

5.9.4 R&D studies have to be initiated, in order to identify and thoroughly explore all issues related to the complex application of 4D navigation. In an increasingly business-orientated environment for air navigation, any effective development plans will have to be based on sound business cases, where CBA results play an important part.

5.9.5 An international standard for the PHARE compatible FMS/RNAV needs to be agreed and cost benefit assessments of alternative infrastructure to be performed. Controller support tools such as trajectory prediction, conflict resolution and arrival/departure managers must be in place to support 4D applications and datalink must be available to permit the ATM system capacity to approach more closely and consistently the system optimum. These imply a complex integration of all system components into a cohesive whole and close relationships and co-ordination with developments in other domains (e.g. Surveillance, Communications). If tackled inappropriately or late, it may delay the and benefits of such systems.

5.9.6 It is expected that the concepts of an integrated air/ground ATM with precise 4D trajectory-following will become the standard by 2015 [ref.1]. For such operations to be undertaken, increased availability of planning tools and accurate short term meteorological forecasts will be required. Operations are expected to be based upon preferred trajectories and will take account of any active airspace restrictions and the sequencing requirements necessary to optimise the airspace capacity.

Initial Approach, Final , Approach and Landing

5.10 Provision and Maintenance of RNAV STARs and Holding Procedures

Objective: to support TMA reorganisation, for increased capacity, flexibility and efficiency of operations

Rationale:

5.10.1 In future, it is anticipated that environmental concerns will have to be accommodated by ensuring that all arrivals and departures follow optimal 3D and 4D routes. In the case of arrivals/approaches, this will probably mean that aircraft will have to conduct continuous descents with engines at, or close to, idle power. Some form of automated arrival management will be necessary, probably supported by data link. Clearances will have to be based upon Required Times of Arrival (RTA) at specific waypoints, if current capacity is to be maintained (ref.[24]).

Enablers:

5.10.2 Considerations related to the implementation of RNAV SIDs (§ 5.2) are equally applicable to RNAV STARs.

5.10.3 EUROCONTROL PHARE studies and experiments demonstrated the feasibility and merits of a future integrated air-ground ATM system in all phases of flight, implying two-way datalink between EFMS and ATC, involving extended, accurate 4D navigation, an advanced airborne HMI and arrival managers. The programme used multi-DME algorithms, or multi-DME integrated with GPS/IRN algorithms and demonstrated an achieved navigation performance of 0.1 NM. 3D RNAV could offer operational benefits where environmental restrictions appear, by allowing continuous descents, and associated fuel savings; however this may lead to negative impact on capacity, which will further require 4D RNAV (§ 5.9). A follow-up EUROCONTROL project has, as its goals, the rapid implementation of RNAV procedures in terminal airspace, 4D departure and arrival managers and integrated airport surface managers, based on existing technology, equipment and capabilities.

Constraints:

5.10.4 The strategic programmes developed within EATCHIP to provide additional capacity en-route are expected to result in the bottlenecks moving towards the runway in the period to 2010. Environmental factors will restrict additional runway developments and it is therefore expected that the main constraint to air traffic growth will be the airport infrastructure.

5.10.5 The TARA Task Force also studies the application of RNAV in TMAs. The minimum level of standardisation is still under consideration but it is clear that only a subset of the currently used B-RNAV equipment could be acceptable for TMA operations. Benefits have been identified for future 4D-capable equipment, but some benefits could also be derived from the existing, less sophisticated equipment.

5.10.6 There are specific requirements defined by TARA for databases. Again the low integrity level of aeronautical data and the need to develop unambiguous rules for procedure description should be seen as major constraints. The further progression of the WGS 84 programme towards a Unified Vertical Reference Frame is expected to support future 4D RNAV developments.

5.10.7 The airborne architecture will need to meet the continuity and integrity requirements for 4D operations (§ 5.9). Separate computers for approach and landing will be needed or, alternatively, a means by which the hardware and software of the RNAV/FMS can provide the required high levels of integrity and continuity of service during these critical portions of the flight.

5.10.8 Automated arrivals manager tools (AMAN) with limited functionality are already in use at a few airports. More advanced tools will be available by 2005 and will be deployed at some major airports. Improved navigation information and the use of two-way datalink will improve AMAN performance, providing the platform for automated sequencing procedures by 2008. For information on other integrated AMAN-DMAN systems see § 5.1.8, § 5.13.8, § 5.16.3, and ref. [1].

5.11 Provision and Maintenance of Conventional STARs and Holding Procedures

Objective: to support continued operations of aircraft with lower capability

Rationale:

5.11.1 The considerations already presented for the continued support of conventional SIDs (§ 5.3) and for en-route operations (§ 5.7) will also apply to conventional STARs and holding procedures.

5.12 Provision and Maintenance of Non precision and Cat I Precision Approaches

Objective: to support non-precision approach and Cat I Precision Approach operations

Rationale:

5.12.1 Supporting non-precision approach and Cat I Precision Approach operations will continue to be required at ECAC airports, in particular in medium and low density areas.

Enablers:

5.12.2 The applicable RNP value is under consideration in various bodies, e.g. EUROCONTROL TARA Task Force, ICAO OCP [ref.19].

5.12.3 Non-precision approach procedures based on GPS stand-alone equipment are expected to replace many NDB procedures before 2005, followed by a progressive rationalisation and withdrawal of NDB before 2010. VOR will continue to support non-precision approach operations until 2010. Its use is expected to decrease progressively, allowing for VOR decommissioning by 2010. The future enhancements to GNSS for civil use are expected to become available by 2005 and could support non-precision approaches, allowing for faster NDB and VOR rationalisation / withdrawal. It should be noted that NPA are often combined with DME.

5.12.4 ILS Cat I is expected to remain in use until the end of its service life at locations where there is no stringent requirement for upgrading/replacing. It is expected that ILS Cat I will be progressively replaced by GNSS, allowing for ILS decommissioning by 2015.

Constraints:

5.12.5 ILS signal quality is likely to be threatened by:

- VHF interference (ILS operates in the VHF band and from 1998 onwards increasing the power of FM broadcast stations in the same band is permitted)
- multipath effects which can be caused by new building works at and around airports
- ILS channel limitations.

5.12.6 In addition, operational limitations on the use of ILS, due to the decreased capacity of runways during low visibility conditions is a very important factor for consideration. The threats that cause the ILS signal degradation can partially be solved by having new generation receivers on board aircraft. These have increased filtering capabilities which would solve the interference problem from the increased power of the FM-broadcast stations. The possibility of maintaining the required ILS service level is the deciding factor when the development of replacement/transition plans is considered.

5.12.7 Planning for transition from ILS must take into account the following issues [ref.19]:

- current and forecast traffic levels;
- the safety of operations;
- CBA;
- the need to guarantee the continuity of operations at, at least, existing levels;
- the required levels of service;
- the lead times for certification and implementation;
- operators' equipage;
- development of new procedures;
- sustainability of a mixed environment during the transition period and its effect on safety.

5.12.8 Frequency issues will become more stringent during the transition period. Moreover, frequency allocation cannot be achieved by a simple transfer and, in addition, several systems (ILS, MLS, GBAS) will need to be supported at the same time.

5.12.9 MMR could provide the means for flexible transition. It may accept ILS, MLS and GNSS signals and is capable of providing ILS-like guidance. MMR with high integrity datalink could support GNSS operations. Differential GNSS could also be integrated into MMR. The development of MMR is critical for maintaining full interoperability in the field of landing systems. It is expected to be available by 1999 and the progressive implementation of MMR is therefore recommended.

5.13 Provision and Maintenance of Precision Approaches (Cat II/III)

Objective: to maintain capacity levels and support continued operations in low visibility conditions

Rationale:

5.13.1 In ECAC, the forecast traffic increase will create major constraints in low visibility conditions. This problem will be felt equally at airports offering Cat III precision approach facilities. The number of airports with such capabilities is expected to increase in future.

Enablers:

5.13.2 The development and application/introduction of ICAO RNP concept to precision approach operations is a main enabler for increased efficiency in a gate-to-gate perspective.

5.13.3 Considerations regarding applicable RNP values and ILS issues as presented in § 5.12 are applicable.

5.13.4 Cat III Precision Approach capability is provided by ICAO standardised non-visual systems to approach and landing, i.e. ILS and MLS. These can also be used for departure operations (ICAO Annex 10) (§ 5.1).

5.13.5 It is expected that GBAS, as required for Cat III operations, may be available in the timeframe covered by this Navigation Strategy. Initially, it may not be an ECAC-wide acceptable system to replace totally ILS Cat III, but this is expected to happen towards 2010 - 2015.

Constraints:

5.13.6 The ICAO RNP Manual Document [ref.20] has to be amended accordingly or a separate manual on RNP for departure and arrival be produced. The required document is under development and is expected to be ready in the 2000-2005 timeframe.

5.13.7 Cat III operations at European airports are currently supported by ILS Cat III. Its continued use to support this level of operations is recommended as long as economically beneficial and operationally acceptable (ILS Cat III will continue to be in use for the following 8-10 years, see ICAO Annex 10, Volume 1). However, the technical limitations of ILS will be a major constraint to its continued use. Considerations regarding ILS limitations as presented in § 5.12 are applicable.

5.13.8 Where the levels of service of ILS Cat III cannot be maintained, MLS is considered the best candidate to replace ILS Cat III in the timeframe 2000-2015 (ref.[5], [19]). Plans are on-going at some major European airports (e.g. London Heathrow, Amsterdam Schiphol).

5.13.9 The main constraints related to GBAS for Cat III operations are associated with technical, operational and institutional issues involved in the development of sole means satellite navigation systems for civil use. However it is expected that satellite technology could provide the required level of service sometime by 2015.

5.13.10 Considerations regarding integrated arrival/departure managers and A-SMGCS with datalink (§ 5.10.8, § 5.16.3) are applicable. The enhanced AIS data integrity necessary to support these advances is not expected to be available before 2005.

5.14 Provision and Maintenance of Runway Guidance for Final Approach and Taxi

Objective: to support continued operations at airports under low visibility conditions, maintaining capacity requirements

Rationale:

5.14.1 The considerations already presented for runway guidance for take-off operations (§ 5.1) and for A-SMGCS (§ 5.16) are applicable.

Enablers / Constraints:

5.14.2 Criteria to cater for autoland operations, when low visibility procedures are not available, are under development by AWOG. Where autoland operations are conducted, ILS, MLS, GPS equipment and signals in space should have suitable frequency protection.

5.14.3 When new navigation aids using primary or stand-alone input devices for precision approach and landing are introduced, airborne equipment will require certification for autoland operations.

5.14.4 Current working methods in CFMU procedures will need to be updated to properly take into account the effect on airport operations of low visibility conditions and procedures.

5.14.5 Other enablers/constraints as presented in § 5.1. are applicable.

5.15 Rationalisation of the Ground Infrastructure

Objective: to increase the cost efficiency of flight operations through a judicious deployment and use of supporting infrastructure for all phases of flight

Rationale:

5.15.1 The airborne requirements for navigation systems are dependent on the area or airspace in which an aircraft operator wants to fly and/or which service he wants to use. Any reduction in the ground-based navigation infrastructure through decommissioning plans and/or its replacement with new technology has implications in aircraft systems which need to be assessed with priority. RNAV systems are designed such that neither the pilot nor the controller necessarily knows which particular elements of infrastructure are used to determine the navigation solution. The current trend is towards defining performance requirements in terms of RNP values, without prescribing any particular combination of equipment [ref.16 and 20.].

Enablers:

5.15.2 The main trigger for rationalisation plans are high maintenance costs for service providers and the impact on charges to users (aircraft operators). Rationalisation plans for the ground-based navigation infrastructure are equally needed to allow full benefits from the satellite systems to be achieved.

5.15.3 In most parts of ECAC there is coverage with high redundancy provided by VOR and DME for en-route operations (i.e. at higher FIs).

5.15.4 It is expected that the actions described in this Navigation Strategy (§ 5.1-15) will allow for the development of transition/rationalisation/withdrawal plans for the existing navigation aids, ensuring the transition to the GNSS in the long term, as recommended by ICAO. All considerations made throughout this Strategy, regarding supporting infrastructure for each phase of flight, are applicable. A graphic illustration is provided in § 4.1.

Constraints:

5.15.5 The shared use of most of the current systems for both en-route and terminal operations creates rationalisation planning difficulties for most of the conventional infrastructure. It also creates problems for the aircraft, which are equipped with a large variation of system mixes, with different levels of capabilities, and different, even contradictory, operational interests. Performance requirements have to be set to the lowest level (of the 'small' users), which may not find the rationalisation/withdrawal plans acceptable. Conversely, the larger operators require a system that allows them to collect benefits..

5.15.6 GPS stand-alone equipment is an acceptable system for B-RNAV operations, provided that the particular aircraft also carries conventional back-up equipment (e.g. VOR, DME, ADF).

5.15.7 The need for a comprehensive coverage to support various RNAV operations at all applicable FLs requires an assessment to be made of the coverage provided by the ground-based infrastructure (§ 5.4.4). Some uncertainties still remain concerning the number of DMEs that would be needed to obtain the required comprehensive coverage at lower levels. For TMA operations the shared use of navigation aids may solve the problems in some areas, but some States have reservations in sharing agreements, mainly due to liability issues.

5.15.8 The relaxation of integrity and continuity requirements associated with BRNAV and PRNAV is only applicable as long as reversion to conventional navigation using VOR/DME and NDB remains available. Once the VOR and NDB infrastructure starts to be decommissioned, operations on RNP 5 and RNP 1 routes will require conformance to the requirements for RNP-5 RNAV and RNP-1 RNAV (MASPS) equipment respectively (§ 6.3).

5.15.9 This Navigation Strategy recognises the emergence of satellite technology and its future role in the global navigation environment. However, it is expected (based on current knowledge) that the rate of technological development of the system and the time needed for the resolution of institutional limitations will result in the need for a ground-based back-up system for GNSS for the foreseeable future.

5.16 Support for Advanced Surface Movement Guidance and Control Systems at Airports (A-SMGCS)

Objective: to support A-SMGCS at airports in order to help maintain capacity and continued operations in low visibility conditions

Rationale:

5.16.1 Surface Movement Guidance and Control operations in low visibility conditions may become a major constraint to the overall system capacity. New technologies for A-SMGCS may have a significant impact on aerodrome operations. These could have an effect on the approach and landing as well as for the ground operations.

5.16.2 A-SMGCS must provide more precise guidance for all aircraft and vehicles on the movement area, between the runway(s) and the stands. It must also be able to ensure separation between all moving aircraft and vehicles in conditions when their speed prevent such separation being maintained visually. To compensate for a lack of visual capability, A-SMGCS must be able to provide situational awareness not only to ATC but also to all those aircraft and vehicles that may come in proximity with each other. An A-SMGCS will need to interface with (the rest of) the ATM system, and will support gate-to-gate operations, rather than merely serving to provide guidance and control to individual aircraft and vehicles.

Enablers:

5.16.3 The integration of A-SMGCS with combined arrivals and departures management systems (§ 5.10.8, § 5.13.8), the use of RNAV techniques, the gradual introduction of GNSS for precision approach operations, optimised traffic routes around airports and more integrated schedule planning between adjacent airports will provide the foundation for progressive improvement in all weather operations by 2010. Arrival and departure rates in poor visibility conditions will be improved and capacity will begin to match that for operations in good visibility conditions [ref.1].

5.16.4 Several tasks related to the optimisation of aerodrome operations have been taken into consideration in the APATSI programme.

5.16.5 The developments for approach and landing operations (§ 5.12-14) should be well coordinated and in line with the developments for ground operations. Special attention is necessary on the interface of landing operations and ground operations. Improving airport capacity in low visibility conditions is strongly dependent on improving the runway occupancy times, which in turn is dependent on guidance functionality for ground operations.

5.16.6 An apparent relationship exists between A-SMGCS and the runway guidance function (§ 5.14), as well as many relationships with domains other than Navigation (e.g. Surveillance). Studies are underway (in EUROCONTROL as well as in some European States) and their results, when available, will in future be considered in this Navigation Strategy.

Constraints:

5.16.7 Currently there is no appropriate ICAO body studying navigation requirements for A-SMGCS [ref. 19]. Further development of technical and operational requirements for such systems that concern the approach and landing phases of flight are addressed by AWOOG.

5.16.8 Enhancements to the A-SMGCS to allow the maintenance of optimal airport capacity under reduced visibility conditions have to take into account cost/benefit considerations.

5.16.9 The navigation system requirements for A-SMGCS can be driven by requirements for ATC surveillance and control systems, when the latter systems are based on some form of ADS (§ 3.4). Related navigation system requirements may include, for example, navigation data, RNP, the availability of other navigation-related parameters (ground speed, intentions, distance to stop), as (uplinked) input into the ATC surveillance and control systems. These requirements will be determined through the Surveillance Strategy [ref.13], and will be taken into account by this Navigation Strategy as soon as they become available.

6. ANNEXE II

6.1 Required Navigation Performance (RNP)

6.1.1 Traditional regional regulations apply for the carriage of specific airborne navigation equipment. ICAO has endorsed the concept of Required Navigation Performance (RNP), which is a statement of the aircraft navigation performance defined in terms of accuracy, integrity, availability and continuity of service necessary for operations within a defined airspace, without requiring specific navigation equipment [ref. 20].

6.1.2 For en-route purposes currently four RNP “Types” have been defined (RNP1, RNP4/5, RNP12.6/10, RNP20), where the type number indicates the containment value in miles. The containment value is the distance from the intended position within which flights would be found for at least 95% of the total flying time. The extension of the RNP concept to the precision approach and landing phase and the corresponding RNP “types” are currently under development.

6.1.3 States must ensure that the navigation infrastructure provided supports adequately the prescribed RNP type in a specific area or on a specific route. RNP is only one parameter in the determination of separation standards.

6.2 Area Navigation (RNAV)

6.2.1 RNAV is a method of navigation which permits aircraft operation on any desired flight path within the coverage of referenced navigation aids or within the limits of the capability of self-contained aids, or a combination of these. 2D RNAV relates to RNAV capabilities in the horizontal plane only; 3D RNAV includes a guidance capability in the vertical plane and 4D RNAV provides an additional timing function. The RNP determines the accuracy with which the RNAV system is required to determine the aircraft *absolute* geographical position (instead of only in terms of its position *relative* to a navaid, as is the case with conventional VOR/DME display instruments). As from 1998 the carriage of RNAV equipment capable of RNP 5 accuracy (B-RNAV) is mandatory in the ECAC area.

6.2.2 The RNAV concept represents a fundamental change in navigation philosophy. Traditionally aircraft used to fly to and from specific navaids, using each navaid as a source of data. An RNAV-capable aircraft can automatically determine its position, from one or more of a variety of inputs, e.g. VOR, DME, GNSS, INS. Single-sensor RNAV systems only use one source of navigation data, such as DME stations, while multi-sensor RNAV systems monitor a number of navaid systems to determine the best source of navigation data.

6.2.3 The RNAV system has access to a sophisticated on-board navigation data base containing details of the pre-programmed routes, the airspace through which the routes pass, the navaids servicing this airspace and the departure, destination and planned diversion aerodromes. The system identifies the next waypoint on the planned route, selects the most appropriate navaids to determine the aircraft position and usually provides steering inputs to the autopilot.

6.2.4 An RNAV route can be flown automatically, with the autopilot coupled to the RNAV system, or manually, with the RNAV system outputs displayed on the flight director/course deviation indicator, with adequate warning of speed, altitude and track changes being provided to allow the pilot time to respond and follow the required track.

6.3 Standards

6.3.1 The EUROCONTROL RNAV Standard [ref.18] defines operational and functional requirements for RNAV equipment meeting RNP-5 and RNP-1 accuracy (B-RNAV and P-RNAV respectively). These requirements are taken into account in the TGL-2 published by JAA in 1997 for certification and airworthiness approval of aircraft for B-RNAV operations in ECAC [ref.17].

6.3.2 Global specifications for RNAV systems are contained in the RNAV MASPS [ref.16]. These standards are intended for designers, manufacturers and installers of avionics equipment, service providers and users of these systems for world-wide operations. The MASPS requirements, formulated as RNP-(x) RNAV, are intended to meet the ICAO definition of RNP while providing increased integrity with repeatable and predictable navigation. RNAV MASPS demand increased functionality and, in particular, define system integrity requirements enabling removal of conventional navigation aids.

6.3.3 The minimum requirements set out in the EUROCONTROL Standard for B-RNAV and P-RNAV systems represent a subset of the total system requirements which have been defined in the MASPS on the basis of global requirements. A relaxation of integrity and continuity values is associated with B-RNAV and P-RNAV. This relaxation is applicable only so long as reversion to conventional navigation using VOR and NDB remains available. Once the VOR and NDB infrastructure starts to be decommissioned, operation on RNP-5 and RNP-1 routes will require conformance to the RNAV MASPS.

6.3.4 The following table summarises the correspondence between the performance requirements set out in the EUROCONTROL Standard and the RNAV MASPS:

Track Keeping Performance	Pre RNAV MASPS Applicability	Post RNAV MASPS Applicability
5 NM 95%	B-RNAV	RNP-5 RNAV
1 NM 95%	P-RNAV	RNP-1 RNAV
<1 NM 95%	-	RNP-x RNAV (x<1)

6.4 References

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6.5 Abbreviations

6.5.1 For the purposes of this Strategy, the following abbreviations shall apply:

ADF	Automatic Direction Finder
ADS (-B)	Automatic Dependent Surveillance (-Broadcast)
AIS	Aeronautical Information Service
AMAN	Arrival Manager
ANT	Airspace And Navigation Team
APATSI	Airport ATS Interface
ARN	ATS Route Network
ATC	Air Traffic Control
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATS	Air Traffic Services
AWOG	ICAO All Weather Operations Group
B-RNAV	Basic Area Navigation
CBA	Cost Benefit Analysis
CNS	Communications-Navigation-Surveillance
DMAN	Departure Manager
DME	Distance Measuring Equipment
EANPG	ICAO Regional European Air Navigation Planning Group
EATCHIP	European Air Traffic Control Harmonisation And Integration Programme
ECAC	European Civil Aviation Conference
EFMS	Experimental Flight Management System
EGNOS	European Geostationary Navigation Overlay Service
FL	Flight Level
FM	Frequency Modulation
FMS	Flight Management System
FUA	Flexible Use Of Airspace
GAT	General Air Traffic
GBAS	Ground Based Augmentation System (ICAO) (equivalent to LAAS)
GLONASS	Global Orbiting Navigation Satellite System (Russian Federation)
GNSS	Global Navigation Satellite System (ICAO)
GPS	Global Positioning System (USA)
HMI	Human Machine Interface
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
ILS	Instrument Landing System
INS	Inertial Navigation System
IRS	Inertial Reference System
JAA	Joint Aviation Authorities
LAAS	Local Area Augmentation System (FAA)
MASPS	Minimum Aviation System Performance Specification
MLS	Microwave Landing System
MMR	Multi-Mode Receiver
MOSD	Mission, Objectives and Strategy Document [ref.9]
NAT	North Atlantic Region

NDB	Non-Directional Beacon
PHARE	Programme for Harmonised ATM Research in EUROCONTROL
P-RNAV	Precision Area Navigation
RAIM	Receiver Autonomous Integrity Monitoring
R&D	Research and Development
RNAV	Area Navigation
RNP	Required Navigation Performance
RVR	Runway Visual Range
RVSM	Reduced Vertical Separation Minimum
SBAS	Satellite Based Augmentation System (ICAO) (equivalent to WAAS, EGNOS, MSAS)
SID	Standard Instrument Departure
(A-)SMGCS	(Advanced-) Surface Movement Guidance And Control Systems
STAR	(Terminal) Standard Instrument Arrival (Route)
TARA	Terminal Airspace RNAV Applications Task Force
TGL	Temporary Guidance Leaflet
TMA	Terminal (Control) Area
VOR	Very High Frequency Omni-directional Radio Range
WAAS	Wide Area Augmentation System (FAA) (equivalent to ICAO SBAS)
WGS	World Geodetic System
State aircraft	Aircraft operating on military, customs or police activities shall be deemed to be State Aircraft (ICAO Chicago Convention)
RNAV Overlay Procedures	RNAV SIDs/STARS which replicate the published conventional procedures (SIDs/STARS)