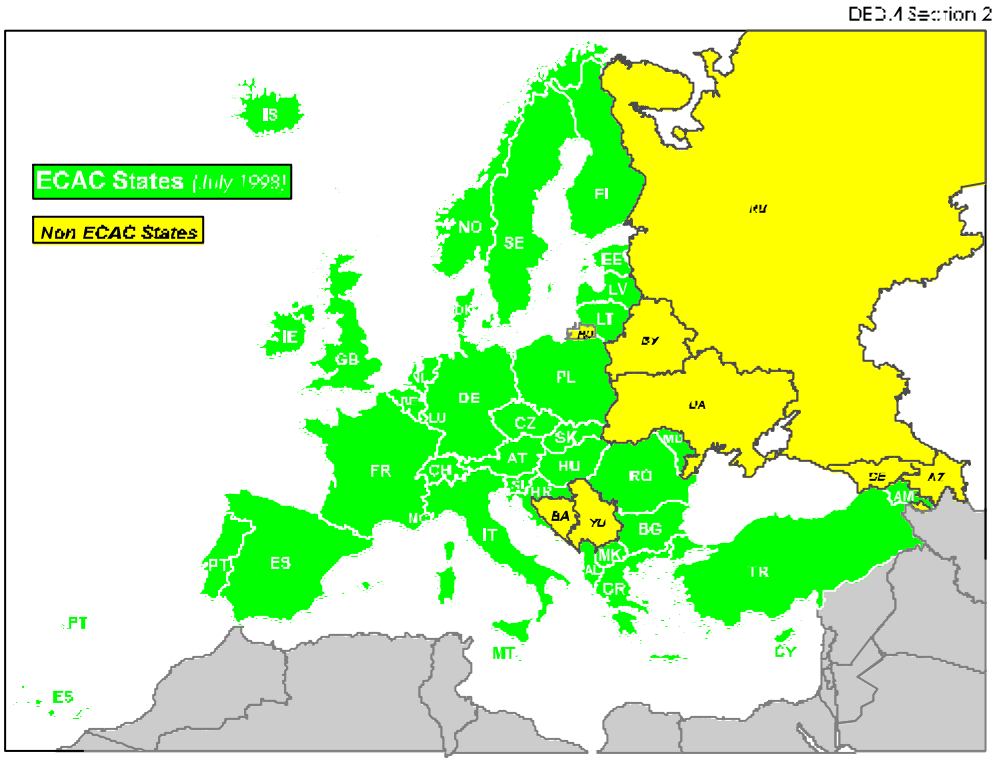
EUROPEAN ORGANISATION FOR THE SAFETY OF AIR NAVIGATION

ARN Version 3

Report on

The Development of Proposals for Amendment of Table ARN-1 of the EUR-ANP



EUROPEAN AIR TRAFFIC CONTROL HARMONISATION AND INTEGRATION PROGRAMME

Report on the Development of Proposals for Amendment of Table ARN-1 of the EUR-ANP

(ARN Version 3)

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Abstract This document reports on the route network development activities of the Route Network Development Sub-Group (RNDSG) in the period October 1996 to May 1998. During this period, the RNDSG were engaged in developing a proposal for amendment of Table ARN-1 of the EUR-ANP (ARN Version 3). **Language** The English Language has been used in preparing the original text of this document		
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AUTHORITY	NAME AND SIGNATURE	DATE
Chairman of the Route Network Development Sub-Group (RNDSG)	Mr. J. Lambert	08 July 1998

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ARN Version 3

Report on

The Development of Proposals for Amendment of Table ARN-1 of the EUR-ANP

EXECUTIVE SUMMARY

In the "ECAC STRATEGY FOR THE 1990s" it is stated that *"Efficient airspace management is fundamental to increasing the capacity of the air traffic services system. The optimisation of the air traffic services' route network and airspace structure is considered as a key element in obtaining the required system capacity."*

The Route Network Development Sub-Group (RNDSG) has been tasked by the Airspace and Navigation Team (ANT) with achieving the above objective. The RNDSG, which commenced operation in 1993, has developed a programme focused on short- and medium-term overlapping projects which are aimed at developing and implementing incremental improvements to the ECAC airspace structure.

This report provides details of the development process and content of Version 3 of the ARN, which is the successor and complement to Version 1 and Version 2, which were also developed by the RNDSG.

Version 3 was developed in the period October 1996 to March 1998 in a series of seven RNDSG meetings attended by representatives from 28 ECAC and interface States and three International Aviation Organisations.

Following approval by ICAO, it is expected that Version 3 of the ARN will be implemented in the time period 1998 to 2001.

Version 3 of the ARN includes proposals for a comprehensive re-organisation of Nordic and German airspace with route alignments and airspace structures based on RNAV. It is expected that substantial efficiency gains in terms of shorter routes and capacity enhancements will accrue in both areas. In addition, significant improvements in route alignments are proposed in Central Europe and at the interface of France and adjacent States. The mandatory carriage of B-RNAV in 1998 also provided the opportunity to incrementally improve the alignment of routes in the remaining ECAC airspace with particular emphasis on the optimisation of transition* routes between TMAs and the en-route system, and sector re-organisation in support of it.

Version 3 is the outcome of considerable development work carried out by specialised groups at the regional level and supported by enhanced evaluation and assessment capability utilising new tools developed by EUROCONTROL.

Optimisation of the ECAC route network is an ongoing requirement if the continuing annual increase in airspace demand is to be met. The RNDSG is confident that it now has in place a co-operative and continuous process that is well suited to its task. Version 3 of the ARN is the latest evidence of the effective operation of the process.

Version 3 of the ARN is detailed in a separate catalogue of route and associated charts which should be read in conjunction with this report.

For the purpose of RNDSG, the term 'transition" is utilised for* ***working purposes only* *and*

refers to both SIDs/STARs and to the non-regional routes which are establised to provide access from and to locations not directly served by the en-route network.

Report
on

THE DEVELOPMENT OF PROPOSALS FOR AMENDMENT OF TABLE ARN-1 (VERSION 3) OF THE EUR-ANP

FOREWORD

This document reports on the route network development activities of the Route Network Development Sub-Group (RNDSG), a sub-group of the Airspace and Navigation Team (ANT), in the period October 1996 to March 1998. During this period, the RNDSG was engaged in developing a proposal for amendment of Table ARN-1 of the EUR-ANP (Version 3 (V.3) of the ARN).

The purpose of the report is to outline the development process and to explain the basis for the proposals, the development process itself and how the proposals were consolidated and validated prior to agreement by the RNDSG.

The report will be used as a supporting document when presenting Version 3 to provide background information on the direction and overall planning philosophy adopted by the RNDSG.

The report will also act as a reference document on which future developments can be based and it will serve as a record of the proposal development and consolidation phase of Version 3 at regional level.

In addition, the support, co-operation and participation of airspace planners at regional and ACC level is required to ensure that both airspace planning and implementation is successfully carried out. This document and associated charts depicting Version 3 will be used to explain the planning process, methodology, rationale and work programme of the RNDSG to audiences at regional, state and ACC levels.

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APPENDICES

1. INTRODUCTION

1.1 Historical Background

The role, mandate and position of the Route Network Development Sub-Group (RNDSG) stem from initiatives by ICAO and ECAC to improve the process of airspace planning in Europe.

1.2 ICAO Initiatives

The European Air Navigation Planning Group (EANPG), set up by the Council of ICAO in 1972, is the senior planning body in the European Region. Spurred on by the unprecedented growth in air traffic movements in Europe in the period 1986 to 1990, the EANPG arranged a series of six Air Traffic Services (ATS) Route Network (ARN) planning meetings in the period 1988 to 1992. The ARN Planning meetings developed an ATS Trunk Route Network for Europe, the first phase of which became operational in November 1993. Arising from the experience gained in developing the Trunk Route Network it was realised that a more systematic and continuous approach to airspace structure development in Europe could provide important capacity and efficiency gains. Such an approach required continuous support facilities, and appropriate institutional arrangements. The EANPG therefore, in Conclusion 35/2, subsequently superseded by Conclusion 36/2 (in 1994), decided that EUROCONTROL:

a) be invited to organise and carry out the necessary coordination of planning and implementation activities for improving and upgrading the ATS route network in the ECAC area of the European Region;

b) invite all European provider States concerned to actively participate in this work;

c) present the results of these activities to the EANPG and/or the ICAO Secretariat for further processing in accordance with established procedures.

This request from ICAO happily co-incided with an ECAC initiative.

1.3 ECAC Initiatives

1.3.1 ECAC Strategy for the 1990s

In the “ECAC Strategy for the 1990s” it was considered that “Efficient airspace management is fundamental to increasing the capacity of the air traffic services system, to providing the optimum response to various user requirements and to achieving the most flexible use of airspace. The optimisation of the air traffic services route network and airspace structure, supported by the implementation of area navigation, is considered as a key element in obtaining the required system capacity”.

The European Air Traffic Control Harmonisation and Integration Programme (EATCHIP) Phase I Appraisal and Evaluation Report confirmed that the present route network and airspace structure did not permit optimum traffic handling. In addition, it indicated that civil and military airspace requirements need to be re-assessed and that the potential of area navigation (RNAV) should be exploited by the application of harmonised RNAV procedures.

It was clear that a special effort, at a Europe-wide level, had to be made in a relatively short period of time if the increasing demand of traffic is to be accommodated whilst taking account of the needs of the different categories of users.

It was recommended to the EATCHIP Project Board that a Task Force be established for "Airspace Structure and Management" with the basic objective of reaching ECAC-wide consensus on improving Airspace Structure and Management in order to increase the European ATC capacity.

1.3.2 Task Force on Airspace Structure and Management (October 1991 - July 1992)

Based on this recommendation, the EATCHIP Project Board, at its 10-11 October 1991 meeting, established this Task Force. The Task Force reached agreement on the requirement for an optimised airspace structure and sectorisation to sustain the development of the future route network, and reported accordingly.

1.3.3 Establishment of ANT (October 1992)

The EATCHIP Project Board accepted the Task Force's Report and in order to develop, monitor, implement and oversee the overall coherency and compatibility of planning in regard to route network and airspace development they set up the Airspace Planning Team (APT); this body was subsequently renamed the Airspace and Navigation Team (ANT), and hereafter this nomenclature will be used in this document.

1.3.4 Establishment of RNDSG (May 1993)

In order to support the work of the ANT, a Sub-Group called the ATS Route Network Development Sub-Group (RNDSG) was set up by the ANT and given specific tasks outlined in its Terms of Reference, which, *interalia,* take into account the invitation from ICAO in EANPG Conclusion 36/2.

1.4 Mandate/Terms of Reference of RNDSG

1.4.1 Initial Terms of Reference

The initial terms of reference of the RNDSG are given in Annex 1 of EUROCONTROL Doc 967007, April 1996 (Report of Development of Proposals for Version 2 of the ARN). In summary, the RNDSG mandate includes:

- Definition of Concepts and Criteria;
- Planning of short, medium and long-term developments;
- Co-ordination of proposals;
- Validation of proposals;
- Implementation of programmes;

in regard to route network and airspace developments in ECAC airspace.

1.4.2 Generic Terms of Reference

As part of the standardisation of the EATCHIP work process, generic terms of reference have been provided and are applicable to all EATCHIP sub-groups. A copy of these terms of reference are given in Annex 2 of EUROCONTROL Doc 967007, April 1996 (Report of Development of Proposals for Version 2 of the ARN). In summary, the RNDSG are required to undertake those elements of the EATCHIP Work Programme assigned to it.

In the context of route network and airspace development the relevant tasks in the EATCHIP Work Programme are:

ST 01 - Improve current ATS Route Network and Airspace Structure;

ST 02 - Establish the longer term European Route Network and the related Airspace Structure needed to support it;

ST 03 - Establish the Future Airspace Organisation Model;

ST 07 - Implement agreed Route Network and Airspace Structure Plans.

The responsibility of the sub-group to ensure co-ordination in regard to these tasks with all relevant agencies and national authorities is emphasised in the generic terms of reference.

Note: This document is addressing progress in regard to ST 01, 02, 03, 07 above, and does not consider activities in regard to TMAs which are covered by EATCHIP tasks:

ST 04 - Develop specific TMA Airspace improvements;

ST 05 - Implement specific TMA Airspace improvements;

ST 06 - Establish improved TMA Airspace design concepts.

1.5 Work Programme for Route Network Development and Associated Airspace Structure

Integrating the four distinct activities as defined by the ANT and the EATCHIP work programme, as amended in July 1994 (by amalgamation of route network and airspace structure tasks), the following work programme has been developed.

RNDSG WORK PROGRAMME
and its relationship to the EATCHIP Work Programme

#	Description	Time Scale	Explanation	EATCHIP Reference
1	**Short Term**	**1993**	**Phased Implementation of ARN V.1**	**ST 07**
		1995 →	**Annual remedial actions**	**ST 01**
		1996 →	**Annual remedial actions**	**ST 01**
		1997 →	**Annual remedial actions**	**ST 01**
		1998 *etc* →	**Annual remedial actions**	**ST 01**
2	**Medium Term**	**1993 - 1995**	**Development of V.2**	**ST 02**
		1996 - 1997	**Implementation of V.2**	**ST 02**
		1996 - 1998	**Development of V.3**	**ST 02**
		1998 - 2001	**Implementation of V.3**	**ST 02**
3	**Longer Term**	**1998 - 2001**	**Development of Future Airspace Structure** *(Free Route Concept)*	**ST 03**
		2001+	**Implementation of Future Airspace Structure**	**ST 03**

A schematic diagram outlining the above work programme is shown on Figure 1.1.

It should be noted that the expressions 'short, medium and longer terms' are relative and, as time passes, they change their meaning.

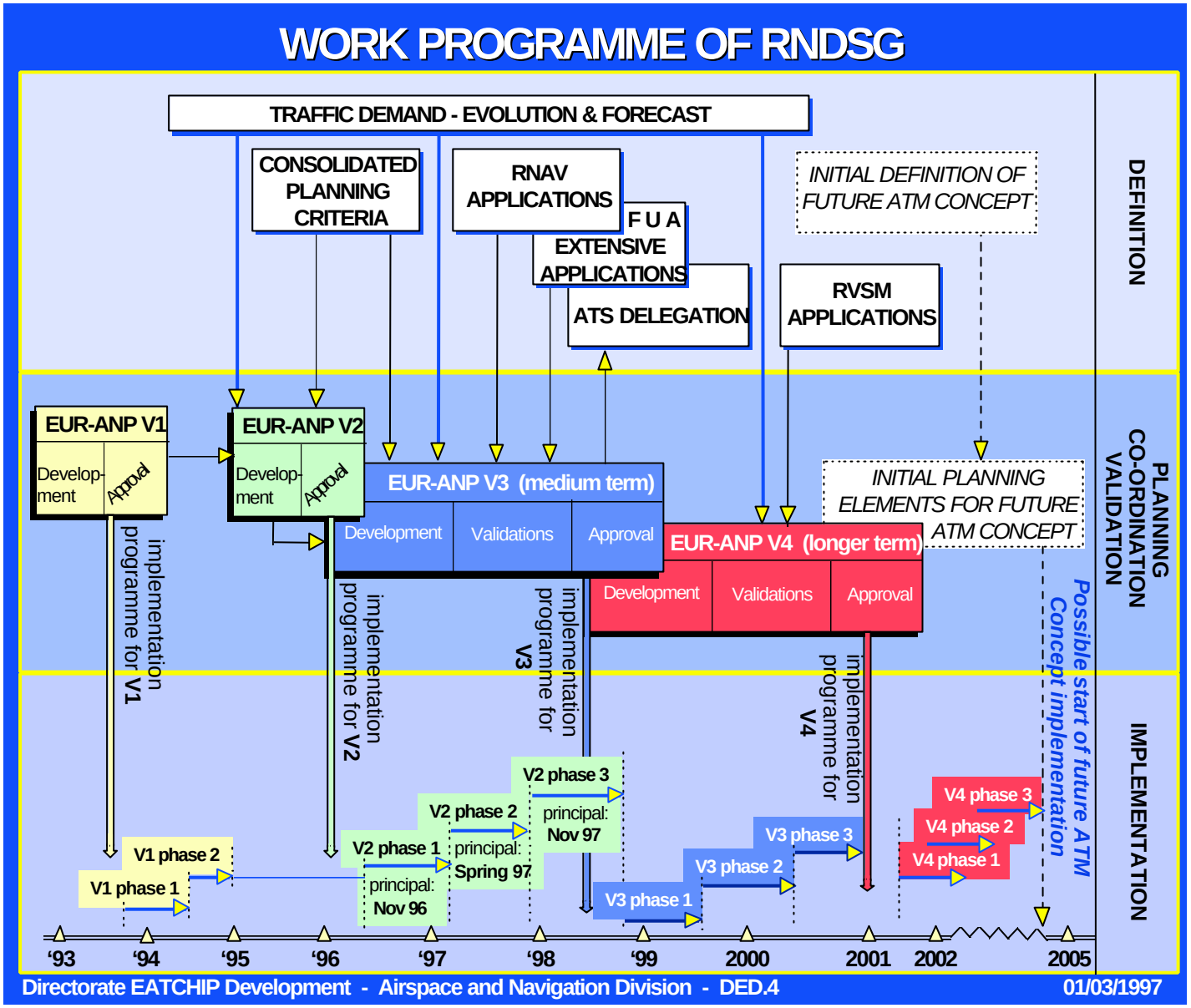


Figure 1.1

1.6 Scope of Activity

The area in which the RNDSG is carrying out its mandate is the airspace of the ECAC States. However, the RNDSG is also required to ensure that the interfaces with adjacent areas are coherent and compatible. It does so through liaison with the States concerned as necessary and through presentation of working and information papers to the ICAO TARTAR Group (Meeting for the Planning and Coordination of Implementation of ATS Routes through the Airspace of the Eastern Part of the ICAO European Region including Middle Asia); as well as the ICAO AFI/EUR Group (Informal Meeting on AFI/EUR Interface).

1.7 RNDSG Meetings

The RNDSG held its first meeting on 21-23 May 1993. Since then, the Sub-Group has convened at regular intervals, approximately four to five times per year. The frequency and regularity of meeting are an essential element in the development process for airspace structure improvements. Details of the dates and attendance at the first 13 RNDSG meetings are given in Annex 3 of EUROCONTROL Doc 967007, April 1996 (Report of Development of Proposals for Version 2 of the ARN).

The dates and attendance at the 14th and subsequent meetings of the RNDSG are outlined in Appendix A.3.

2. CONCEPT

2.1 Introduction

Version 3 of the ARN is designed to enhance the capacity of the ECAC ATM system to match forecast demand through airspace structure and route network improvements. The planning process adopted in developing proposals for Version 3 is a "Top Down[1]" approach where enhancement of the overall capacity of the ECAC ATM System is the driving force and main objective. In order to achieve its objective it will make use of available concepts and techniques and its planning will be compatible with the airspace environment that will exist in the time frame 1996-2001. Version 2 of the ARN, as originally planned, will be used as a starting point. The focus of Version 3 will be aimed at developing airspace structure improvements where it is most necessary to alleviate existing and future capacity shortfalls, and/or bottlenecks. In specific terms, Version 3 objectives, methodology, planning considerations, and content will be as outlined in the following paragraphs. National and regional plans, developed within the overall concept, must be harmonised to ensure a coherent and seamless ECAC wide airspace structure.

[1] A "Top Down" approach is the process by which, at ECAC-wide level, the major traffic flows are translated into a basic route structure which simplifies identified bottlenecks. Built upon the agreed planning principles, the resulting network skeleton should provide the overall framework for more detailed developments at national or regional levels. The "Top Down" approach remains a co-operative process in order to combine specific requirements within the general interests of the users.

2.2 Objective : Enhancement of European ATM capacity

The overall objective of Version 3 of the ARN is the enhancement of European ATM capacity through the development and subsequent evolutionary implementation of an improved route network, sustained and supported by the development and evolutionary implementation of an optimised airspace structure and sectorisation.

Note:
Optimisation in this sense means achieving the correct balance between increased ATM capacity on the one hand and the most efficient flight profile on the other.

3. METHODOLOGY : A CO-OPERATIVE AND CO-ORDINATED PLANNING PROCESS

3.1 ATS Route Network Development Methodology

The planning process should provide States with an internationally agreed broad and basic concept of airspace and ATS route structure in the ECAC area, serving as a basis for future national or regional planning.

The methodology for progressing work in regard to route network development and airspace structure improvements is organised around the following key elements:

- Cooperative planning between all parties concerned; ECAC States *(Civil & Military Authorities)*, ICAO, Airspace Users; co-ordinated by EUROCONTROL.
- Development of proposals through a systematic overall approach at Europe-wide level ("Top Down") to serve as the basis for national planning and implementation. The representatives of the Airspace Users should be consulted throughout this process.
- Planning work is based on agreed principles and criteria.
- Definition of a single methodology for medium and long term planning/development to ensure a coherent and evolutionary process.
- Validation of planned proposals carried out by Specialised Groups with operational expertise at ACC level, where necessary, to secure approval by States and acceptance at operational level.

The methodology developed by RNDSG has been endorsed by the ANT and is indicated in detail in a schematic diagram at Figure 3.1.

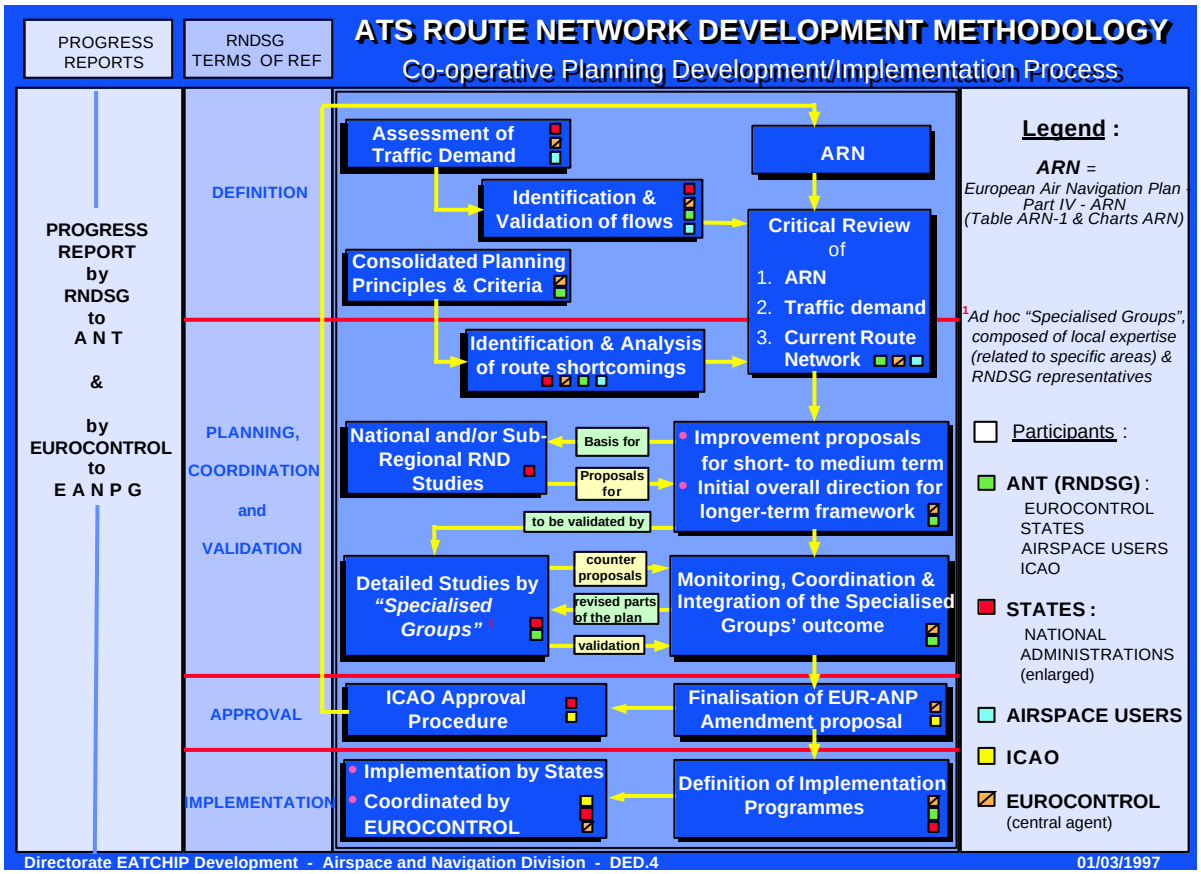


Figure 3.1

States should commit themselves in this process through an active participation to the elaboration of proposals (national/regional groups), the validation of proposals (studies and simulation) and to the implementation of the agreed proposals.

3.2 Role of Specialised Groups in the Management and Co-ordination of the Development of ARN Version 3

3.2.1 Utilisation of Specialised Groups

RNDSG/20 agreed that the management and coordination of the development of Version 3 of the ARN would be facilitated by the utilisation of specialised groups to support the RNDSG. A description of the management process and the role of the specialised groups is given in RNDSG/20 WP 1 (09/01/97). A list of the specialised groups is outlined in Appendix A.4. A simplified diagram of the proposed management and coordination mechanism is indicated in Figure 3.2. Further clarification of the roles of the respective groups is given below.

3.2.2 Role of RNDSG

The full terms of reference of the RNDSG are given in Annex 1 and 2 of EUROCONTROL Doc 967007, April 1996 (Report of Development of Proposals for Version 2 of the ARN). In summary, the ANT has given the RNDSG the following mandate :

- Definition of Concepts and Criteria;
- Planning of the short, medium and long term developments;
- Coordination of Proposals;
- Validation of Proposals;
- Implementation of programmes;

in regard to route network and airspace development in ECAC airspace.

All of the ECAC States, the EUROCONTROL Agency, ICAO and International User and Provider organisations are entitled to be represented at RNDSG meetings. The overall responsibility for carrying out the mandate from the ANT is vested in the RNDSG. The RNDSG will provide a broad overview of how the route network and airspace structure should be developed based on agreed principles and criteria. In carrying out its work it may use subordinate groups or task forces as appropriate, but final decisions rest with the RNDSG or can be referred up to the ANT. In order to efficiently progress the work associated with the development of Version 3 of the ARN, the RNDSG has agreed to utilise a drafting group, and a number of regional groups.

3.2.3 Role of the Drafting Group

The drafting group will develop outline, or draft, proposals within the broad overview provided by the RNDSG. The development of Version 2 indicated that a drafting group with appropriate expertise is an efficient mechanism to expedite the development and consolidation of initial proposals and to develop solutions to outstanding issues. In order to be efficient the group should not be too large and it should have appropriate expertise, especially in regard to the core area, so that it can contribute to the development of initial proposals that are coherent with the concepts and criteria drawn up by the RNDSG. In order to ensure transparency, the drafting group should include experts from the users, the provider States, and EUROCONTROL. For specific problems or issues, the drafting group may be expanded as necessary. It should be noted that, when carrying out their work, the members of the drafting group act in their expert capacity rather than as formal

State or user representatives. The initial composition of the drafting group is given in Appendix A.4.

3.2.4 Role of Regional Groups

The regional groups provide regional expertise to ensure that proposals for Version 3 as drafted by the RNDSG, are coherent with local or regional requirements. In particular, the regional groups have a major role in:

- developing transition* routes;
- validating Version 3 proposals, and ensuring that the regional airspace structure and sectorisation is compatible with and can support the proposals made by the RNDSG.

Reports of the activities and results of the meetings held by regional groups will be made to the RNDSG. Members of the drafting group may attend meetings of the regional groups when they consider such attendance would be beneficial.

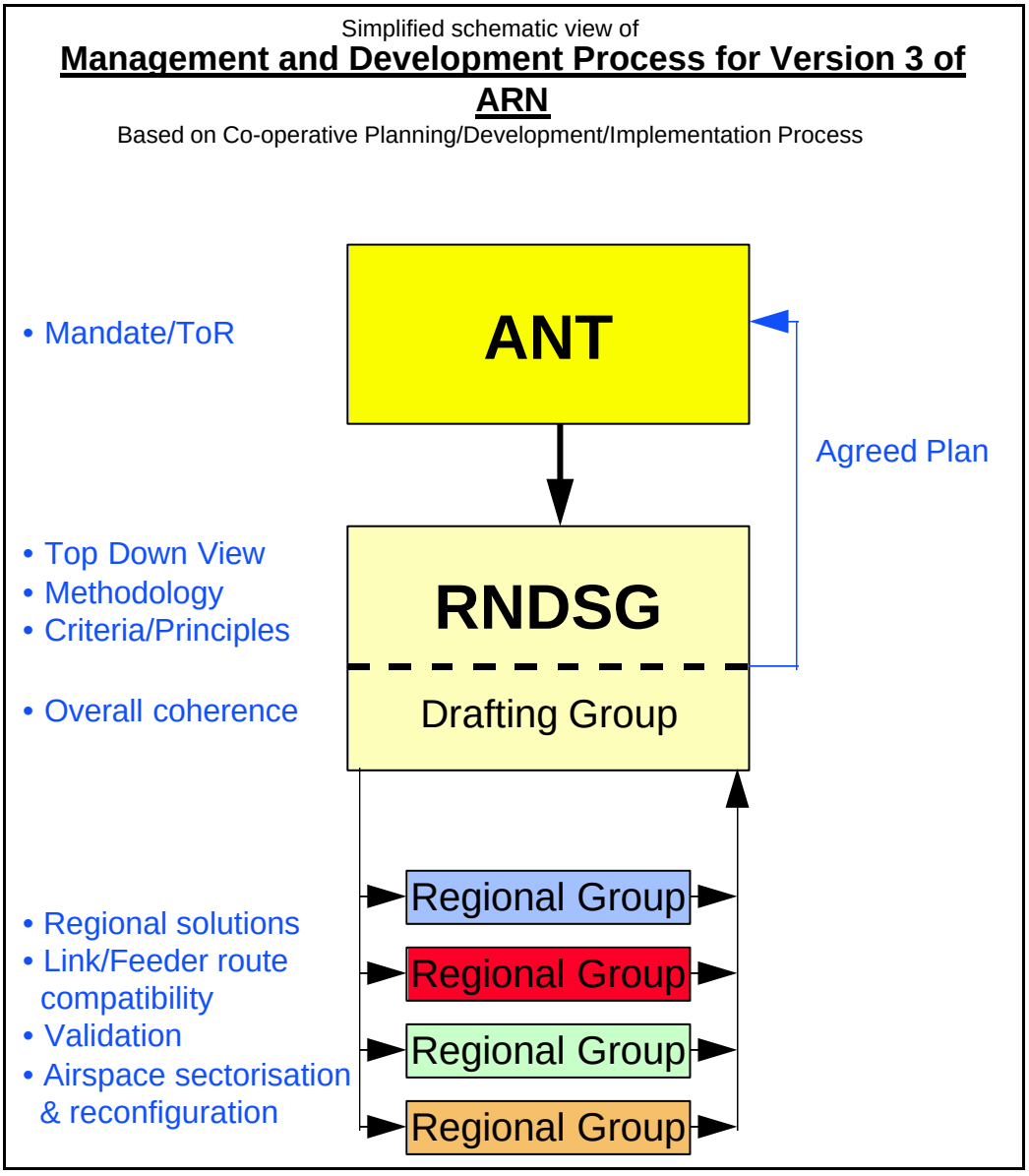


Figure 3.2

4. PLANNING PROCESS

4.1 A "Top Down" Approach

This is a process progressing from broad proposals towards specific solutions.

Step 1 - Starting from in-depth analysis to identify current and foreseen problems, the planning work should highlight the actual causes of the weak links in the airspace structure.

Step 2 - Based on agreed general principles and criteria, the planning work should build overall route proposals to accommodate major traffic flows reducing the airspace structure complexity and balancing the ATC workload.

Step 3 - Within this defined framework, detailed proposals of airspace structure should be elaborated, consolidated and validated through appropriate regional expert groups.

The result of local studies must feed back into the initial proposals in a dialectical and iterative process.

Step 4 - A phased implementation programme must be agreed before coming into force.

4.2 Planning Principles (PP)

PP 1 - **Planning should take into account the needs of both civil and military airspace users.**

PP 2 - **Planning should normally expand from the core to the periphery.**

It is well recognised that the question of ATM en-route capacity in ECAC airspace is essentially a problem of airspace capacity in the core area. Therefore, the architecture of the network should normally be developed from the core area toward the periphery by building the structure upon the most heavily loaded intra-European routes linking the top origin/destination areas. However, in applying this principle the specific problems of the periphery, such as ATM capacity, transition tasks etc, should be taken into account.

PP 3 - **Planning should integrate route network and supporting sectorisation at an early stage.**

Although the start of airspace development process is network-oriented, there is a close two-way interrelationship between the network's structure and sectorisation definition. Consequently, from the initial planning phase onwards, it is necessary to ensure that a proper sectorisation scheme, including ATS delegation is feasible and viable in relation to the planned network.

PP 4 - **Planning should integrate into the en-route network, transition* routes to/from TMAs in the initial planning phase.**

The traffic in the ECAC area is predominantly short haul traffic with nearly half of the flight distance spent in climb or descent phases. Interfacing segments are usually heavily loaded. From the first stage of the network planning, it is therefore necessary to consistently integrate transition* routes into the overall route structure and to ensure TMA-Network interface compatibility.

PP 5 - **Planning of ATS routes should aim at enabling a majority of flights to operate along or as near as possible to the direct route from origin to destination.**

Network development should be processed in such a way that major traffic flows can be carried out in as straight as possible channels in so far as this does not adversely affect ATM capacity.

PP 6 - **Planning of ATS routes should be in accordance with relevant ICAO Standards and Recommended Practices (SARPS).**

4.3 Facilitating Concepts (FC)

FC 1 - **B-RNAV as the primary concept of navigation**

Airspace planning should be based on a BRNAV navigation system (not constrained by the location of station referenced navaids).

Note:
With effect from 1998, the EATCHIP Programme proposed that the carriage of B-RNAV equipment, approved for RNP-5 operations, would become mandatory for non-State aircraft on the entire ATS route network in the ECAC area, including designated feeder (transition) routes (SIDs & STARs) in/out of notified TMAs. States may designate domestic routes within the lower airspace as available for aircraft not fitted with RNAV.*

FC 2 - **Full application of the FUA concept and extension to civil/civil flexibility through additional optional routeings.**

In application of the Flexible Use of Airspace concept, conditional routes should be planned to reinforce the permanent ATS route network based on pre-defined utilisation scenarios compatible with operationally efficient sector configuration.

The establishment of CDRs should be supported by the generalisation of area type controlled airspace.

FC 3 - **Route network planning in ECAC airspace should take place in a seamless way, disregarding FIR boundaries.**

Delegation of ATS should be utilised where necessary to enhance the capacity and efficiency of the ATM system. FIR boundaries and ATS limits of responsibility should not constrain such delegation. The following examples indicate where such ATS delegation should take place:

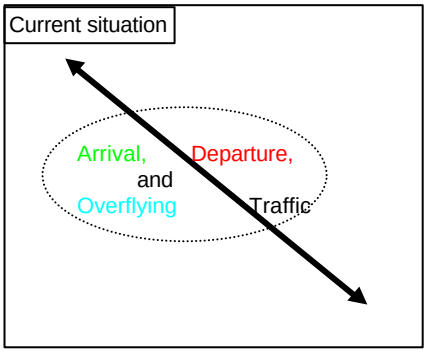
- when alignments of routes drawn independently of FIR boundaries determine the location of crossing points close to existing FIR/sector boundaries, in order to provide the controller with sufficient anticipation with respect to entering traffic;
- when alignments of routes affect an FIR airspace for a short distance, in order to avoid the hand-over of aircraft and additional co-ordination workload;
- for terminal sectors (vertical and/or geographically) in order to enable the controller to anticipate the regulation/vectoring of inbound traffic flow.

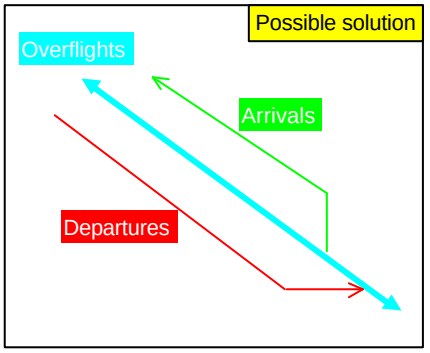
FC 4 - **In designing Version 3, airspace planners should be aware that the proposed implementation of RVSM (in 2001) should provide additional ATM capacity.**

4.4 Planning Techniques (PT)

PT 1 - **Establish specialised routes.**

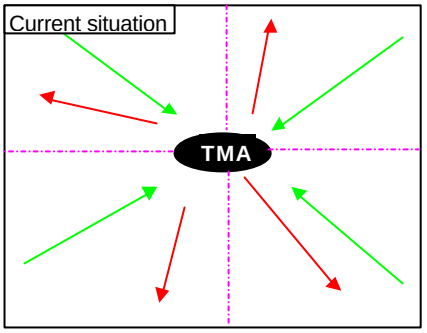
In dense areas, additional capacity can be gained by the segregation and deconfliction of arrival/departure routes and their separation from overflight routes. This structure should be applied for climbing and descending phases.

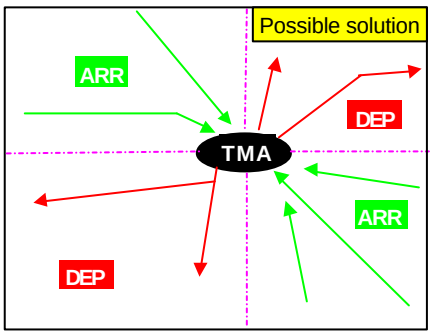




PT 2 - **Establish specialised sectors.**

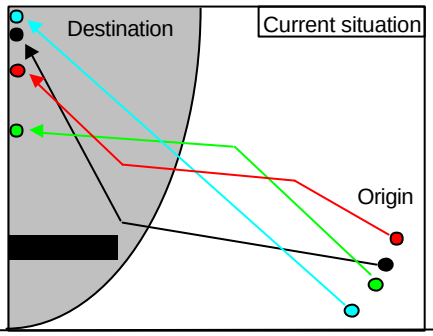
Based on the structure described above, specialised sectors should be established, grouping sets of routes of similar nature (arrival/departure; see illustration below), direction, and/or flight level series (odd level specialised sector, even level specialised sector). Where practicable, sectors should be specialised to solve one main specific problem.

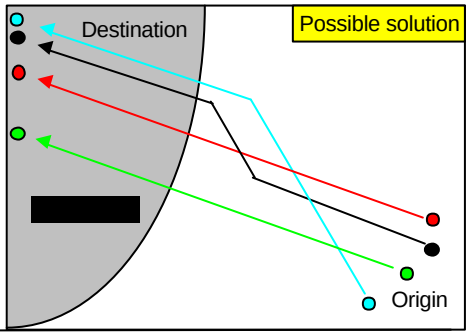




PT 3 - **Organise any essential crossing of ATS routes carrying major traffic flows as close as practical to their origin.**

Network development should be done in such a way that any essential crossing of ATS routes carrying major traffic flows can be carried out as close as possible to their origin. However, taking into consideration the network complexity in the vicinity of the origin area, it may be more appropriate to transfer the crossing into areas where the network/traffic density is lower.





5. CRITERIA

5.1 Criteria for ATS Route Network Development

5.1.1 Version 2 of the ARN was based on an agreed list of criteria developed by the RNDSG and endorsed by the ANT. These are included as Annex 5 to EUROCONTROL Doc 967007, April 1996 (Report of Development of Proposals for Version 2 of the ARN).

5.1.2 The planning of Version 3 was initially based on these criteria. However, the RNDSG considered that the criteria should be reviewed and revised as necessary, to take account of any change in circumstances since the development of Version 2.

5.1.3 It was also recognised that as the concept and criteria for Version 3 is a deliverable in the framework of EATCHIP (ASM.ET1.ST02 Del 01), it would be useful to produce a more comprehensive document which, through the use of diagrams and additional guidelines on sectorisation, could fulfill both the deliverable requirement and also act as a stand alone document for use by airspace planners.

5.1.4 Accordingly, a drafting group was set up to develop a Concept and Criteria document, drawing on the work already carried out by the Task Force on Airspace Structure and Management (July 1992) and the principles and criteria agreed by RNDSG/4 and endorsed by the ANT in 1994.

5.1.5 The content and layout of the Concept and Criteria document [*Full title; Concept and Criteria for Medium Term European Route Network Development and Associated Airspace Sectorisation (ARN Version 3)*] was agreed by RNDSG/23 (16-18 September, 1997) and was, with minor amendments, endorsed by ANT/14 (28-30 October 1997). Extracts from this document are included in Section 4 of this report and the criteria for Version 3 development in the context of ATS Route Network Development are attached as Appendix A.1.

5.2 Criteria for Airspace Sectorisation Development

In developing the Concept and Criteria document, referred to above, it was agreed that it would be useful to develop a section dealing with sectorisation issues. This was developed and reviewed as part of the main document. The section dealing with sectorisation aspects is attached as Appendix A.2.

6. TOOLS AND DATA SOURCES

6.1 Need for Analytical Tools

From an early stage, the RNDSG recognised that in addition to the standard Fast Time and Real Time Simulations currently available, new tools were needed to enable airspace planners to evaluate and assess the behaviour of traffic in the current route network and airspace structure and especially to assess the impact of new proposals on the entire route network at the microscopic and macroscopic level. A particular requirement was that such a tool should be capable of providing results very quickly.

Based on earlier development work on the Master Simulator Facility (MSF) jointly funded by the European Union and EUROCONTROL, the Airspace Division of EUROCONTROL has developed such a tool. The prototype with the initials SAAM - System for Assignment and Analysis at a Macroscopic level is a software tool which is capable of providing assistance to route planners by giving a quick and broad assessment of loads on ATC structures, for instance:

- loads on route segments
- loads on airspace volumes (sectors, centres, etc.)
- density maps for a given flight level slice.

It is designed to work on a Europe wide scale with a large amount of traffic demand. The users have the possibility of creating and modifying route network as well as airspace structures and they can tune the automatic traffic flow assignment process in order to manage, if necessary, the allocation of main flows. At any time, it is possible to request the path followed by a given traffic flow or for an exhaustive identification of the traffic flow present on a given route segment: origin, destination, type and status (evolving, steady) of aircraft. Several analysis functions are provided, along with geographical maps which allow the users to check, experiment with and establish comparisons. In particular, they permit examination of the:

- effect of the creation of new ATS routes or modification of the network structure;
- effect of strategic traffic re-organisation (e.g. structural routeing, specialising ATS routes or traffic distribution scheme to relieve congested areas);
- effect of a new traffic demand (e.g. increasing the demands of x% between two countries) or the use of a traffic forecast in order to test the validity of a scenario for the future; and
- comparison of different scenarios combining network modification, traffic orientation changes and traffic demand variation, in particular, comparison with the current situation (in terms of loading of ATC structure, route extensions, number of conflicts).

It is a useful tool for quickly preparing scenarios before fast time simulation, while the short response time also allows it to be used interactively during planning meetings.

The SAAM tool, although still under development, is sufficiently advanced in its prototype form to provide high quality evaluations of proposals for Version 3 and has been used to carry out in-depth analysis of a number of problem areas. The results of these analyses are described in Section 7 and 8 of this document. Figure 6.1 provides a schematic diagram of the SAAM Evaluation Process Cycle.

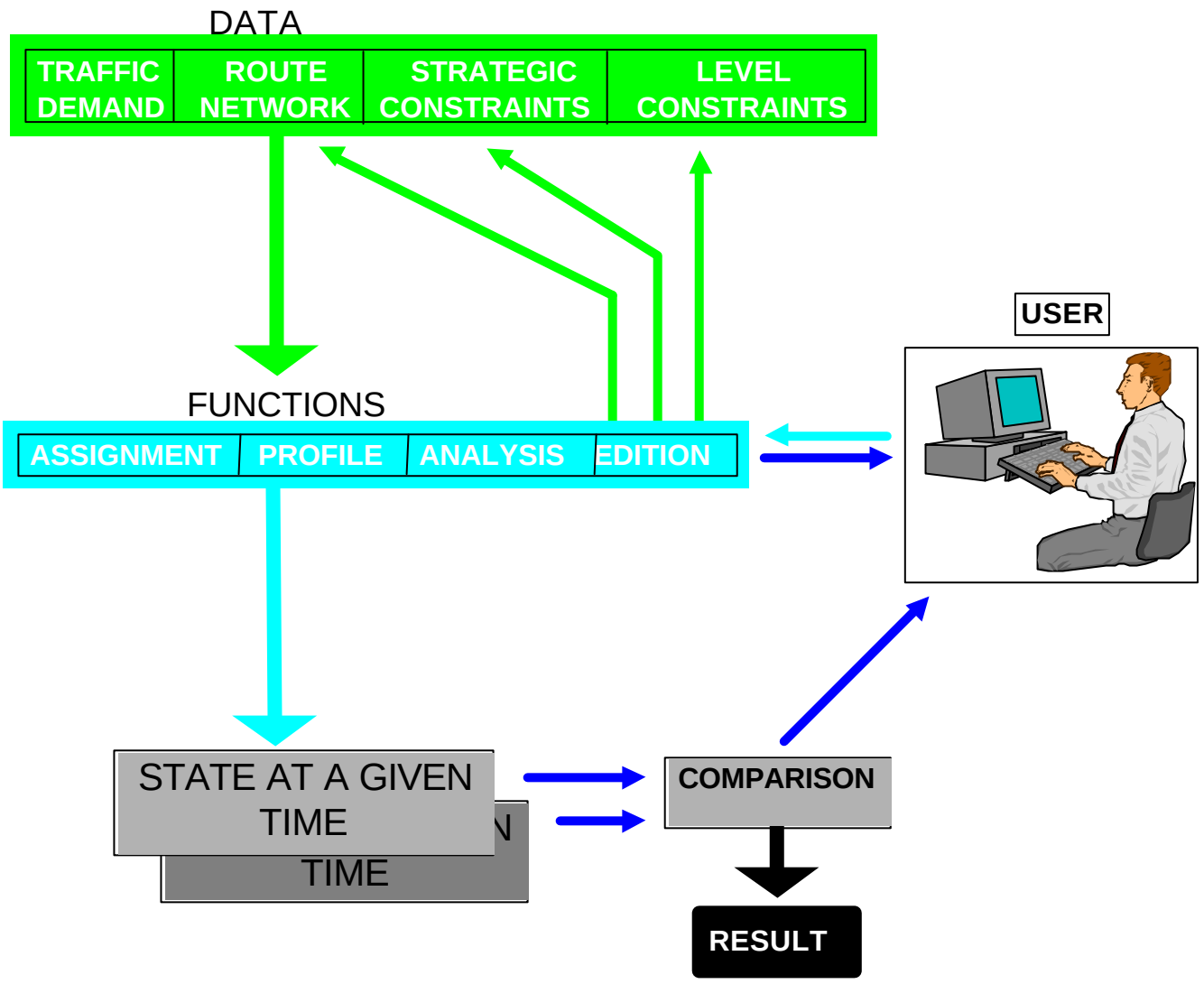


Figure 6.1

6.2 Data Sources

Up-to-date data is available to the RNDSG from the CRCO and CFMU(IFPS) which, when processed through the SAAM tool, is capable of providing an overview of the operation of the ECAC ATM system on an hourly or daily basis at ACC and sector level. As a first step in the development of Version 3, in line with the agreed methodology of the ARN, a comprehensive analysis of the pattern of demand on the ATM system was provided to RNDSG/18 and RNDSG/19. This analysis provided an initial indication of the demand on the current route network, the relative loadings in the core and periphery of Europe and the main traffic flows which must be accommodated. The full analysis is contained in RNDSG/19/DP01 (December, 1996). Where relevant, extracts from this document are included in this report.

7. PREPARATION FOR THE DEVELOPMENT OF ARN VERSION 3

7.1 Preparatory Work

The preparatory work for the development of Version 3 was initiated at RNDSG/18 (October, 1996) with the consideration of working papers reviewing the performance of the current route network and presentations by State representatives of their short and medium term plans for airspace structure development in the period 1998-2005.

7.2 Review of Current Route Network

RNDSG/18 (October, 1996) was presented with Working Paper 8 which provided an analysis of the traffic on the current route network. The major elements highlighted in this working paper are indicated below:

i. Core area problem

The concentration of traffic in the core area was clearly indicated. 70% of the total ECAC traffic is either internal, transit or entering/leaving this area. The diagrams associated with WP 8 confirmed the importance of the core area and emphasised that the Benelux/UK interface, the Frankfurt/Munich/Vienna axis, Frankfurt/Zurich axis and most of Switzerland were areas of particular traffic concentration (Figure 7.1 refers).

Outside the core area, Southern Hungary was noticeable for very dense traffic due to the concentration of routes as a result of the Contingency Routeing Scheme (CRS).

ii. Traffic distribution versus Range

An element of considerable significance in airspace planning in the ECAC region is the relatively short route length of traffic in the area with 60% of the traffic flying less than 400 nautical miles (Figure 7.2 refers). An exacerbating element is that a considerable volume of this traffic is located in the core area as indicated in Figure 7.3.

iii. Interaction between Upper network and Transition* routes

Earlier planning exercises (Version 1 and Version 2 of the ARN) tended to concentrate on the upper route network; this was a valid approach where the number of transit flights is relatively high as in the peripheral areas. However, this approach would not yield an appropriate improvement in the core area where the majority of flights are climbing from or descending to the major origins/destinations. Accordingly, the optimal route network must include adequate consideration of transition* routes where appropriate. Figure 7.4 illustrates the close inter-relationship between the Upper network and Transition* routes, particularly in the core area.

iv. Flexible Use of Airspace (FUA) Concept

The conflicting requirements between civil and military users of airspace in the ECAC area are highlighted in Figure 7.5. Greater use of the FUA Concept and the acceptance of the principle that all airspace should be considered as one continuum is, therefore, a vital ingredient in developing Version 3 of the ARN.

v. Predominant influence of major Origins/Destinations (O/Ds)

Clearly, the top twenty-five O/Ds have had a predominating influence on the development of the existing network and will continue to influence the future ECAC route network. (Figure 7.6 refers).

7.3 Tabling of Proposals

7.3.1 As a part of the preparation for the development of Version 3, States represented at RNDSG presented an outline of their airspace structure plans for the period 1998-2005 at RNDSG/18 (October 1996) and RNDSG/19 (December 1996). These plans were derived from the long term proposals for network development as elaborated by RNDSG (Map 1, 1995) and further described in paragraph 7.5.

7.3.2 The details of these plans are contained in Annex 3 to the report of RNDSG/18. Some of the major elements which needed to be integrated into Version 3 were as follows :

- Nordic States : A comprehensive re-design of the entire Nordic airspace aimed at producing a common and efficient route structure in the airspace of the States concerned, utilising the flexibility of RNAV, was envisaged for implementation in October 1998, coincident with the opening of a new airport at Oslo/Gardermoen.
- German airspace : A complete new route network based on RNAV and direct routes was planned for implementation as part of Version 3. The planning was based on previous work of the RNDSG (Version 2) and is aimed at providing a better distribution and a good balance of traffic over the total airspace. The plan would also incorporate new transition* routes compatible with climb/descent profiles and segregation of transition* routes from the en-route system. Appropriate sectorisation to support the revised network would also be developed utilising a more rational system of vertical sector splitting.
- France : Increased capacity in the Paris area, as a result of the construction of new runways, is required and will be developed. This development will be integrated into the work of the former “Nattenheim Group” (now the “EUROCONTROL/5-States Route Structure Working Group”). France expects to bring into service a considerable number of additional controllers which will allow them to increase the number of operational sectors significantly.
- South-East Europe : It is expected that some political developments, including the resolution of the FIR boundary problem in the Black Sea area, in the south-eastern region of Europe will open opportunities for en-route improvements which will enhance capacity in the period 1996-2001.

In addition to the presentation by States, the RNDSG also took into account a presentation from the CFMU dealing with known areas/units in ECAC airspace which are heavily loaded or are a constraint in the ATM system. This list of known bottlenecks and areas where delays occur because of limited capacity was based on CFMU data as of October 1996 (RNDSG/18/IP1 refers).

7.4 Main Flows

7.4.1 In developing Version 2 of the ARN, the RNDSG adopted a strategic approach by identifying a number of major traffic flows; then proceeding to organise these flows in a manner which would provide the following benefits :

- relief of known areas of congestion where current demand exceeds capacity;
- resolution, where possible, of identified problems;
- increase in overall capacity by balancing demand on the total route network.

7.4.2 The major identified flows were organised in a schematic way as an initial basis for developing Version 2. A full description of the flows and associated charts is given in Annex 8 of EUROCONTROL Doc 967007, April 1996 (Report of Development of Proposals for Version 2 of the ARN).

7.4.3 Version 3 of the ARN, as an evolutionary development of Version 2, is based on the same schematic organisation. In developing Version 3, the RNDSG, through the input of both the users and the providers, was at all times conscious of the need to strike an appropriate balance between the requirements of the users for as much flexibility in routeings as possible, and the need for service providers to plan their systems and to allocate their resources in such a manner so as to maximise the efficiency of their operations.

7.5 Relationship to Version 2

7.5.1 Evolutionary Process

Because of the complexity of the ECAC ATM system and the need to maintain a continuous service to the users at high levels of capacity, it is clear that changes to the ATM system should be evolutionary in nature and that the planning process should be based on providing incremental improvements on a regular basis to match the annually increasing user demand. Accordingly, the strategy adopted by the RNDSG for Version 2 of the ARN was to start from the ICAO Trunk Route Network (Version 1 of the ARN), then to analyse the user requirements based on the demand between origin and destinations (which changes only slowly over time) and to develop a route network based on the major traffic flows and focused in the elimination of known bottlenecks. In developing Version 2, this process resulted in a Draft Map 1, dated 23/9/94, which is included as Chart 10 in EUROCONTROL Doc 967007, April 1996 (Report of Development of Proposals for Version 2 of the ARN). It was clear to the RNDSG at that time, that not all proposals in Map 1 could be implemented in the time scale for Version 2. Correspondingly, those elements which could be implemented were outlined in a Map 2 which, when subsequently agreed by the RNDSG and endorsed by the ANT, became Version 2 of the ARN.

7.5.2 Continuity with Version 2

In order to maintain continuity with Version 2 of the ARN, the starting position for Version 3 was Map 1 as described above. Map 1 was amended to include the known proposals for the Nordic airspace (which had not been included in Version 2) and the comprehensive proposals for German airspace which were based on Map 1. The outcome of this process, a draft Map 0.1 Version 3 dated 9/12/96, was presented to RNDSG/19 to initiate the development process for Version 3. The development process proposed was to produce an amended and updated Version 3 map for each meeting of the RNDSG to be reviewed and amended following each session. In addition, a list of outstanding issues/problems would also be produced for resolution either through the RNDSG, sub-regional group meetings, or bi-lateral meetings, supported by SAAM evaluations where necessary.

Figure 7.1

Figure 7.2

Figure 7.3

Figure 7.4

Figure 7.5

Figure 7.6

8. ELABORATION AND REFINEMENT OF PROPOSALS FOR VERSION 3

8.1 Initial Proposal

Following preparatory work described in Section 7, the initial outline proposals were presented to RNDSG/19 (December, 1996) in the form of a draft map (Version 3 - Map 0.1 dated 9 December). This initial proposal was based on Version 2 - Map 1 and integrated the available information from States on their plans, in particular those of the Nordic States and Germany. Transition* (or feeder) routes were not included in this draft but it was emphasised that transition* routes would be an important element of Version 3 and would be developed in parallel using separate charts for clarity. It was clear at this stage, that some incompatibilities already existed in Map 0.1 which would need to be resolved through sub-regional discussions and the carrying out of evaluations using the SAAM tool, while ensuring overall coherence by use of drafting groups and plenary RNDSG meetings.

8.2 Development Process

Between RNDSG/19 (December, 1996) and RNDSG/24 (December, 1997), each RNDSG meeting was presented with an updated Version 3 map and a list of outstanding issues in Version 3. Progress between each RNDSG meeting was achieved through national input, the outcome of sub-regional meetings and/or SAAM evaluations, where appropriate. Where necessary, drafting group meetings were held to ensure overall coherency. Following each RNDSG meeting the Version 3 maps were amended to incorporate agreed changes. This process is shown in Figure 8.1 and 8.2.

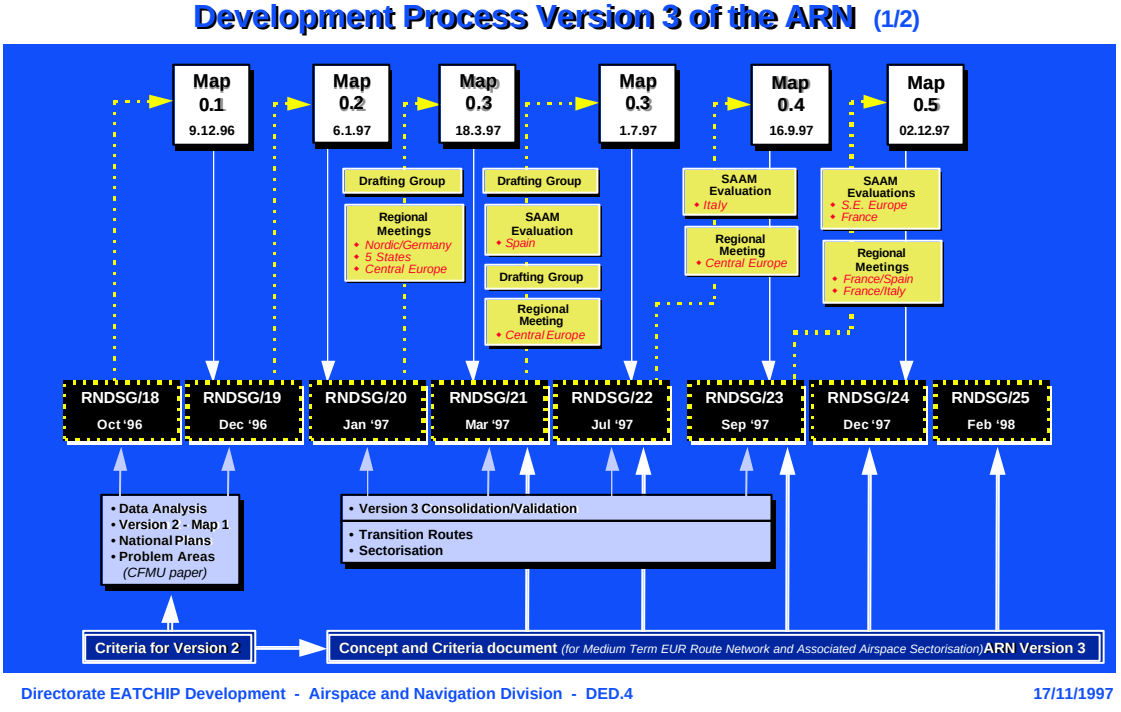


Figure 8.1

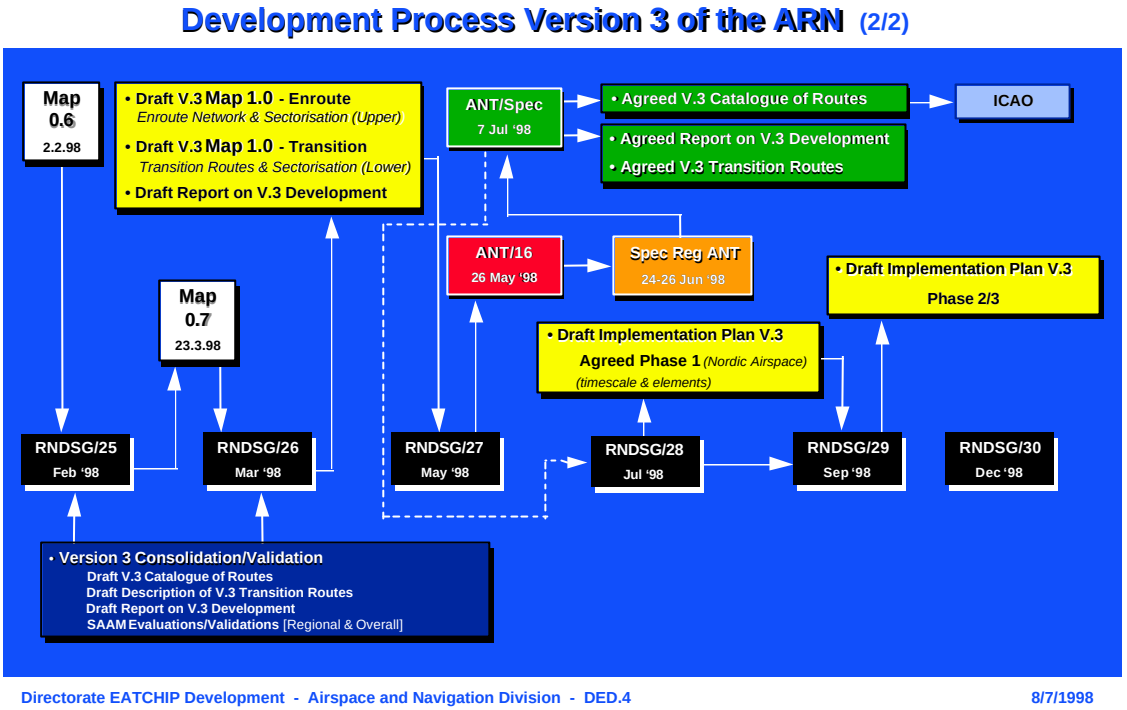


Figure 8.2

8.3 Windows of Opportunity

From an early stage in the planning of Version 3 it was realised that several developments of a technical and political nature provided a window of opportunity to include a number of key elements. These are:

- German airspace re-organisation.
- Nordic airspace re-organisation.
- French airspace re-organisation of interfaces with adjacent States.
- Re-organisation of routes in South-East Europe as a result of gradual re-opening of former Yugoslavian airspace and resolution of Black Sea FIR delineation problem.
- Re-organisation of routes in area of the 5-States Working Group.
- Optimisation of transition* routes based on RNAV.
- Increased emphasis on improved sectorisation.

8.4 Results of the Development Process

8.4.1 Results

Availing of the windows of opportunity outlined in paragraph 3 above, a number of key elements were successfully integrated in Version 3.

i. German Airspace Re-organisation

A comprehensive re-organisation of German airspace including both routes and supporting sectorisation is proposed in Version 3. The routes are based on RNAV and are direct, where possible, with minimum route extension. The supporting sectorisation will be more efficiently configured with a reduction in the number of sectors from 61 to 57. This reduction will be underpinned by a reduction in the working time per flight of approximately 24% permitting an expected overall increase in capacity of more than 50% with the above mentioned reduction in sectors.

In summary, the proposals in Version 3 in German airspace include the following:

- new route network based in RNAV routes;
- optimised arrival and departure (transition*) routes allowing climb/descent trajectories clear of overflying routes;
- general implementation of free profiles.

Results from simulations (Precis of EEC Note No 5/97) indicate:

- reduction in number of conflicts;
- reduction in workload associated with co-ordination and radar tasks;
- reduction in average working time per aircraft;
- reduction in R/T time per aircraft;
- a better balance of workload between different working positions.

ii. Nordic Airspace Re-organisation

The re-organisation of Swedish airspace in order to increase efficiency for civil and military users and the opening of the new Oslo/Gardermoen airport in October 1998 are the catalysts for a general re-organisation of the airspace in the Nordic States (Sweden, Norway, Denmark and Finland). This re-organisation is based on RNAV and through the dualisation and specialisation of routes is expected to enhance the capacity and efficiency of the ATM system in the airspace of the States concerned.

In summary, the proposals in Version 3 in the Nordic airspace include:

- more direct routes with average route reductions of approximately 3%;
- Improved sectorisation with enhanced capacity.

iii. Central Europe

The comprehensive realignment of routes in Germany required the adaptation of the routes in the adjacent airspace of Central Europe; the Czech and Slovak Republics, Austria, Hungary, Slovenia, Croatia and the Federal Republic of Yugoslavia. This provided the opportunity to remedy some potential bottlenecks in the area and to provide extra capacity on crossing routes (north/south axis) through dualisation.

iv. French Airspace and Interface with Adjacent States

Due to internal problems in France, some elements of the ZOE Project were not implemented in France when Version 2 of the ARN was implemented. Interim proposals are included in Version 3 in this area. For further details, see paragraph 8.5.4. Efforts to improve the handling of traffic at the France/Spain interface have been underway for some time. Significant airspace organisation improvements were agreed for inclusion in Version 3.

v. South East Europe and Interface with Eastern Europe

The gradual reopening of former Yugoslavian airspace and the resolution of the FIR delineation problem in the Black Sea provides many additional options in this area. These options will be enhanced as complementary routes through Ukrainian airspace to link the Black Sea routes with north-western Europe are implemented and utilised.

vi. 5-States interface area

The EUROCONTROL 5-States Route Structure Working Group, a Sub-regional group of the RNDSG has developed proposals to optimise the route network in this crucial part of the core area. Some elements of their work is included in Version 3. Paragraph 8.5.3 provides more details.

vii. Transition* Routes
An important element in Version 3 will be increased emphasis on transition* routes to/from Terminal airspace. In the past, the siting of point source aids limited the potential for changes to these routes. The mandatory carriage of B-RNAV permits a more dynamic approach to the organisation of transition* routes thus reducing constraints on the en route system.

viii. Sectorisation
The RNDSG has recognised from its inception that improving sector capacity is a key requirement in enhancing overall capacity in Europe. Version 3 provides an opportunity to progress this concept through the specialisation of routes and the implementation of the criteria for airspace sectorisation development as outlined in Appendix A.2.

8.5 Major Issues

8.5.1 Background

The successful inclusion of the foregoing key elements in Version 3 required the resolution of a number of major issues:

i. How to reach agreement on the many possible route alignments in South-East Europe due to the reopening of airspace over former Yugoslavia without exacerbating capacity problems in the core of Europe.

ii. How to harmonise the German airspace plan with the requirements in the 5-States working group area.

iii. How to address the non-implementation of the initial ZOE Project elements in Version 2.

iv. How to harmonise the requirements of different parties so as to develop an agreed proposal which would enhance capacity at the:
- interface Greece/Turkey;
- interface Greece/FYROM/Bulgaria;
- interface Greece/Italy/Albania.

8.5.2 Traffic Flow Alignments in South-East Europe

A considerable amount of discussions took place at RNDSG/20, 21 and 22 in regard to the alignment of routes feeding the south-east of Europe. Following the closure of parts of the airspace over former Yugoslavia, traffic was diverted onto routes further north and east. This led to a large increase in demand in the airspace of both Hungary and Romania which was handled by an equivalent increase in capacity in the States concerned. It is clear that as the airspace over former Yugoslavia becomes available, there will be a demand by the users to revert to operating more direct routes in this airspace. A problem arises however, in that the airspace in both Germany and Austria is designed to cater for either the CRS (Contingency Routeing System) system of routes or the more direct routes available through former Yugoslavian airspace. Germany and Austria cannot efficiently handle traffic using a simple addition of both alignments without reconsidering the overall route structure. In particular, the retention of a route on the alignment of UL605 is contrary to the proposals for route organisation in Germany as such a south-bound route would need to be fed through an area of considerable congestion where three north-bound routes converge. A number of evaluations where held to try to resolve this issue in a manner which would satisfy all States without exacerbating the congestion problem in Germany and Austria. It should be noted that this issue arose from the potential availability of new routes and extra capacity rather than the usual problem of a lack of capacity. Consequently, many

options for increasing capacity were possible.
However, many concerns were expressed by individual States who felt that certain different options had significant adverse effects for them. Therefore, the achievement of consensus took a lot of time and effort.

8.5.3 5-States Interfaces

The EUROCONTROL / 5-States Route Structure Working Group, a mixed civil/military group, is tasked with developing short- and medium-term proposals aiming at improving the capacity and flight profiles in the 5-States focus area. The development of the interface with Northern France, a short-term issue and also a major element of ARN Version 3 is momentarily postponed until the civil/military institutional agreement is reached in France. The interface with Germany is considered to be a medium-term airspace improvement proposal. Although some interface elements may already be considered for early implementation, the proposed interface route structure and sectorisation plans will require validation through simulations. The Version 3 route alignments in the 5-States interface area reflects the current state of development. Modifications to the route alignments in this area may need to be made at the implementation stage of Version 3. For information, an outline of the current state of development is given in the following paragraphs.

a. Interface BENELUX-Northern France

Currently traffic into France via West Belgium is restricted because of insufficient capacity provided by the single routeing into France and of ATS capacity shortage at Paris ACC.

The following airspace improvements will provide significant capacity increase as already demonstrated by real-time simulations:

- Triple routeing structure into France via the Chièvres VOR (CIV).
- Dedicated and segregated arrival routes to Paris airports from the North via the Nicky VOR (NIK) and the North-east via the Diekirch VOR (DIK).
- Improved Brussels airport departure route into France.
- Resectorisation at Paris ACC and Reims UAC.
  - Raising of the division level to FL265 to ease co-ordination workload.
  - Segregated TE sector at Paris ACC (Paris TMA arrival sector).
- Withdrawal of 2 French military areas and reshaping of some others.
- Creation of Cross-Border Areas (CBAs).

b. Interface Brussels FIR/UIR with Amsterdam FIR

- Creation of a dedicated and segregated arrival route to Brussels airport through Amsterdam FIR.
- Resectorisation at Amsterdam ACC by creating specialised sectors (Splitting of Sector 3 interfacing Brussels FIR into 2 sectors: Sector 3A for traffic northbound and Sector 3B for traffic southbound). This measure, already the subject of fast-time simulation will considerably increase the capacity at Amsterdam ACC.
- Proposal to develop a B/NL CBA.

c. Interface BENELUX/Germany

The German airspace optimisation project requires that specific interfaces with Amsterdam FIR and Brussels FIR/UIR be elaborated. In this context the following measures are considered:

- Development of segregated departure and arrival routes to/from Amsterdam, Brussels, Düsseldorf, Frankfurt and Köln-Bonn airports and from overflying routes.

- Re-organisation of the Spijkerboor (SPY) - Pampus (PAM) area in the Amsterdam upper airspace in close co-operation with military partners. The spreading of the conflicting cross-over points will improve the overall capacity of the Amsterdam FIR.
- Development of a supporting sectorisation plan through airspace model simulations. The sectorisation plan will also consider the new division of flight levels between lower and upper airspace (generally at FL295) required for the application of the future "Free Route Airspace" concept.

d. Re-organisation of the Luxembourg TMA

The re-organisation of the Luxembourg TMA will:

- Permit more optimum departure and arrival profiles from/to Luxembourg airport.
- Allow direct and system-supported co-ordination procedures with neighbouring ACCs to increase the overall capacity.

e. Harmonisation of Cross-Border CDRs

The harmonisation of the category and operating times (at night and during weekends) of those international CDRs crossing the 5-States area is of direct benefit for aircraft operators.

8.5.4 Resolution of the Airspace Issues in ZOE Area and adjacent Areas

An important component of Version 2 of the ARN was the so called ZOE concept which aimed at an improvement of the interface between France, Switzerland and Italy. Unfortunately, it was not possible to implement the ZOE concept, as originally foreseen, in Version 2. Accordingly, a strong effort was applied in the development of Version 3 of the ARN to rectify this shortcoming. A number of fast time and real time simulations were carried out with the objective of producing a new organisation of traffic flows and sectorisation in this interface area, which would be acceptable to all of the parties concerned, and which would enhance the overall capacity in the area.

The difficulties in achieving an acceptable solution in this area are considerable as some solutions entail a cross-border approach, which in turn raises issues which have not been possible to resolve in the time scale available to develop Version 3. Efforts continue to be made to develop efficient solutions to traffic flows to enhance the capacity in the area concerned and adjacent areas.

The proposals included in Version 3 of the ARN are a compromise and an interim solution to enable progress to continue to be made. It is quite clear that modifications may be made at the implementation stage aimed at enhanced capacity for the overall system. In particular, the alignment of UL613 is still an issue of controversy, the background of which needs to be outlined in some detail.

The purpose of UL613, as originally envisaged, was to provide an alternate route from the south-east of Europe to off-load both the Milano and Geneva ACCs, thereby releasing extra capacity in both Centres to relieve congestion and to provide extra capacity for the continuing growth in demand. As implemented in Version 2, for a number of reasons, UL613 carries less than 30% of its potential capacity. Even with the current low take up, the route is not well received by France as it has an adverse effect on Reims sectors when used with link route UL615 (SRN-MILOS-RLP). The preferred arrangement for Reims is to use *either* UL615 or UL613, but not both. If UL613 *only* is used, it is difficult to find an appropriate alignment for departures from Milano. If the UM613 is *only* used, this is a direct contradiction to the philosophy underlying Version 2 aimed at off-loading both Milano and Geneva Centres.

An acceptable resolution of this issue was not possible in the time taken to develop Version 3. It was agreed to include both UL613 and UL615, and to continue the discussions to resolve the issue so as to have an acceptable solution at the implementation stage. In particular, France requested that it be noted that the alignment in Version 3 of the ARN of UL613 was not acceptable at present. Likewise, Switzerland and Italy indicated that if UL613 was omitted or substantially re-aligned, the alignment or inclusion of other routes would have to be re-considered.

8.5.5 Harmonisation of requirements at the Greece/Turkey interface

At RNDSG/24, Turkey reiterated their long-standing objection to the implementation of routes over the eastern Athinai FIR (Version 2 while retaining routes also included Note 4 from the Turkish authorities). Nevertheless, it was agreed that the optimum development of the ECAC enroute system required a resolution to this problem and that, therefore, an initiative to raise the issue to a higher level should also be put into action. To this end a working paper highlighting the above issue was presented to ANT/15 (January, 1998). The members of the ANT asked the Chairman of the ANT to try to convene a meeting between Greece, Turkey, Bulgaria and Romania, IATA and IACA, together with ICAO to try to resolve this issue.

Note:
Evaluations carried out by Section 2 of DED.4 indicated that the lack of routes in this area resulted in a penalty of up to 4,839 nautical miles of daily route extension, costing up to 7,1 MECU extra and needless expenditure to the airlines.

Following discussion at a Special ANT meeting held in Bucharest (24-26 June 1998), agreement was reached on the inclusion in Version 3 of a number of additional routes in South East Europe. The meeting also recognised that proposals for routes 'KAL-RODOP-KULAR' and 'KULAR-BLO-TIMOT' meet a long felt need for efficient connections between the core area of Europe and the West of Turkey and beyond. Accordingly they recommended that they should be considered for inclusion in Version 4 of the ARN.

8.5.6 Harmonisation of requirements at the Greece/FYROM/Bulgaria interface

The need for improvement in the airspace structure at the interface between Greece and Bulgaria, Albania, FYROM and Italy was recognised from an early stage in the development of Version 3. It was clear that the implementation of full radar cover in Greek airspace would be an important facilitator in implementing new routes. Unfortunately, although it is expected that radar would be implemented in the spring of 1998, the Greek authorities consider that a period of confidence building and experience gaining by the controllers would be essential before radical changes could be expected. The changes, therefore, at the above interface should be considered as interim in nature, to be further refined and developed in the next version of the ARN.

9. CONSOLIDATION OF ARN VERSION 3

9.1 Consolidation and Validation

9.1.1 Background

In support of the development proposals for Version 3 carried out and/or co-ordinated by the RNDSG, a number of validation studies were or are being completed by States or groups of States at three levels:

i. Evaluations (segment/sector loadings) using the SAAM tool.

ii. Fast Time Simulations (RAMS-TAAM).

iii. Real Time Simulations.

9.1.2 Version 3 validation at macroscopic level (SAAM evaluations)

- Nordic airspace, (Sweden/Denmark/Finland/Norway). (SAAM 1)
05-07 MAR, 1997
- Nordic airspace complementary study including sectorisation, (SAAM 15)
20-21 NOV, 1997 (Nordic States).
- German airspace, general assessment of traffic flows on V.3 (SAAM 0.1)
route network, JAN, 1996.
- Interface Austria/Germany, (SAAM 3)
03-05 JUN, 1997.
- Interface Wien/Budapest/Bratislava, (SAAM 4)
24-26 JUN, 1997.
- Interface Hungary/Bulgaria/Turkey/Romania, (SAAM 8)
06-07 NOV, 1997.
- Interface Austria/Bulgaria/Hungary/Croatia/Slovenia/Yugoslavia (SAAM 9)
12-13 NOV, 1997.
- Interface FYROM/Bulgaria/Greece, (SAAM 10)
14 NOV, 1997.
- Italian airspace with V.3 network, (SAAM 5+11)
14-15 JUL & 25-26 NOV, 1997.
- Milano airspace, transition* routes for Milano TMA, (SAAM 14)
27-29 JAN, 1998.
- French airspace, Bordeaux ACC, V.3 network and (SAAM 13)
sectorisation, NOV, 1997.
- French airspace, Marseille ACC, V.3 network Org. 2 and (SAAM 7)
sectorisation,
27-28 OCT, 1997.
- 5-States W/G zone of responsibility, traffic flow evaluation for V.3 (SAAM 12)
15-16 DEC, 1997.
- Spanish airspace, V.3 network and sectorisation, (SAAM 2)
20-22 MAY 1997.
- Romania/Hungary,12-13 AUG 1997. (SAAM 6)

Draft reports of all the above validations were prepared and submitted to the States concerned. Agreement has been indicated in all cases except SAAM 0.1 - a preliminary overview; SAAM 7 which was a contribution to the development of scenarios in France; and SAAM 12 which is part of the ongoing development process in the 5-States area.

9.1.3 Fast Time Simulations related to Version 3 developments (EEC/Bretigny - RAMS)

- German airspace :
  - *Phase 1 - General evaluation EEC No 2/96 Task AF51, JAN 96*
  - *Phase 2 - Control unit design EEC No 5/97 Task F04, JAN 97*
  - *Phase 3 - Optimisation route, transition, sectors EEC No 1/98 Task F16, JAN 98*
- French airspace :
  - *Marseille UIR sectorisation NORD EEC No 2/98 Task F07, JAN 98*
  - *Reims UIR sectorisation and network EEC No 283 Task AF49, JUN 95*
  - *Marseille UG5 inversion AF23 (92)*
  - *Bordeaux UG5 inversion (94)*
- Ljubljana FIR sectorisation EEC No 21/97 Task F15, SEP 97
- 5-States zone of responsibility :
  - *Fast time simulation scheduled for 1998 and 1999*
- Milano F14, FEB 98
- Central Europe F18, 1998 (Austria/Hungary/Slovenia/Croatia/Italy)
- Romania F10, 1997
- Czech Republic F24, 1998
- Bulgaria F27, 1998

Arithmetical simulations related to Version 3 developments : National studies

- Switzerland airspace :
  - *France/Swizerland interface (TAAM sim ZOE/98)*
  - *Geneva interface (TCCW) 20 FEB 96 (using TAAM)*
- German/Switzerland interface (TAAM sim DSS 1995/96; Switerland FIR/UIR, Munich FIR, Rhein UIR)
- German airspace in complement to EEC simulations (TAAM) :
  - *Frankfurt area (TAAM5; Fast time simulation for optimisation of Frankfurt FIR, May 1995)*
  - *Munich area (TAAM9; Optimisation of sectorisation in the southern part, February 1996)*
  - *Munich/Karlsruhe area (TAAM12; Optimisation of airspace structure, February 1997)*
  - *Munich/Karlsruhe area (TAAM19; Optimisation of airspace structure, February 1998)*
  - *Bremen area (TAAM11; Optimisation of airspace structure, TMA simulations, May 1996)*
  - *Berlin area (TAAM15; Optimisation of routeings/flight profiles, 1997)*
  - *Dusseldorf area (AF31/AF45-EEC; Segregation of DEPs and ARRs, 1992-1994)*
    (plus various smaller TAAM-simulations for optimisations of EAM04 recognitions)
- Netherlands '98

9.1.4 Real Time Simulations (EEC/Bretigny or National facilities)

- Switzerland/France interface, DEC 97 (CEE)
- Spain, NOV 97 (CEE)
- France --> Bordeaux/Barcelona, MAR 98 (Toulouse)
- France --> Paris Transition area, JAN/FEB 98 (CEE; S17)
- France --> Northeast interface, DEC 97 (Toulouse)
- France --> Reims/Paris, JAN/FEB 96 (CEE, No 304, AT34, OCT 96)
- Hungary, Budapest FIR, OCT 95, (CEE No 299, AR40, JUN 96) completed by SA4, 29 MAY 96 (V.3 sectorisation and RVSM)
- German airspace (entire German project) scheduled for last quarter 98
- Romanian airspace, MAY/JUN 97

- Switzerland --> Geneva ACC (NST), OCT/NOV 97
- Sweden --> Malmö ACC, OCT 97 (Malmö)
- Sweden --> Stockholm ACC, MAR 98 (Malmö)

9.2 Version 3 Results and Comparison with Current Route Network

Preliminary comparisons between traffic loadings on Version 3 and the current route network have been carried out. However, the RNDSG considered that the inclusion of charts showing differences in loadings on both networks could be misleading and might result in misunderstandings. Accordingly, it was agreed to develop a more detailed supporting document outlining the results of evaluations and comparisons. The following overview is provided as a summary comparison. In general there is a better traffic distribution on the proposed Version 3 network, the axes Geneva-Zurich, Milan-Zurich-Frankfurt, Brussels-Karlsruhe-Vicenza are de-congested through the dualisation of routes and the creation of links to TMAs.

The heavy traffic loadings on the axis TOMPA-BLC-KAL (current), may be transferred in V.3 onto the segment KFT-ZAG-BLC which would then appear overloaded. However, additional options (GOTAR-BABIT-KAL and GOTAR-SOMOV) exist to relieve this route when necessary. The re-opening of the airspace over Bosnia-Herzegovina allows a more even distribution of traffic to/from South-East Europe, although the lack of links over the eastern Athinai FIR in V.3 still contributes to congestion in the RAD/EKI area.

The most congested points, BZO, INN, LNZ, HLZ, SPY/PAM and PAS/SPR appear less loaded in V.3 as a result of the route re-organisation over these areas (de-concentration of converging points). However, the well known bottlenecks in the core area remain overloaded; NIK; LNO/NTM; FFM; TGO; TRA. This can be explained by the traffic demand linked to major airports in the area which cannot be moved elsewhere. The proposed answer to that problem in V.3 is an increase in capacity through a more efficient sectorisation. An adapted sectorisation in support of the rationalised network (uni-directional and specialised routes) will provide the additional capacity to cope with current and future demand (the German project and related fast-time simulations refer). The congested points which appear in V.3 south of Paris result from the re-organisation of traffic flows on the routes PTV-CAROS; PTV-CMF: PTV-MTL. Sectorisation (specialised southbound sectors, no crossing routes) is designed to match the traffic demand.

The above comparison can only give an overview of the results expected in ARN Version 3. In order to measure the actual improvements derived from the proposed airspace structure, it will be necessary to carry out further evaluations detailed at sector level (some completed, some being processed, some yet to be planned; see list of evaluations/simulations in paragraph 9.1).

Additional detailed comparisons and the results of evaluations will be outlined in a separate document which will be associated with this report.

10. CONCLUSIONS

10.1 Development Process

Work commenced on the development of Version 3 in October, 1996 at RNDSG/18. The initial proposals were refined through seven RNDSG meetings and agreed at RNDSG/26 (March, 1998). In addition, a number of drafting group meetings and regional meetings were held to address particular issues. Throughout this process the methodology developed by the RNDSG worked quite well, with a strong involvement from the majority of the ECAC States. It was quite clear that the experience gained in developing Version 2 was of major assistance in gaining the co-operation of all of the ECAC States. It was also clear that the RNDSG has achieved recognition as the forum in which airspace improvements can be successfully co-ordinated.

10.2 Analytical Tools

The continuing improvement in the analytical tools available to the RNDSG ensured that the proposals put forward and agreed in Version 3 were subject to a much more stringent evaluation and assessment than was possible with previous versions of the ARN. The number of Regional SAAM evaluations carried out (15) between April 1997 and February 1998 is indicative of the improvement in evaluation capability that is available and necessary to support the work of the RNDSG. However, additional functionalities in the evaluation tools are still required and need to be developed if the process of airspace optimisation is to continue to improve. In particular, workload assessment at the sector level is an urgent necessity.

10.3 Content of Version 3

As detailed in the report, the major elements in Version 3 are:

- a comprehensive re-organisation of the airspace in the Nordic States and Germany utilising the flexibility of RNAV;
- improvements in the 5-States interface airspace;
- comprehensive improvements in Central Europe including the dualisation of routes on the north/south axis,
- interim arrangements in the ZOE area which will allow work to continue towards a more permanent solution;
- improved alignments at the interface France/Spain;
- improved routes in the Black Sea area and with the interface with Eastern Europe;
- incremental improvements in the alignment of routes in the rest of Europe;
- improved transition* routes throughout Europe;
- improved sectorisation (Germany, Nordic States, Austria, Hungary, Benelux, N.E. France, France/Spain interface) resulting in significant capacity increases.

It should not be considered that ARN Version 3 is the ultimate step in an optimised airspace structure in Europe. For a number of reasons this is not the case. In some areas because of technical (lack of radar) or other reasons, it was not possible to achieve all of the improvements required. Accordingly, the improvement of the airspace structure in Europe should be seen as a continuous process where improvements are developed and co-ordinated in an incremental manner through agreed programmes which focus on shortcomings and make use of windows of opportunity as they occur. In this context, the RNDSG will continue to support studies and evaluations aimed at improving the airspace in the 5-States area and at the interface between France, Switzerland and Italy because of the crucial strategic

importance of these areas in the core area. The RNDSG will also continue to support the initiative undertaken by the ANT in regard to the development of routes in the eastern part of the Athinai FIR/UIR and will integrate any proposals arising from this initiative into the V.3 implementation programme.

10.4 Commitment to Implementation

The content of Version 3 will be proposed as an amendment to the EUR-ANP. The RNDSG will then co-ordinate its implementation in an agreed phased implementation programme. The commitment of all of the ECAC States to implementation of the agreed proposals in a cohesive and co-ordinated manner will be a crucial and essential element in the success and credibility of the work of the RNDSG and its parent body, the ANT.

10.5 Co-ordination with the Aeronautical Information Services (AIS)

Before introducing the ARN Version 3 changes to the air navigation system, due account should be taken of the time needed by AIS for the preparation, production and issue of relevant material for promulgation. Timely and close co-ordination between the services is therefore required.

10.6 Promulgation of Changes

Whenever major changes to the air navigation system are planned, such as the ARN Version 3, requiring cartographic work and updating of navigation databases, it is essential that these changes be promulgated with an advance notice of 56 days, i.e. twice the minimum AIRAC cycle.

(Extract from "Concept and Criteria for Medium Term EUR Route Network and Associated Airspace Sectorisation")

APPENDIX A.1

A.1 CRITERIA FOR ATS ROUTE NETWORK DEVELOPMENT

A.1.1 Basic Structure

A network of ATS routes should form the basis for the determination of the airspace organisation and the required air traffic services and facilities. It should be so established as to enable a majority of flights to operate along, or as near as possible to, the direct route from point of departure to destination.

Region-wide ATS route structures should be set up along broad alignments joining major origin/destination areas. These alignments must be structured in an operationally viable way.

In order to achieve optimum ATM capacity there may be a need for non-optimum flight levels and routeings.

The restructuring of the ATS Route network should be performed in an evolutionary manner. As the restructuring of entire portions of the airspace, e.g. a major traffic axis, is agreed, implementation should not be delayed whilst waiting for the plans for restructuring of additional portions to be completed. States may need to ensure, where they cannot accept proposals being made, that they present an alternative.

A.1.2 International Planning

The process should provide States with an internationally agreed broad and basic concept of the airspace and ATS Route structure in the ECAC area serving as a basis for national or regional planning.

States should plan major changes of their airspace and ATS Route structure affecting the basic ATS Route Network with prior co-ordination and exchange of information with the largest possible number of international parties concerned. This should be carried out well in advance and preferably in multilateral fora.

A.1.3 Relationship between Network and Sectorisation

There is a close two-way inter-relationship between the network's structure and sectorisation. Consequently, from the planning phase onwards, it is necessary to ensure that a sectorisation scheme, including possible delegation of ATS, is feasible and viable in relation to the planned network. In particular, the definition of the directions of use on the uni-directional routes, as well as the final alignment of these routes may have to be adapted in consideration of sectorisation efficiency. This could be validated through simulations.

A.1.4 Civil/Military Interface

Civil/Military co-operation related to the more efficient and flexible use of airspace should be applied on as wide a scale as possible along the principles of the FUA Concept.

A.1.5 Extension of the FUA concept

Extension of the FUA concept to additional direct routeings should be made available under pre-defined civil/civil conditions (Staffing/sectorisation/traffic density). This would mean the extension to larger airspaces (groups of sectors/ACCs) of the current tactical ATC practice of direct routeings which is today generally applied within one sector. The automated reprocessing of flight plans would facilitate the further application of this concept.

A.1.6 Network Architecture

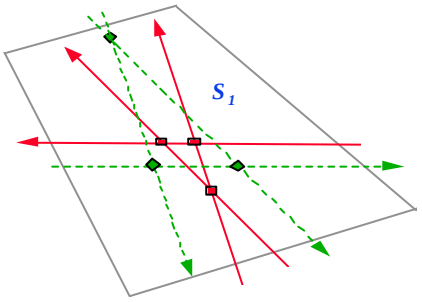
The definition of major traffic flows should include heavily loaded intra-European routes and/or segments which should be integrated in the overall structure at an early stage of the planning.

The architecture of the network should normally be developed from the core area towards the periphery.

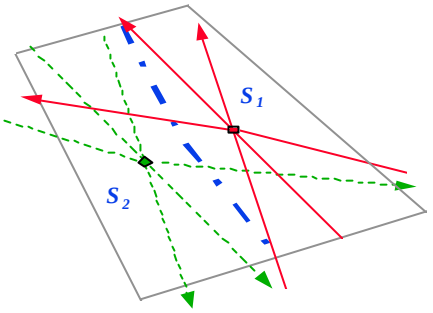
Efforts to eliminate specific traffic bottlenecks should include, as a first step, an in-depth analysis of the factors causing the congestion. In this regard, particular care should be taken to avoid worsening the situation in one area by attempting to improve it in the other.

"Roundabout[2]" network structure should be conceived to fit with specific sectorisation and to allow the splitting of multiple crossings into different sectors.

[2] *In the context of complex multiple crossing points, "Roundabout" means the grouping of uni-directional routes of the same series of flight levels (odd and even) on to two different points (areas), thus separated one from the other, in order to allow the establishment of two different sectors and thereby achieving a spread of the workload.*



Direct routeings :
Square shaped crossing points (even levels) and diamond shaped crossing points (odd levels) are complex and may result in an overloaded sector which cannot be split. (limited maximum capacity)



Structured routeings with "Roundabouts" :
The resulting location of the actual crossing points makes it possible to split the former sector into two sectors and enhance the maximum capacity.

The number of ATS Routes shall be kept to a minimum but should be in line with the traffic demand in respect of ATM capacity and most direct routeing.

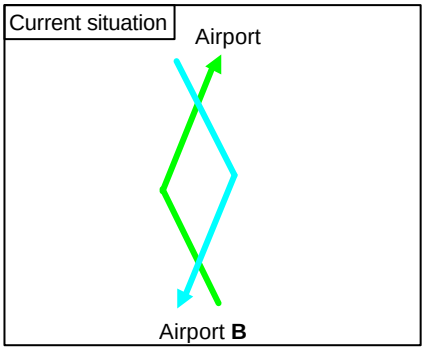
Although it is accepted that a large number of ATS routes can improve route capacity, it is also recognised that a large number of crossing points, especially in congested areas, can reduce sector capacity. Planners should optimise capacity by introducing new routes with as few crossing points as possible and these crossing points should be well clear of congested areas.

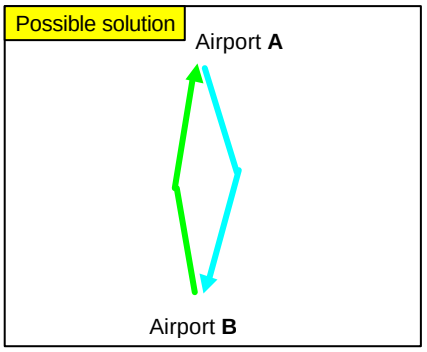
Whenever in the planning phase and based on forecast demand, an ATS route has been planned to accommodate a specific flow of traffic, its subsequent implementation should - if the traffic demand by that time is no longer met - be reconsidered. Redundant ATS routes should be deleted.

Use of uni-directional routes should be extended, particularly in areas where the interaction of climbing and/or descending traffic is a limiting factor, with the expected advantage that the improved structuring of the traffic would increase ACC Sector capacities.

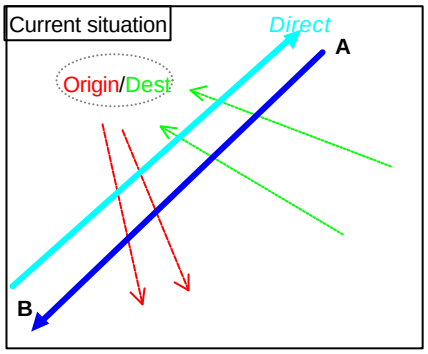
A.1.7 Planning of Routes

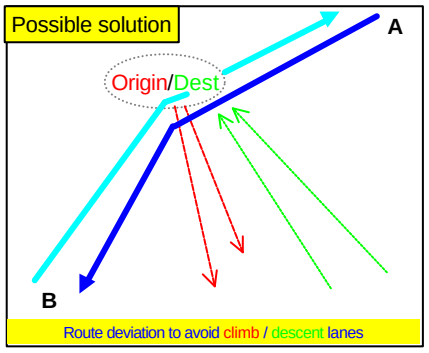
Planning should ensure that where dualised routes are used uni-directionally for opposite traffic flows, cross-overs are avoided as far as possible.



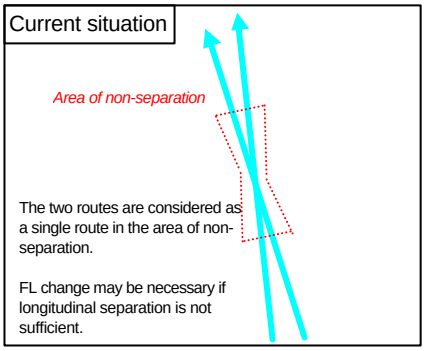


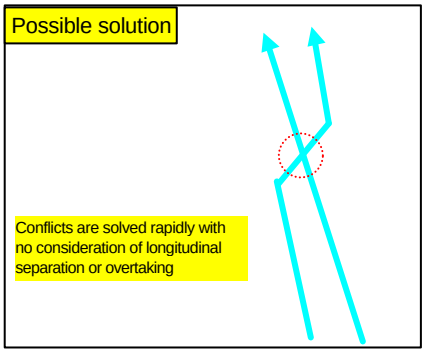
Crossing areas should not conflict with climb or descent lanes of major airports.



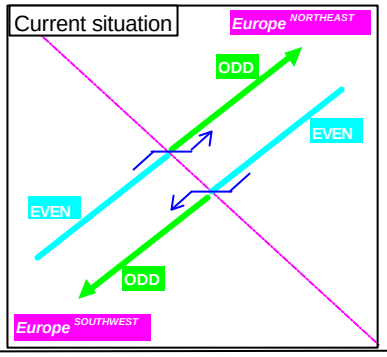


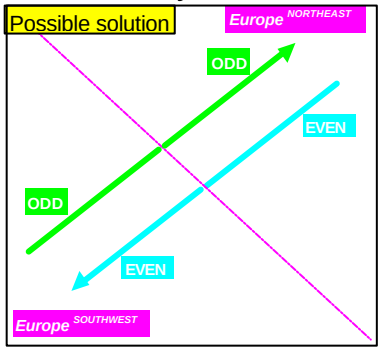
The extension of crossing areas between ATS Routes should be kept to a minimum (crossing at right angles).





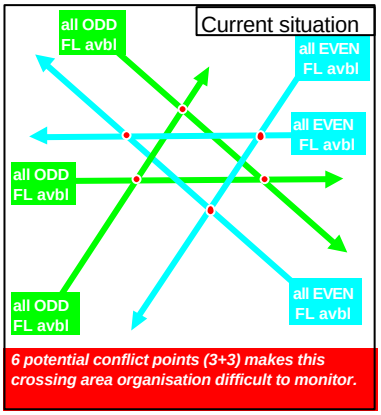
Currently two different applications of the ICAO table of cruising levels coexist in the EUR Region. This leads to a requirement for aircraft transiting the boundary between the two application areas to change flight levels. Consideration should be given to the possible increase of system capacity which would result from a less rigid application of the present method of segregation of eastbound and westbound flight levels. This is already practised in some “one-way” ATS routes.

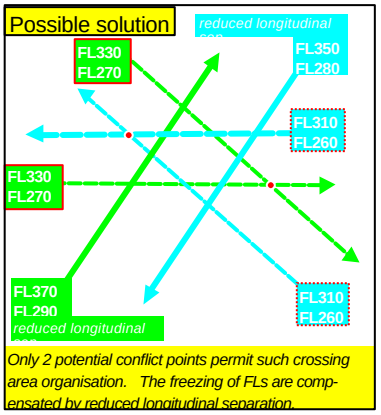




APPENDIX A.1

It should be recognised that the definition of a given flight level allocation scheme will have a direct impact upon the way in which major crossing points will have to be organised.





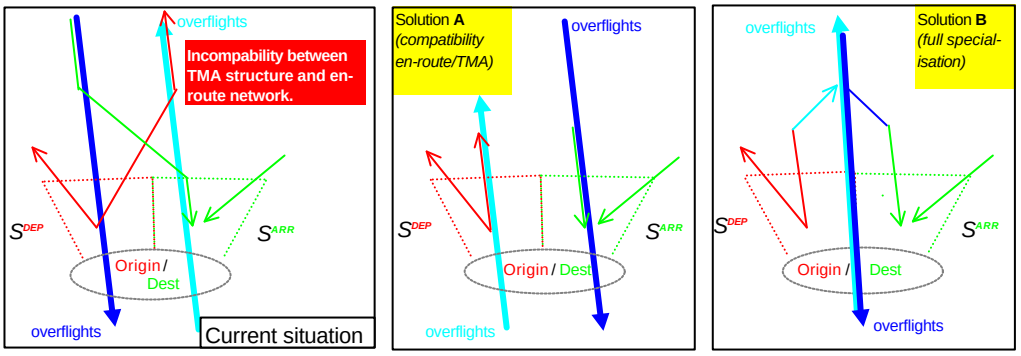
A.1.8 Shorthaul Routes and Levels

Specific routeing and/or flight level allocation for short haul city pairs may be established.

A.1.9 Transition* Routes

The traffic in the ECAC area is predominantly short haul traffic with nearly half of the flight distance spent in climb and descent phases. From the first stage of the network planning, it is therefore necessary to consistently integrate major transition* routes in the whole structure and to ensure TMA-Network interfaces compatibility *(see Solution A below)*. This is valid for the major origin/destination areas.

Fixed routes systems based on RNAV should, if necessary, be applied at airports with high traffic density to specialise arrival and departure routes. Such route systems (specialised routes) should be designed to enable arriving, departing and overflying traffic to be separated systematically, while seeking to permit economical flight paths *(see Solution B below)*. In order to optimise the use of airspace and aerodrome capacity route systems should be designed, where possible, to take account of different aircraft performance capabilities.



(Extract from "Concept and Criteria for Medium Term EUR Route Network and Associated Airspace Sectorisation")

APPENDIX A.2

A.2 CRITERIA FOR AIRSPACE SECTORISATION DEVELOPMENT

A.2.1 Introduction

At present many of the constraints in the ECAC ATM system are caused by a lack of adequate **sector capacity**. With traffic demand increasing steadily at average annual rates of 4 to 5%, it is clear that achievement of enhanced sector capacity is a crucial objective if congestion problems and their associated delays are to be minimised.

A number of studies and analyses have been carried out in Europe, which have identified the close interrelationship between sectorisation and route network configuration. Therefore, this relationship must be taken into consideration in planning the improvement of the ECAC ATM system. In particular, it is essential to ensure that route network and airspace sectorisation are coherent and compatible, if optimum capacity gains are to be realised. In particular, the planning of Version 3 incorporates this consideration.

A.2.2 Method/Rationale

In developing the optimum airspace structure the RNDSG has adopted a Top Down or overall ECAC wide approach *(see paragraph 3.1)*. This approach is an outcome of the following rationale.

FIR boundaries which are mainly contiguous with State boundaries can have the effect that ATC sector boundaries are not always optimal for air traffic flows and ATM requirements. The non-optimal airspace structure then dictates the structure of the route network on which the traffic flows are accommodated. This former approach (see Figure A.2.1 on page 9) constrains the options for solutions, whereas the **Top Down or Network-oriented approach** (Figure A.2.2 on page 10 refers) is less constrained.

With this "Top Down" approach the main traffic flows are accommodated into a route network, which is independent of the existing sectorisation. Subsequent and suitable sectorisation must be developed to support the network, including the accommodation of all relevant traffic flows. A consequence of the above approach will be a re-organisation of sectors, involving at sector boundaries a delegation of ATS where necessary. At this initial proposal development stage the network requirements take precedence over sectorisation.

However, it must be recognised that because of the two-way relationship it may not be possible to develop an operationally viable and efficient sectorisation. As pointed out above, sector capacity is the crucial element in the whole ATM system. Route structure, although one of the main factors, is only one of the elements which determine sector capacity. Therefore, in those instances where the lack of adequate sector capacity may be a significant constraint on the ATM system, and whenever a proposed improvement in route alignment leads to a complication of the sector's organisation, resulting in an unacceptable reduction in capacity, then both the route alignment and sector configuration should be re-examined. Because of this two-way dependency between airspace sectorisation and route network, it is essential that both are addressed immediately after the initial proposal development stage and throughout the planning process this relationship is always taken into consideration.

APPENDIX A.2

Summary of method/rationale:

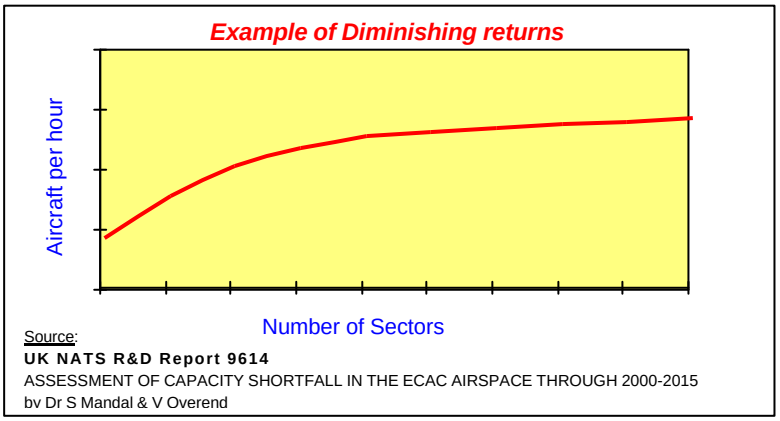
- Step 1: Route Network initial proposal
- Step 2: Examination of sectorisation viability
- Step 3: Harmonisation of outcome of step 1 and step 2

A.2.3 Airspace Structure: Options to enhance ATM capacity at the sector level

Air traffic control is currently based on sector structures. Sectorisation is the means of subdividing the totality of control tasks into manageable portions, at which throughput and capacity can be quantified. ECAC airspace has currently in excess of 400 sectors distributed in more than 50 ACCs. Capacity is a theoretical indicator of traffic loads, which can safely be handled by a sector team, rather than the loading they are currently subject to.

The main constraints on ATM capacity are airspace limitations and controller workload. The classic method to overcome these constraints is to **provide more sectors**. By either resizing or providing additional sectors, one can reduce the airspace volume, the number of routes/crossing points (conflictions) and the number of aircraft on the frequency at any time. This results in a **reduction of workload** and a corresponding increase in capacity, while maintaining at the same time a balanced co-ordination workload (e.g. through the use of improved/ automated co-ordination procedures).

The sub-division of sectors is a finite strategy and a point is reached, when the benefit of further reduction is outweighed by other factors (especially in the core area). Furthermore, the increase of capacity is not proportional to the number of sectors available (law of diminishing returns).



Source:
UK NATS R&D Report 9614
ASSESSMENT OF CAPACITY SHORTFALL IN THE ECAC AIRSPACE THROUGH 2000-2015
by Dr S Mandal & V Overend

Therefore, the efforts to handle traffic growth have to be focused on a more efficient method, which is to **increase sector productivity** and consequently capacity. This can be achieved by reducing the complexity of the airspace structure, resulting not only in a more balanced distribution of traffic within different sectors, but also in a **redistribution of workload**. The redistribution should be made on a sector to sector balanced basis.

Note:
Whichever method is used will entail a cost in either human and technical resources or non-optimum route/flight profiles

APPENDIX A.2

A.2.3.1 Option 1 : Additional Sectors

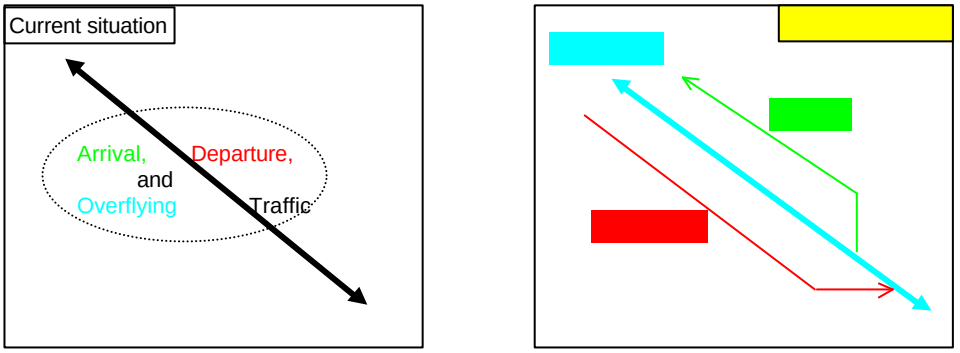
The provision of additional sectors is the classic method of increasing capacity. Although scope still exists for this in most of the ECAC airspace outside the core area or in the upper layers (vertical split), this is not always the most efficient method. Furthermore, in the core area the introduction of additional sectors is not always possible because:

- limits are almost reached (diminishing returns)
- frequency shortage
- co-ordination burden (workload increases)
- short transit times
- complex network (within Lower Airspace, especially close to TMAs)

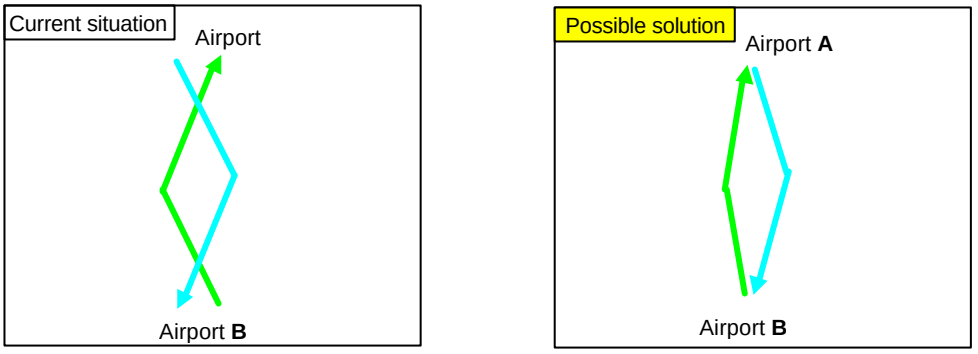
A.2.3.2 Option 2 : Increased Sector Capacity

In the core area especially, therefore, the efforts of the RNDSG must be focused on **increasing sector capacity**. This objective can be facilitated, if airspace planners in the overall design of the route network bear in mind the need to reduce the complexity of ATS route structure and thereby control tasks by:

- keeping the number of ATS routes controlled by a sector to a minimum
- specialisation of routes (dualised routes/deconflicted ARR/DEP routes)

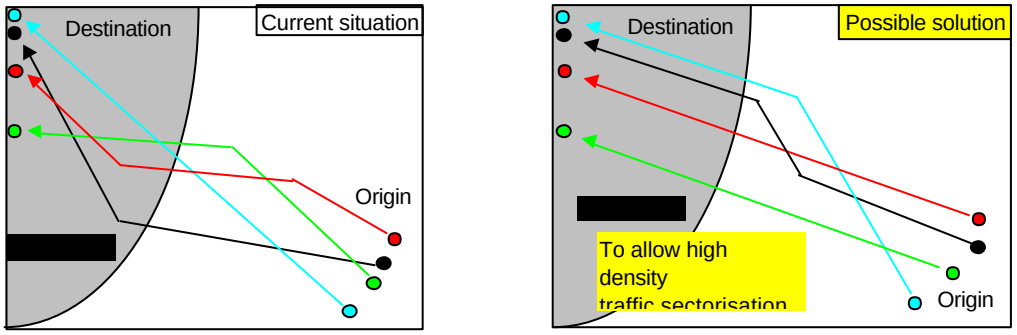


- deconfliction of traffic flows (elimination of unnecessary cross-overs)

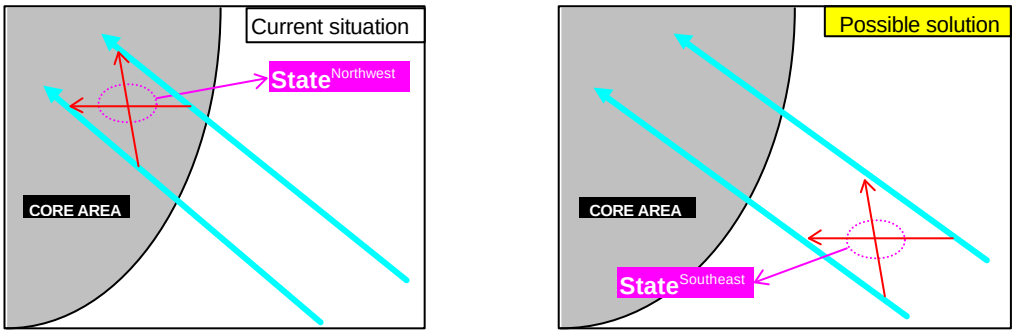


APPENDIX A.2

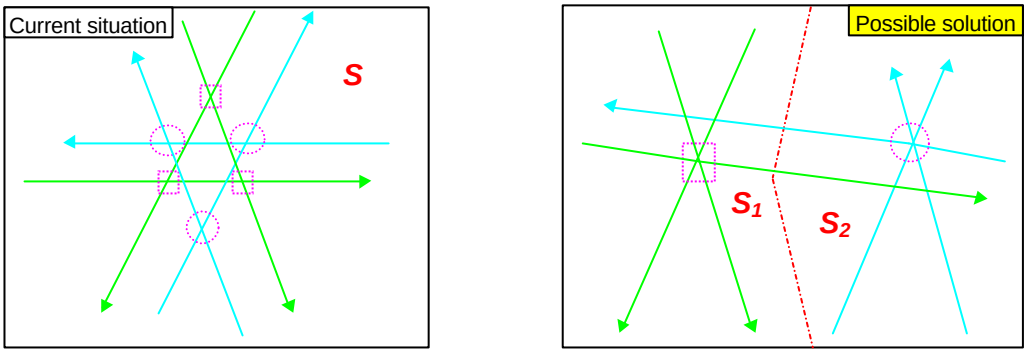
- organisation of traffic flows (segregation of main traffic flows)



- appropriate relocation of crossing points, where possible



- rationalisation of crossing points, where possible



Consequently, from the planning phase onwards, it is necessary to take into account a certain number of **criteria** to ensure that a given sectorisation scheme is feasible in relation to a planned network.

A.2.4 Criteria

As a fundamental tool to ensure the relationship mentioned above, it is necessary to have standardised criteria developed by the RNDSG in order to establish, modify or validate en-route and Terminal sectors.

A.2.4.1 General Criteria Applicable to Sector Development :

Sectorisation architecture should be:

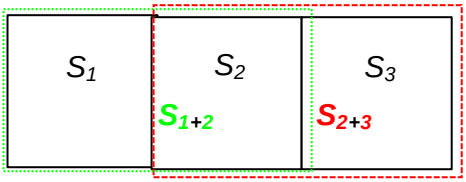
- based on operational requirements
- planned on a coordinated, international basis
- drawn up independent of FIR or national boundaries

- operationally efficient, i.e. maximise ATM capacity while accommodating user demand

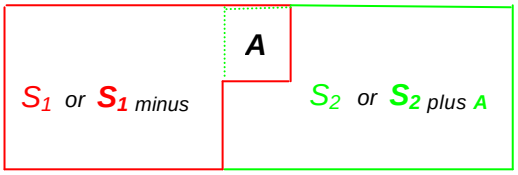
APPENDIX A.2

- fully consistent with the evolution of the route network
- fully consistent with the airspace utilisation (CDRs / route scenarios)
- sufficiently flexible to respond to varying traffic demand and to temporary changes in traffic flows (morning, evening, week, week-end traffic), this includes:

1. *the combination of sectors to balance varying demands*



2. *the reconfiguration of sector boundaries through use of air blocks to match prevailing traffic flows*



- constructed to ensure operational and procedural continuity across national borders
- designed to take into account military requirements and those of other airspace users
- configured to ensure optimum utilisation of the ATS route network (balanced load on the sectors)
- configured to minimise co-ordination workload
- designed, where appropriate, to utilise techniques based on specialisation of task depending on the nature of traffic and its density
- designed, in general, to be laterally larger for high level sectors than the underlying lower sectors in respect to traffic density and complexity

Requirement for additional vertical sectorisation may be necessary when RVSM (Reduced Vertical Separation Minima) is implemented

- based on the following factors:
  - traffic volume/density utilising up-to-date data and projected trends
  - traffic complexity
  - nature of traffic (en-route, climbing or descending traffic)
  - ATC system capability

A.2.4.2 Specific Criteria To Enhance Sector Capacity :

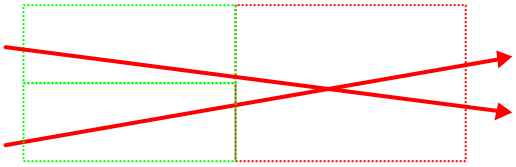
I. Conflict Points:

Sectorisation architecture should:

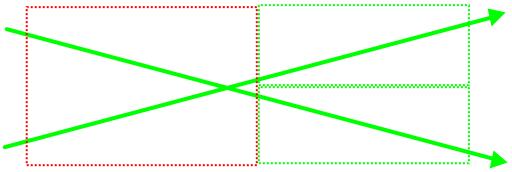
- limit number of conflict points in the same sector involving major traffic flows

APPENDIX A.2

- avoid different sectors feeding the same sector with converging traffic, when action to separate individual aircraft is required (two different co-ordinations for the receiving sector)

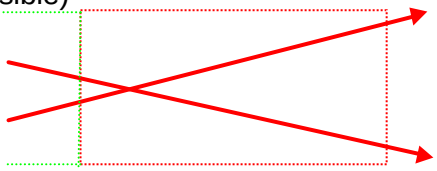


NO



YES

- avoid conflict points close to the boundary of a sector for entering traffic (increasing workload because of excessive co-ordination/no anticipation possible)



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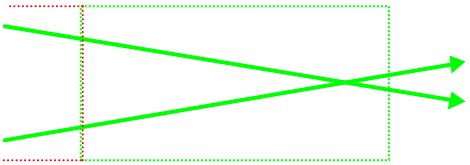


YES

II. Sector Functions/Specialisation

- in order to enhance sector capacity the functions (arrival, departure and en-route) carried out by one sector should be minimised
- 'Flight Level Allocation' procedures should be evaluated and the optimum system applied

  Note:
  Due to the upstream and downstream impact such procedures should be coordinated.

III. Sector Size *(Big Sectors ¬ ¾ ® Small Sectors)*

- The shape and size of a sector is a function of the tasks which can be efficiently carried out in the sector. The configuration and size of the sector therefore involves trade offs involving traffic volume, complexity and control task.
- regarding vertical and horizontal extension a sector should be:

  small enough to accommodate sector functions, while providing a balanced workload, and allow:

  - one specialised function
  - high rate of entering traffic
  - short transit time and low instantaneous loads

and at the same time

big enough to accommodate sector functions while not imposing an excessive workload and allow:

- anticipation and resolution of conflicts with a minimum of co-ordination
- the establishment of holding patterns without requiring co-ordination
- RNAV offset procedures
- radar vector separation techniques

APPENDIX A.2

- tactical direct routeings
- reasonable transit time (less co-ordination)

Low traffic density allows bigger sectors, whereas as density increases, a resizing into smaller ones becomes inevitable. The relative benefits from different sizes of sectors can be indicated as follows:

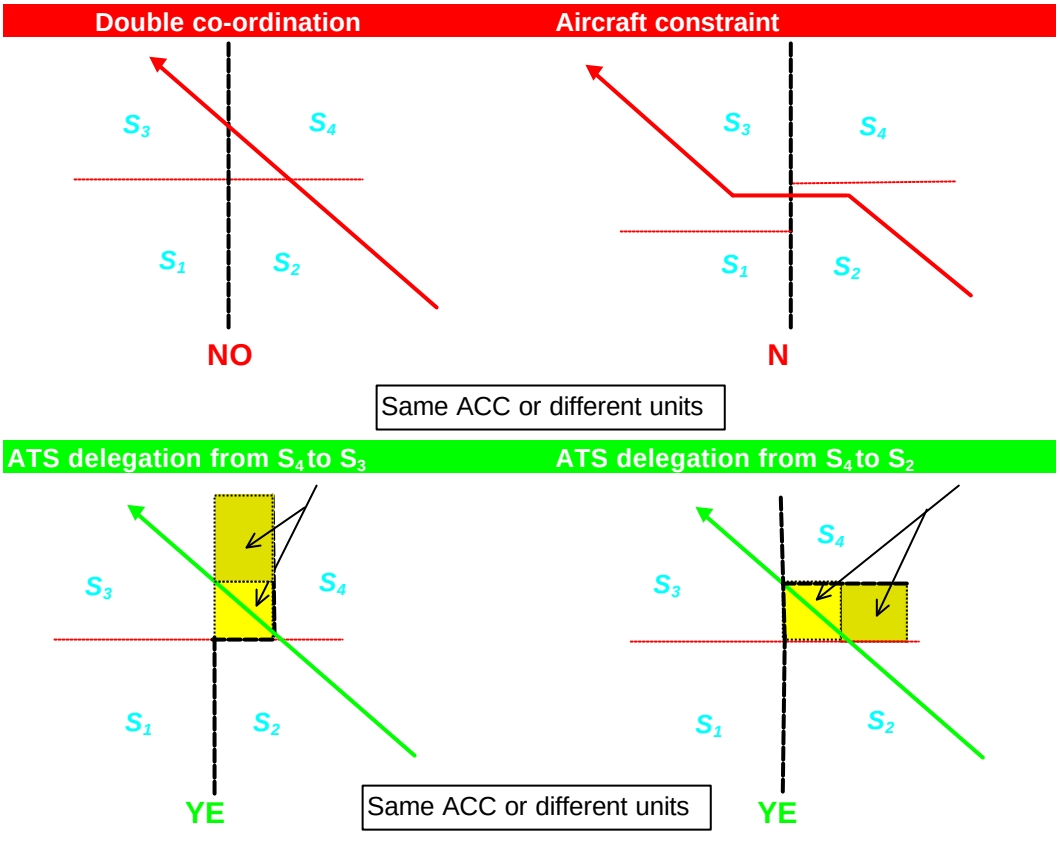
big sector	⟵ *versus* ⟶	**small sector**
better flexibility		better productivity
better anticipation		better efficiency through specialisation
more appropriate for varying flow demand		more rigid

The optimum size of sectors will therefore depend upon a case-by-case analysis.

IV. Sector Boundaries/Sector Shape

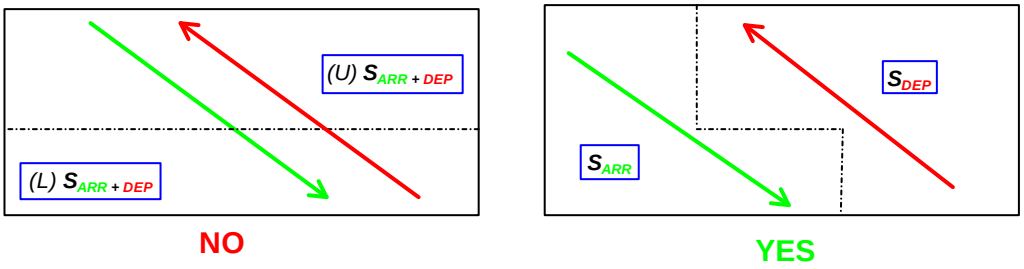
Sectorisation architecture should:

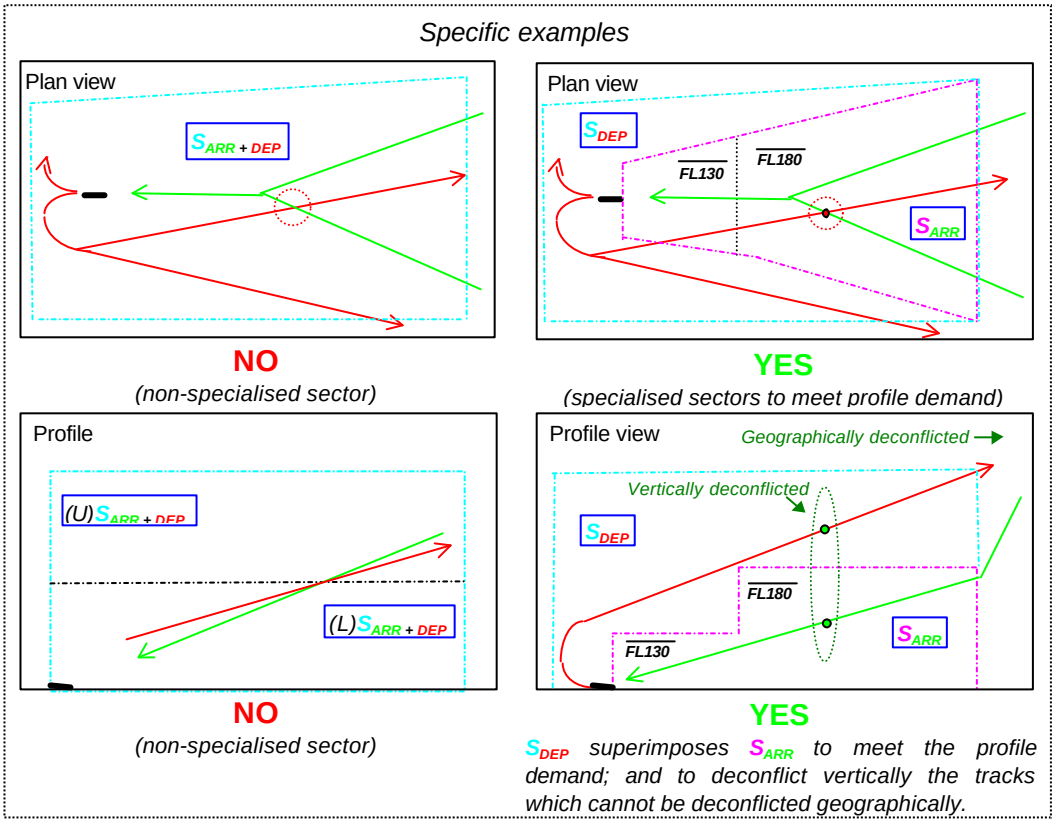
- be based on operational requirements rather than national boundaries
- promote overall system flexibility (grouping/de-grouping of sectors/collapsed sectors because of FUA/CDRs or during low traffic periods)
- reduce co-ordination/workload and facilitate radar hand-over
- avoid too short a transit time within one sector, e.g. by delegating a part of the airspace (ATS delegation)



APPENDIX A.2

- shaped along main traffic flows
- take into account the ideal profile and performance of aircraft





- promote overall system flexibility in support of fuel-efficient direct routes
- have varying division levels/level splits all over Europe depending on traffic patterns/source of traffic and the performance of aircraft (this means that a "standard" division FL 245 between Upper and Lower Airspace could be a constraint)
- arrange sector splits horizontally, if overflying traffic is dominant (sector slices)
- arrange sector splits vertically, if climbing and/or descending traffic is dominant (sector columns)

A.2.5 Application of Criteria

In regard to the all of the foregoing criteria it should be noted that local requirements will dictate their appropriateness or otherwise. Airspace planners must also ensure that the application of any of the criteria or the solution of a local problem should not adversely affect adjacent airspace, or the overall capacity of the ECAC airspace.

APPENDIX A.2

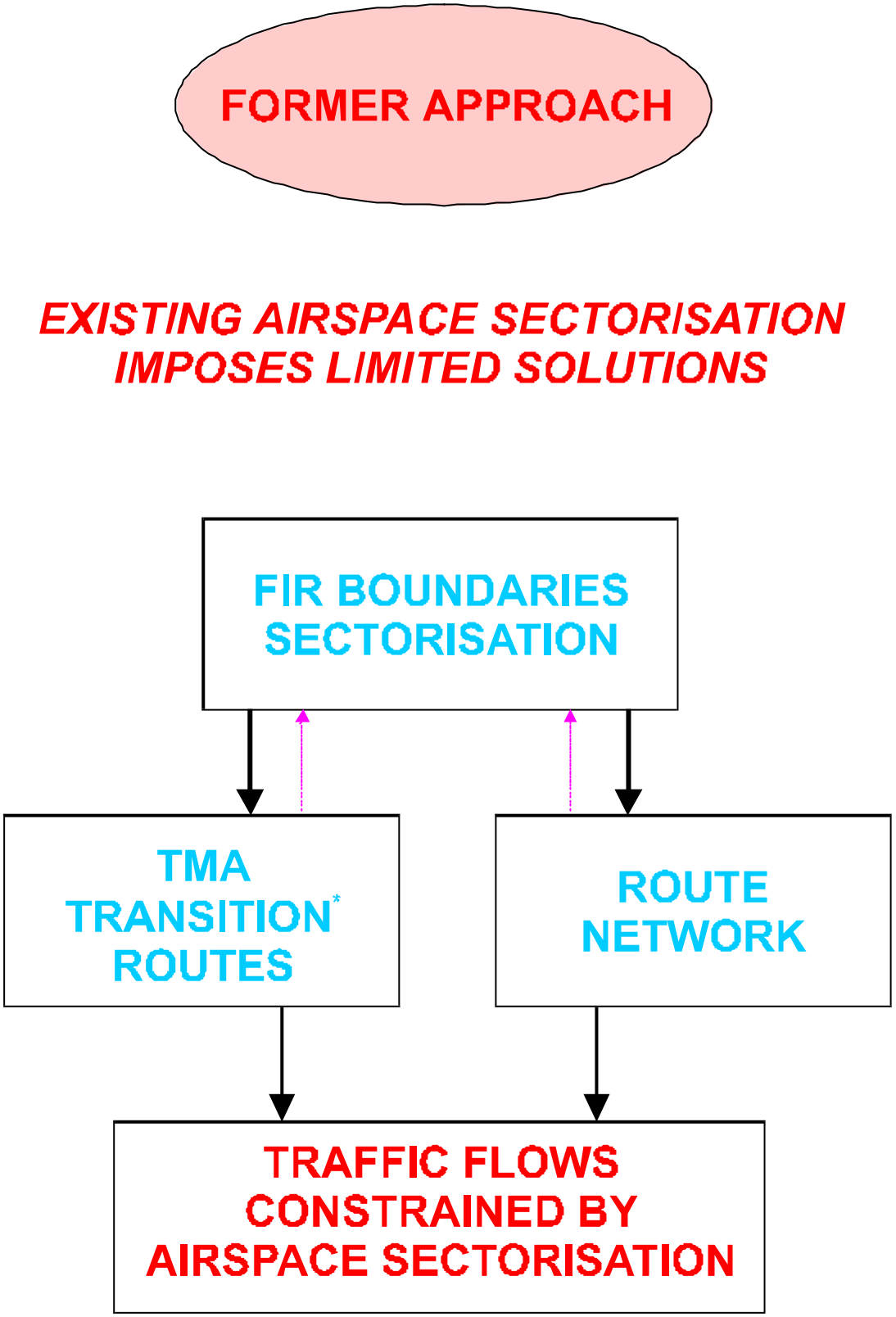

FORMER APPROACH
EXISTING AIRSPACE SECTORISATION
IMPOSES LIMITED SOLUTIONS
FIR BOUNDARIES
SECTORISATION
TMA
TRANSITION*
ROUTES
ROUTE
NETWORK
TRAFFIC FLOWS
CONSTRAINED BY
AIRSPACE SECTORISATION

Figure A.2.1

APPENDIX A.2

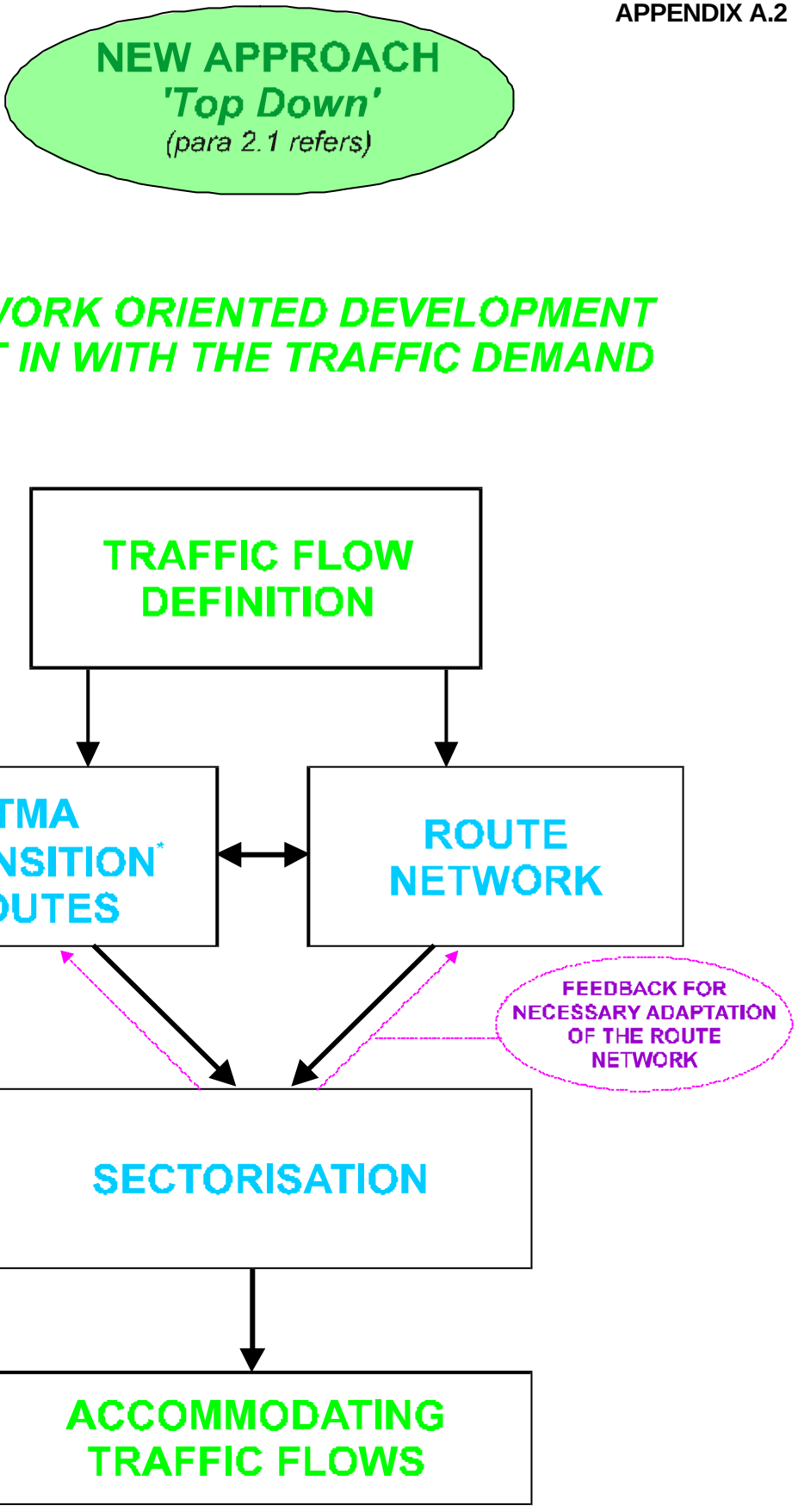


Figure A.2.2

APPENDIX A.3

APPENDIX A.3

APPENDIX A.3

APPENDIX A.3

APPENDIX A.4

Composition of Special Groups:

(1) **Drafting Group** (Initial)

J. Lambert/DED.4 Chairman
A. Duchene/DED.4 Secretary
J-M Leboutte/DEI.3
G. Guizien/CFMU
K. Nilsson/IATA
M. Smith/IACA
P. Defauw/SCTA (FR)
H. Pritz/Austrocontrol (AT)
A. Mevenkamp/DFS (DE)
H. Burns/CAA (GB)

additional members may be added as necessary.

(2) **Regional Groups**

i. Nordic States - Germany - Netherlands - Poland Co-ordination Meetings. *(Baltic States as necessary)*

ii. Germany - Switzerland - Austria Interface Group.

iii. EUROCONTROL / 5-States Route Structure Working Group (5SWG) .
(It should be noted that the 5SWG was set up independently by the States concerned and has a separate reporting structure. However, in order not to duplicate structures, the 5SWG is considered by the RNDSG to be the appropriate group to develop and co-ordinate airspace structure improvement proposals for their area of responsibility.)

iv. France - Spain - Portugal Airspace Group.

v. UK - France Interface Co-ordination Meetings.

vi. France - Italy Airspace Working Group.

vii. France - Switzerland Airspace Working Group (ZOE Cell).

viii. Italy - Austria - Czech Rep - Slovak Rep - Hungary - Romania - Bulgaria - Slovenia - Croatia - Bosnia-Herzegovina - FR Yugoslavia Interface Group. *(Moldova - Ukraine as necessary)*

ix. Bulgaria - Romania - Turkey Airspace Co-ordination Group. *(Ukraine as necessary)*

x. *Greece - Italy - Albania - Bulgaria - FR Yugoslavia - FYROM - Croatia Interface Group.*

The structure an frequency of these meetings depends upon the nature of the problems they will be faced with. Additional participation by neighbouring States and/or user representatives should be considered for specific issues and/or where necessary.

The groups may operate formally or informally and the larger groups may need to appoint a rapporteur.

APPENDIX A.5

A copy of the agreed ARN Version 3 map 1.0 to be included here in the Released Issue of this report.