EUROPEAN ORGANISATION FOR THE SAFETY OF AIR NAVIGATION

EUROCONTROL

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EUROCONTROL MANUAL FOR AIRSPACE PLANNING

- COMMON GUIDELINES -

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Abstract

This document contains planning elements and methods of application for a common airspace design and change process in the ECAC area. This Planning Manual would then serve as a model for States to update and harmonise their own national airspace planning and allocation process with their neighbours.

The material in this document is intended to supplement the provisions specified in ICAO documents and in the EUROCONTROL Handbook for Airspace Management and it should therefore be used in conjunction with these documents.

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Contact Person(s)	Tel	Unit
Jean Paul LEMAIRE	93381	AFN BD

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EATMP Infocentre
EUROCONTROL Headquarters
96 Rue de la Fusée
B-1130 BRUSSELS

Tel: +32 (0)2 729 51 51
Fax: +32 (0)2 729 99 84
E-mail: EATM.infocentre@eurocontrol.int

Open on 08:00 - 15:00 UTC from Monday to Thursday, incl.

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

AUTHORITY	NAME AND SIGNATURE	DATE
Airspace Management Sub-Group Chairman	Mr. J. DOS SANTOS	15/12/04
Route Network Development Sub-Group Chairman	Mr. A. DUCHENE	15/12/04
ATM Procedures Development Sub-Group Chairman	Mr. A. HALLGREN	15/12/04
Airspace and Navigation Team Chairman	Mr. A.W.F. HENDRIKS	15/12/04
Senior Director Acting	Mr. V. AGUADO	10/1/05

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FOREWORD

1 PRESENTATION OF THE MANUAL

1.1 About the Document

1.1.1 This document constitutes Volume 2 of the EUROCONTROL Manual for Airspace Planning which contains detailed planning elements and methods of application for a common airspace design and change process in the ECAC area.

1.1.2 The guidelines contained in this document have been developed by ECAC Member States, with a view of supporting the ECAC airspace planning and design process so as to ensure that Safety is improved or at least maintained by the design or changes to airspace structures[1].

1.1.3 The manual will be reviewed periodically to ensure that the planning criteria remain valid in the light of the progress made and experience gained, and to reflect the actual changes which take place in aviation.

1.1.4 The EUROCONTROL MANUAL FOR AIRSPACE PLANNING is intended to serve as a model for States to update and harmonise their own national airspace planning and allocation process with their neighbours. Therefore, the material contained in the present Volume 2 is mainly focused on guidance for airspace planners.

1.2 Responsible Body and Acknowledgement

1.2.1 This document has been developed by the EUROCONTROL Airspace and Navigation Team (ANT). It is expected that the EUROCONTROL Manual for Airspace Planning and its future amendments will be endorsed in accordance with the EUROCONTROL EATM procedures.

1.2.2 The EUROCONTROL Agency wishes to acknowledge the valuable assistance received from Member States and the International Council of Aircraft Owner and Pilot Associations (IAOPA) in preparing this Planning Manual.

1.3 Structure of the Manual

1.3.1 The EUROCONTROL Manual for Airspace Planning comprises two volumes. Volume 1 describes the institutional framework and applicability of the document, whereas Volume 2 (this document) contains detailed guidelines and planning criteria.

Section 1 - **General Guidelines for the Establishment of Airspace Structures** - identifies general principles for the establishment and use of airspace structures.

Section 2 - **ATS Airspace Classification** - provides guidance for the harmonisation and simplification of ECAC Airspace Classification.

Section 3 - **Airspace Restriction/ Reservation Design** – deals with planning consideration for the design of Airspace Restrictions and Reservations and for re-shaping the airspace to accommodate user-preferred trajectories.

Section 4 - **ATS Route/Sector Design** -describes the general criteria used for the development of the European ATS Route Network (ARN) and associated airspace sectorisation, as well as planning consideration for the establishment of Conditional Routes.

[1] *In the context of this manual, "**Airspace Structure**" includes Control Area (CTA), Terminal Control Area (TMA), Control Zone (CTR), ATS Route, ATC Sector, Conditional Route (CDR), Danger Area (D), Restricted Area (R), Prohibited Area (P), Temporary Segregated Area (TSA), Temporary Reserved Area (TRA), Cross-Border Area (CBA), Reduced Co-ordination Airspace (RCA), Prior Co-ordination Airspace (PCA), …*

Section 5 - **Terminal Airspace Design** - provides a methodology and identifies principles associated with Terminal Airspace design.

Section 6 - **Delegation of the Responsibility for ATS Provision** - provides guidance for the Delegation of the Responsibility for Air Traffic Services Provision.

Section 7 - **Free Route Airspace Design** - provides initial guidance material for the design of Free Route Airspace over a group of States.

Section 8 - **Terms and References** - provides a list of acronyms and abbreviations, as well as an explanation of terms and a list of references and source documents used to develop the manual.

2 PURPOSE

2.1 Need for an EUROCONTROL Manual for Airspace Planning

2.1.1 In order to reconcile competing requirements in airspace utilisation between Commercial Aviation (*highest possible protection from other airspace users*), General Aviation & Aerial Work (*maximum freedom in all airspace*) and Military Aviation (*highest possible flexibility, freedom of access to all airspace, protection for special activity and low altitude flying*), airspace design and allocation is often a compromise between all expressed requirements and lead usually to lengthy discussions between the parties concerned. Therefore, in order to ensure more transparency and predictability of airspace management measures, it is necessary to establish within each State objective criteria for the design of airspace.

2.1.2 As identified in the EUROCONTROL Airspace Strategy for the ECAC States, there is now a strong need to evolve to a more collaborative airspace management at international level to ensure harmonisation of airspace organisations between all ECAC States. To that end, it is necessary to first establish an "EUROCONTROL MANUAL FOR AIRSPACE PLANNING", which would provide guidelines and criteria for a uniform airspace design and change process for ECAC States to be mirrored in their own national Airspace Guidance Material.

2.2 Relationship between ICAO and EUROCONTROL Documents

2.2.1 The material contained in this document should be used in conjunction with the provisions specified in ICAO and other EUROCONTROL documents.

2.2.2 The EUROCONTROL Manual for Airspace Planning should not be considered as the substitute for official national regulations in individual ECAC States nor for the ASM Part of the ICAO European Region Air Navigation Plan.

2.2.3 Specifically, States are reminded that by virtue of Article 38 of the *“Convention on International Civil Aviation”,* Contracting States are required to notify ICAO of any differences between their national regulations and practices, and International Standards contained in Annexes to the Convention, and any amendments thereto. ICAO has invited Contracting States to extend such notification to any differences from Recommended Practices contained in the Annexes, when the notification of such differences is important for the safety of air navigation.

2.2.4 Additionally, Annex 15, Chapter 4, 4.1.2 c) and d) specify that national Aeronautical Information Publications shall include a list of significant differences between the national regulations and practices of the State and the related ICAO Standards, Recommended Practices and Procedures given in a form that would enable a user to differentiate readily between the requirements of the State and the related ICAO provisions, and the choice made by a State in each significant case where an alternative course of action is provided for in ICAO Standards, Recommended Practices and Procedures.

2.2.5 Furthermore, attention is drawn to the ICAO publication *“Procedures for Air Navigation Services – Air Traffic Management”* (PANS-ATM), Doc 4444 ATM/501, Chapter 2, Section 2.6, which specifies that the relevant authority designated by the State responsible for providing air traffic services in the airspace concerned shall ensure that a safety assessment is carried out in respect of proposals for :

a. significant airspace reorganisations;

b. significant changes in the provision of ATS procedures applicable to an airspace or an aerodrome; and

c. the introduction of new equipment, systems or facilities.

2.3 Management of the Document

2.3.1 It is anticipated that the Airspace & Navigation Team (ANT) will be responsible for the maintenance of the Planning Manual and for monitoring the progress of its adaptation into national Guidance Material.

2.3.2 As it is intended that this Planning Manual should also reflect, in consolidated form, best practices and collective experience gathered in the field of airspace design, ECAC States, International Users Organisations and ATS Providers, all are encouraged to provide EUROCONTROL with their comments and suggestions for modification and/or extension to cover new aspects of airspace planning.

3 SCOPE

3.1 General

3.1.1 The scope of the EUROCONTROL Manual for Airspace Planning is that which was defined by the EUROCONTROL Airspace Strategy for the ECAC States. It is concerned with the needs of all airspace user groups on a basis of equity. Consequently, an important goal of the common guidelines for airspace design in the ECAC area described in this Planning Manual is to enable equal access to the airspace providing maximum freedom for all users consistent with the required level of safety in the provision of ATM services, while making due allowance for the security and defence needs of individual States.

3.1.2 The evolution of the ECAC airspace structure will follow closely the strategic principles and objectives of the ATM 2000+ Strategy. Due account will be taken of the increasing need for the provision of a seamless ATM service and the associated requirements for the interoperability between civil and military systems.

3.2 Applicability

3.2.1 Material contained in the present Volume 2 should be used as guidance by States in the continued development of their own national airspace planning process and also serve as a basis for bilateral or multilateral discussion with neighbouring States aiming at the harmonisation of their planning activities.

4 SPECIFIC REMARKS RELEVANT TO THE SECOND EDITION

4.1 Complete Edition

4.1.1 This document takes into account existing material and best practices related to ATS Route/Sector Design (Section 4), Terminal Airspace Design (Section 5) and the Delegation of the Responsibility for ATS Provision (Section 6).

4.1.2 It also provides general guidelines for the Establishment of Airspace Structures (Section 1) and details the specific guidelines for Airspace Restriction/Reservation Design (Section 3), as well as the update of guidelines for ATS Airspace Classification (Section 2).

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SECTION 1

GENERAL GUIDELINES FOR THE ESTABLISHMENT OF AIRSPACE STRUCTURES

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SECTION 1

GENERAL GUIDELINES FOR THE ESTABLISHMENT OF AIRSPACE STRUCTURES

1.1 INTRODUCTION

1.1.1 Planning Considerations

1.1.1.1 The "*General Guidelines for the Establishment of Airspace Structures*" have been developed by ECAC Member States on the basis of best practices in use in some States, agreed Flexible Use of Airspace (FUA) principles as stated in the FUA Reference Documents and in accordance with the directions for change identified in the "*EUROCONTROL Airspace Strategy for the ECAC States*".

1.1.1.2 Airspace organisation and management should evolve to a more collaborative function at an international level in order to support the ECAC's collective responsibility for all aspects of planning, design, update, civil/military co-ordination, regulation and airspace legislation.

1.1.1.3 The main objective of airspace management is to maximise the efficient use of airspace whilst maintaining the level of safety applicable to air traffic operations within such airspace. In order to achieve this objective, the airspace structures[2] throughout the ECAC airspace should be based on common criteria with regards to airspace design, lateral and vertical delineation, and designation.

1.1.1.4 Within the context of airspace planning and design, the attention of airspace planners and designers is drawn to the following ICAO and EUROCONTROL safety requirements which are not limited to :

- <u>ATS safety management</u> as per ICAO Annex 11, para 2.26;
- <u>Safety assessments</u> as per ICAO Doc 4444, Chapter 2;
- <u>Guidance to ATM Safety Regulators</u> contained in ESARR 3;
- <u>Risk Assessment and Mitigation in ATM</u> contained in ESARR 4.

1.1.2 Common Guidelines for the Establishment of Airspace Structures

3.3.2.1 As stated in the "*EUROCONTROL Airspace Strategy for the ECAC States*" Document, <u>Volume 2</u> of this Manual provides States with common guidelines for the establishment of airspace structures including general criteria for the design, lateral and vertical delineation and designation of each type of airspace structure.

3.3.2.2 Harmonised application of ICAO provisions for the delineation and classification of ATS airspace and as regards to safety measures relating to military activities including the need for airspace reservation and/or restriction provides the foundation of general guidelines for the establishment of airspace structures within ECAC area.

[2] *In the context of this manual, "**Airspace Structure**" includes Control Area (CTA), Terminal Control Area (TMA), Control Zone (CTR), ATS Route, ATC Sector, Conditional Route (CDR), Danger Area (D), Restricted Area (R), Prohibited Area (P), Temporary Segregated Area (TSA), Temporary Reserved Area (TRA), Cross-Border Area (CBA), Reduced Co-ordination Airspace (RCA), Prior Co-ordination Airspace (PCA), …*

3.3.2.3 A number of essential principles have been developed to provide an integrated approach to the delineation, establishment and use of specific portions of airspace by civil and military users, including sharing of common boundaries between them. Relevant ICAO references are :

- delineation of CTR/CTA and ATS routes : Annexes 4 & 11, PANS-OPS (Doc 8168) Vol. II, Doc 9426 ;
- definition of protected airspace : Annexes 2 & 11, PANS-ATM (Doc 4444);
- establishment of separation minima : PANS-ATM (Doc 4444), Doc 9689 ;
- determination of spacing between ATS routes : Annex 11, Doc 9426 and EUR 001/RNAV/5;
- military activities as regards civil traffic: Principle of '*Due regard for the safety of navigation of civil aircraft'* as per the Chicago Convention (Doc 7300) Art. 3 (d).

3.3.2.4 General Guidelines for the establishment of Controlled Airspace form also part of the present Section 1, whereas specific and detailed guidelines and planning criteria are provided in:

- Section 2 for the harmonisation and simplification of ATS airspace classification;
- Section 3 for the design of airspace restrictions and reservations;
- Section 4 for the design of the ATS Route and Sectorisation; and
- Section 5 for the design of Terminal Airspace.

1.2 PROVISIONS FOR AIRSPACE ORGANISATION

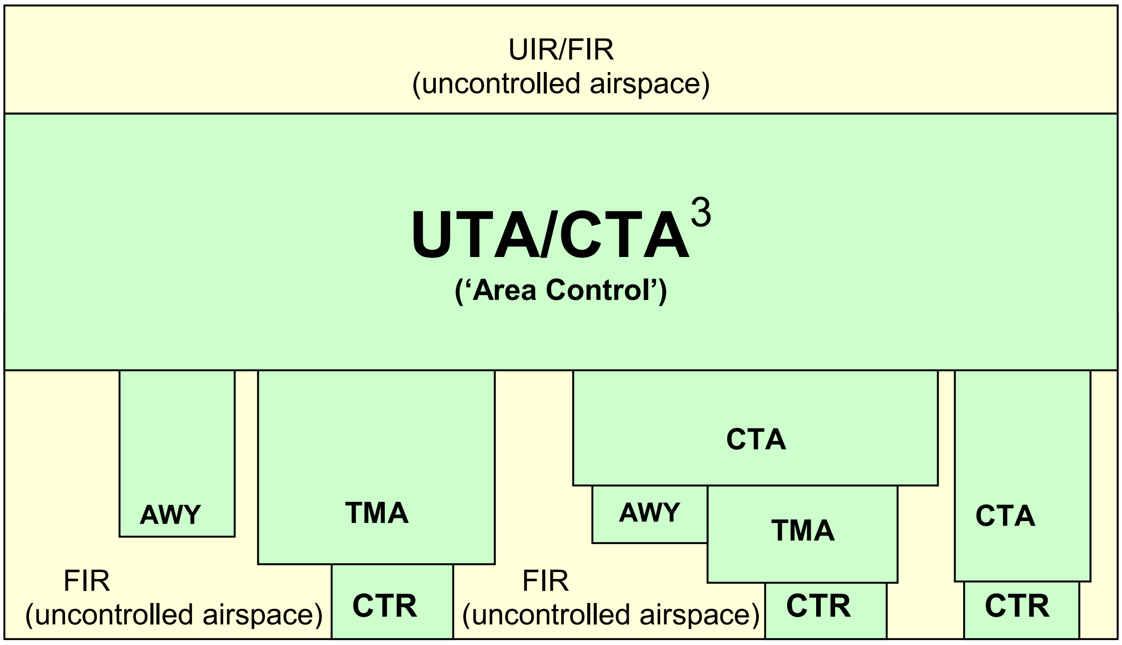
1.2.1 Airspace Organisation for ATS Provision

1.2.1.1 As stated in ICAO Annex 11, when it has been determined that air traffic services will be provided in particular portions of the airspace, then those portions of the airspace shall be designated in relation to the air traffic services that are to be provided, as follows:

- **Flight Information Regions (FIRs)** for those portions of the airspace where it is determined that flight information service and alerting service will be provided - *FIRs shall be delineated to cover the whole of the air route structure to be served by such regions. Such delineation shall be related to the nature of the route and the need for efficient service rather than to national boundaries.*
- **Control Areas (CTAs) and Control Zones (CTRs)** for those portions of the airspace where it is determined that ATC service will be provided to IFR flights - *CTAs including inter alia,* **Airways (AWYs)** *and* **Terminal Control Areas (TMAs)** *shall be delineated so as to encompass sufficient airspace to contain the flight paths of those IFR flights or portions thereof to which it is desired to provide the applicable parts of ATC service, taking into account the capabilities of the navigation aids normally used in that area.*
- **Upper Flight Information Regions (UIRs) and Upper Control Areas (UTAs)** for those portions of the upper airspace where it is desirable to limit the number of FIRs or CTAs through which high flying aircraft would otherwise have to operate - *UIRs or UTAs, as appropriate, shall be delineated to include the upper airspace within the lateral limits of a number of lower FIRs or CTAs.*

1.2.1.2 FIR/UIR boundaries in the ECAC area are determined on the basis of European Regional (EUR) Air Navigation Agreements approved by the Council of ICAO to provide for the least number of such regions compatible with efficiency of service and with economy (see Doc 7754 – EUR Basic ANP – Part VII).

1.2.1.3 Lateral and vertical limits of those portions of the airspace (UTA, CTA[3], AWY, TMA, CTR), where ATC service will be provided are determined by individual States for the territories over which they have jurisdiction. However, ECAC States should establish Controlled Airspace in consistency with the FUA Concept to ensure that unnecessary restrictions are not imposed.



ECAC Airspace Vertical Organisation

1.2.2 Safety Measures relating to Military Activities - Civil/Military Co-ordination

1.2.2.1 ICAO Annex 11, paragraphs 2.15 and 2.16, and more particularly Doc 9554 contain provisions for the co-ordination between the military authorities planning activities potentially hazardous to civil aircraft and the responsible ATS authorities.

1.2.2.2 Within ECAC States, the objective of such civil/military co-ordination is to de-conflict military and civil operations[4] to the effect that they do not constitute a danger for each other.

1.2.2.3 Through the application of the Flexible Use of Airspace (FUA) Concept, the best arrangements will be reached to ensure that military operations are conducted so as to minimise interference with the normal operations of civil aircraft. Ideally, this means the selection of locations outside promulgated ATS routes for the conduct of the potentially hazardous activities.

1.2.2.4 If the temporary closure of certain ATS routes is unavoidable, agreement should be sought by ATS authorities with the State(s) concerned on the temporary use of promulgated alternative routes bypassing the area of activity or, if no convenient promulgated alternative routes exist, on the establishment of temporary routes. Such type of agreement is covered for the ECAC States under the Conditional Route (CDR) Concept (see Section 4).

[3] In the context of this manual, the term CTA is not used as a generic term, but only to designate a control area established in the form of an entire block of airspace with area control arrangements.

[4] This includes Test Flights or any other aerial operations such as gliding, UAV, ballooning, …

1.2.2.5 At present in the ECAC area, compatibility of civil and military operations is mainly governed by national rules which are in accordance with the level of civil/military ATS system inter-operability in place within each State. Regardless of the organisation adopted by the individual States, it has always been necessary to implement co-ordination procedures between civil and military ATS to ensure safe compatibility between Operational Air Traffic (OAT) and General Air Traffic (GAT) operating in the same airspace. Essentially, for the ECAC States, civil and military activities are reconciled either by the means of separating flights through tactical avoidance actions or by temporary segregation of airspace using the Temporary Airspace Allocation (TAA) process (see Section 3).

1.2.2.6 More generally the ICAO Convention states in Article 3(d), that "*the contracting States undertake, when issuing regulations for their state aircraft, that they will have **due regard** for the safety of navigation of civil aircraft*". The effect of the non-applicability of the ICAO Convention to military aviation, as stipulated in Article 3(a), has been, amongst other things, the setting aside of airspace temporarily reserved for the exclusive use of military aircraft within which the Convention has no application.

1.2.2.7 However, the ECAC States have developed and implemented the Flexible Use of Airspace (FUA) Concept within which, when a joint share use of airspace is no longer possible, ECAC States should endeavour to establish either a Temporary Reserved Area (TRA), Temporary Segregated Area (TSA) or an AMC-Manageable Danger or Restricted Area with associated Conditional Routes (CDRs).

1.2.2.8 This situation should occur whenever military aircraft manoeuvres are unpredictable, sensitive to external interference or difficult to alter without adversely affecting the mission and/or when due to the nature of their activities, some military flights need to be temporarily segregated to protect them as well as non-participating aircraft.

1.2.3 Airspace Restriction and Reservation

1.2.3.1 Because of the potential risk to GAT generated by some aerial activities and of the need for the protection of sensitive areas on the ground from possible disturbance by overflight, ECAC States have usually established **Airspace Restrictions** of varying degrees of severity in accordance with the following ICAO definitions:

- **Danger Area (D)** is an airspace of defined dimensions within which activities **dangerous** to the flight of aircraft may exist at specified times;
- **Restricted Area (R)** is an airspace of defined dimensions, above the land area or territorial waters of a State, within which the flight of aircraft is **restricted** in accordance with specific conditions;
- **Prohibited Area (P)** is an airspace of defined dimensions, above the land area or territorial waters of a State, within which the flight of aircraft is **prohibited**.

1.2.3.2 In addition, because of some aerial activities by specific airspace users require the reservation of portions of the airspace for their exclusive use for specific periods of time, several ECAC States had established reserved-type airspace using sometimes quite different procedures.

1.2.3.3 However, ICAO Annex 11, paragraph 2.17.5, recommends that "*in order to provide added airspace capacity and to improve efficiency and flexibility of aircraft operations, States should establish procedures providing for a flexible use of airspace reserved for military or other special activities. The procedures should permit all airspace users to have safe access to such reserved airspace*".

1.2.3.4 As ICAO Doc 9426 provides only a generic definition for **Airspace Reservation** as "*a defined volume of airspace normally under the jurisdiction of one aviation authority and temporarily reserved, by common agreement, for exclusive use by another aviation authority*", the FUA Concept provides, for a common understanding, clear definitions of the two following different types of temporary airspace reservations taking into consideration the activity that would take place associated with the transit possibility (see Section 3):

- **Temporary Reserved Area (TRA)** is a defined volume of airspace normally under the jurisdiction of one aviation authority and **temporarily reserved**, by common agreement, for the specific use by another aviation authority and through which other traffic may be allowed to transit, under ATC clearance.
- **Temporary Segregated Area (TSA)** is a defined volume of airspace normally under the jurisdiction of one aviation authority and **temporarily segregated**, by common agreement, for the exclusive use by another aviation authority and through which other traffic will not be allowed to transit.

Note: Pending results from consultation with ICAO on above definitions, the current TSA definition is maintained i.e.:

"***Temporary Segregated Area (TSA)*** *is an airspace of defined dimensions within which activities require the reservation of airspace for the exclusive use of specific users during a determined period of time".*

1.2.3.5 Restrictions and reservations constitute a limitation to access such airspace by non-participating aircraft, with the associated restrictive effects on flight operations.

1.2.3.6 For the ECAC States, in accordance with Flexible Use of Airspace (FUA) principles, airspace restrictions and reservations should only be applied for limited periods of time and should be terminated as soon as the relevant activity ceases. [see EUROCONTROL Handbook for Airspace Management].

1.3 TERMS ASSOCIATED WITH AIRSPACE DELINEATION

1.3.1 Controlled Airspace

1.3.1.1 ICAO Annex 11, Chapter 2, contains Standards and Recommended Practices (SARPs) regarding the delineation of controlled airspace, including Recommended Practices which address the establishment of lower and upper limits for a control area whilst taking into account both IFR and VFR flights.

1.3.2 Airspace subject to Reservation/Restriction

1.3.2.1 If specific guidelines for the delineation of reserved/restricted airspace do not exist in State publications or legislation, it is recommended that relevant guidelines as contained in this manual be taken into account.

1.3.2.2 When establishing TRAs/TSAs, D or R areas, the boundaries should encompass airspace to contain the activity and ensure that VFR aircraft which are operating on the vertical and/or horizontal limits of the reserved/restricted area are not endangered by the activity within.

1.3.2.3 In addition to establishing ATS Airspace Class C above FL 195, accommodation of various types of 'special' GAT VFR flights above FL 195 will be made in airspace reserved for that purpose (TRAs/TSAs) or in accordance with specific arrangements agreed by the appropriate ATS authority (see Section 2).

1.3.3 Published Limits and Protected Airspace

1.3.3.1 Being three dimensional, airspace structures have to be described in terms of horizontal and vertical dimensions and the limits thereof published in national AIPs will be called "***Published Limits***" (see para. 1.4.7).

1.3.3.2 In order to provide protection between activities in adjacent airspace, a "***Protected Airspace***" should be developed to contain each activity safely within its horizontal and vertical *published limits.*

1.3.3.3 It is recommended to clearly specify assumptions applied when establishing the published limits of any airspace structures. Any such assumptions, particularly with regards to contingencies, should also form part of safety assessment.

Note: *Amongst several criteria in establishing airspace structures, consideration should be given to the availability of radar monitoring. Particular attention should be given when designing cross-border structures.*

1.4 PRINCIPLES FOR THE DESIGN OF AIRSPACE STRUCTURES

1.4.1 General

1.4.1.1 A number of essential principles regarding the delineation of airspace boundaries and conditions of use of any airspace structures are defined below to ensure common understanding and full awareness of all airspace users and ATM providers concerned, whilst avoiding waste of airspace and ensuring safe sharing use of airspace between civil and military operations.

1.4.1.2 These principles should be seen as an integrated approach to the delineation of airspace by adopting a common development process. This approach allows implementation according to the means (procedures and/or system) set in place.

1.4.1.3 As indicated in ICAO Doc 9554, paragraph 6.1, in order that due regard will be given to the safe and efficient operation of civil aircraft, States should ensure that military authorities responsible for the planning and conducting activities potentially hazardous to such aircraft are fully familiar with the area of activity in terms of:

- type(s) of civil aircraft operations;
- ATS airspace organisation and responsible controlling/monitoring unit(s);
- ATS routes and their dimensions, as appropriate; and
- relevant regulations and special rules in force, including airspace restrictions.

1.4.1.4 In these circumstances, it should be stressed that for the delineation of any airspace structures, only the strict application of the essential principles below and in particular the Third Principle will ensure that activity in any airspace volume will not endanger non-participating aircraft flying at or near its published limits.

1.4.1.5 ECAC States should therefore endeavour to reconsider all their airspace organisation using the following essential principles for a common interpretation of rules related to the delineation, establishment and use of specific portions of airspace by civil and military users (see Annex 1A).

1.4.2 Essential Principles

1.4.2.1 First Principle - *Responsible Authorities*

A responsible authority will be determined by each State in regard to:

- ***airspace design;***
- ***type of Air Traffic Service provision; and/or***
- ***any other activity carried out in specified airspace structures.***

- The responsible authority for airspace design should be the permanent high-level policy body in charge of Strategic ASM Level 1 activities (*see Section 3 of the EUROCONTROL Handbook for Airspace Management*).

1.4.2.2 Second Principle – *Design Efficiency*

The dimensions of airspace structures should be established to encompass the absolute minimum airspace necessary to contain operations.

1.4.2.3 Third Principle – *Containment of Operations*

The published limits should contain enough airspace to ensure that activity in that airspace structure will not endanger non-participating aircraft operating at or near its published limits.

1.4.2.4 Fourth Principle – *Protected Airspace*

Airspace structures should be established in such a way that associated protected airspaces do not overlap.

1.4.2.5 Fifth Principle - *Boundaries*

Distinct/individual boundaries should preferably be defined for activities in adjacent airspace. However, where it is necessary to define a common boundary, appropriate measures governing operations in the proximity of the common boundary should be established.

- Letters of Agreement (LoA) are the way in which standard co-ordination procedures between the two parties should be formalised.
- Letters of Agreement should contain normal practices for standard co-ordination and contingency plans for instances when communication between two units is not possible.

1.4.2.6 Sixth Principle - *Published Limits*

The published limits of any airspace structure will be described in accordance with ICAO provisions stated in Annexes 4 & 15 and Doc 8126.

- The published limits refer to the horizontal and vertical dimensions of a defined airspace structure.
- Application of the above for the publication of ATS routes will include:
  - Upper/Lower Limits, as appropriate;
  - Lateral Limits or RNP Type, as appropriate;
  - Significant points; and
  - Magnetic track of the ATS route (*not applicable for RNAV routes*).

1.4.2.7 Seventh Principle – *Rules of Use*

The Responsible Authority bears the obligation for ensuring that rules of use are established, published and complied with for the airspace structure within its area of responsibility.

- Agreement should be established between parties involved to minimise any limitations imposed by rules of operations and/or ATS Procedures for the use of adjacent airspace structures through tactical co-ordination on a flight-by-flight basis, while ensuring the application of required separation minima.

1.4.3 Illustrations of Delineation of Airspace Boundaries

1.4.3.1 The principles (specified in paragraph 1.4.2) to be considered when delineating airspace are illustrated in the following horizontal and vertical diagrams:

Illustration of Horizontal Delineation of Airspace

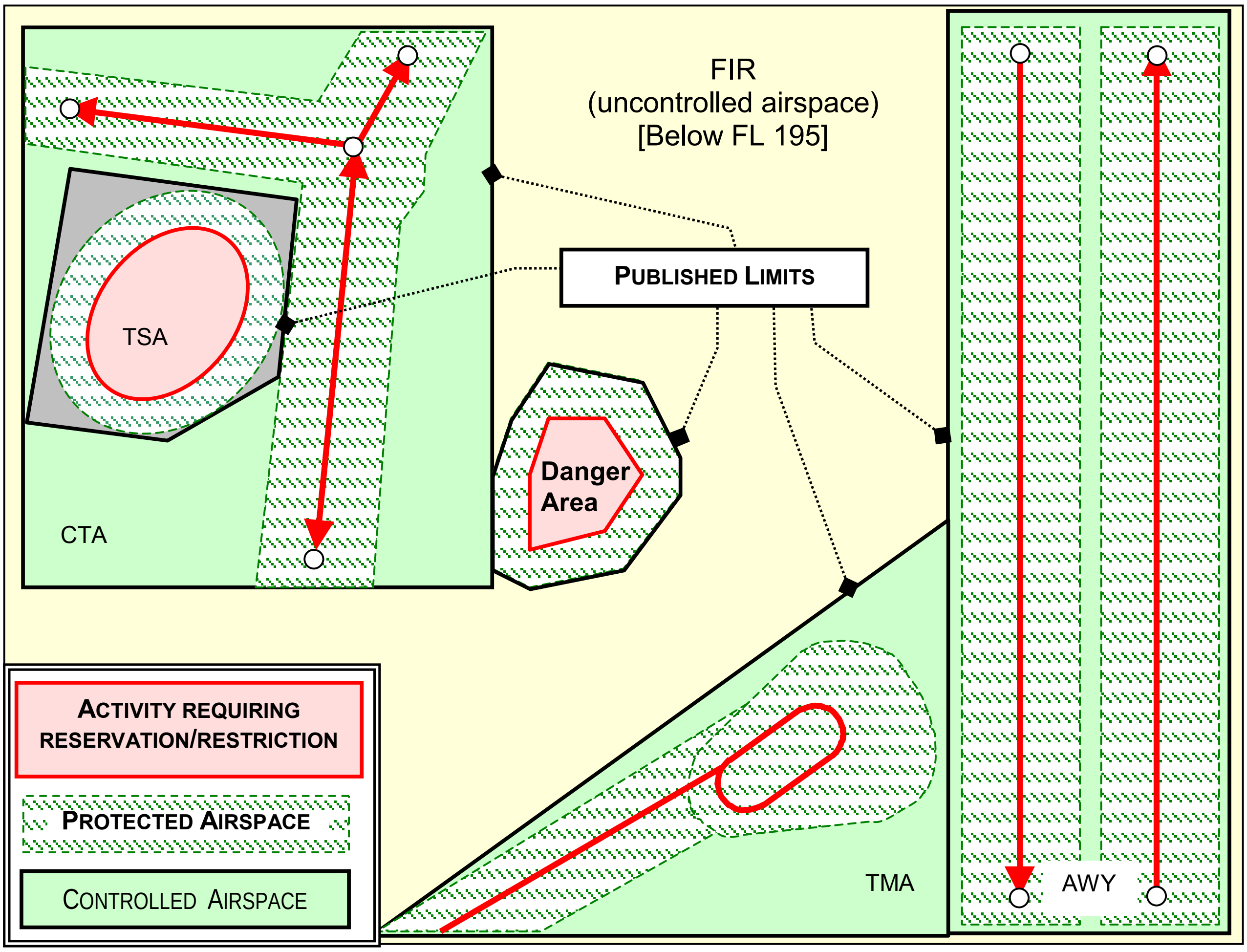
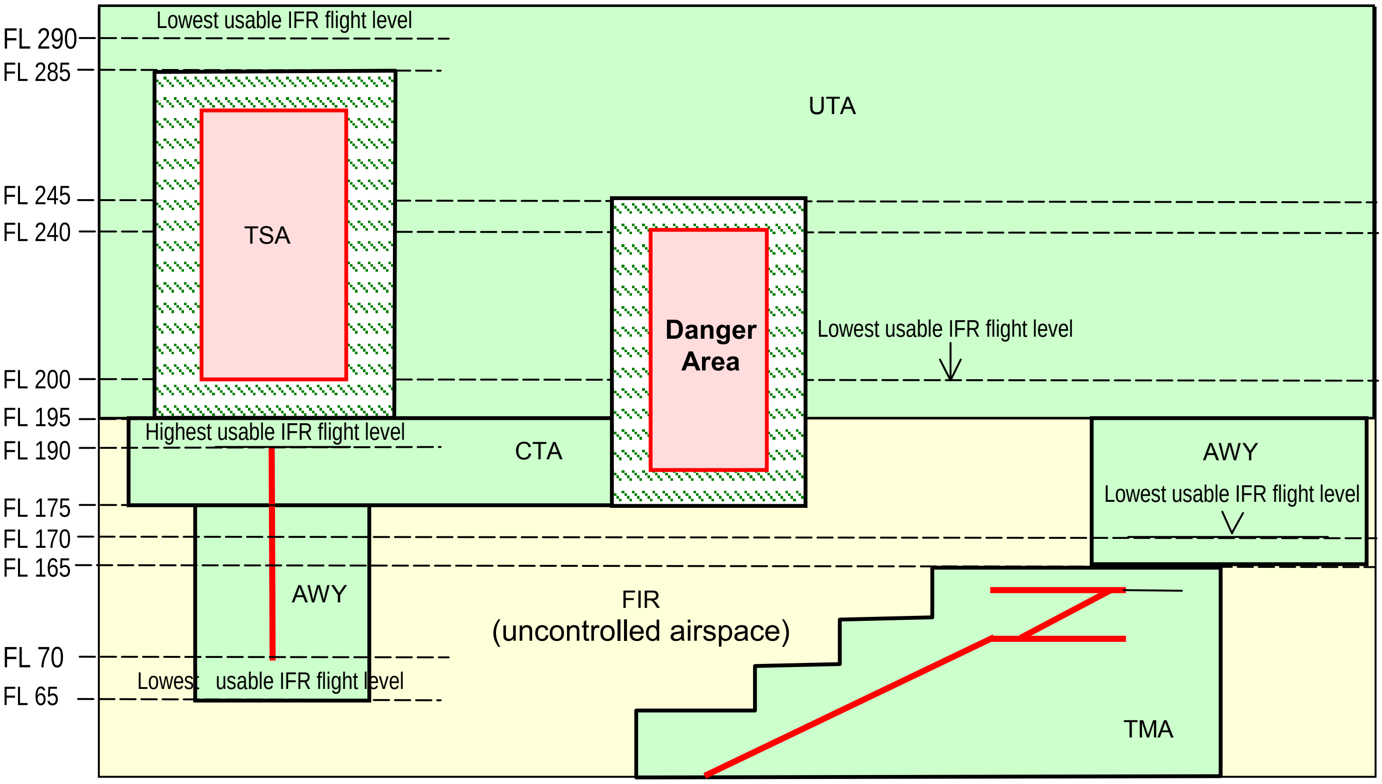


Illustration of Vertical Delineation of Airspace



1.5 COMMON BOUNDARIES

1.5.1 General

1.5.1.1 The essential principles specified in paragraph 1.4.2 and the rules for the establishment of ATS routes, airspace reservations (TAA Concept) and airspace restrictions (P, R, D) need to be combined in such a manner to ensure no waste of airspace. In this regard, common boundaries can be used as the published limits of any adjoining airspace reservations and/or restrictions and controlled airspace, without either infringing safety or requiring additional buffer in between.

1.5.2 Application of Protected Airspace

1.5.2.1 On one hand, airspace structures for potentially dangerous aerial activities need to be established in such a way that State 'Due Regard' obligation is strategically observed. On the other hand, sufficient controlled airspace should be established to encompass the flight paths of the traffic to which it is necessary to provide ATC.

1.5.2.2 ECAC States should endeavour to use the highest level of containment to define the protected airspace around the activities or for an ATS route, for the strategic delineation of airspace reservations or restrictions in close proximity of a RNAV or non-RNAV ATS route.

1.5.3 Definition of Tactical Rules

1.5.3.1 The establishment of a common boundary should always be complemented by tactical rules. These can be part of the national air law and/or take the form of LoAs between units involved. Such rules should be as flexible as possible taking into account the following :

- Efficient airspace design and operation ensuring no waste of airspace;
- Radar vectoring in achieving efficient use of airspace.

1.5.4 Illustrations of Tactical Rules (see Figures A, B and C)

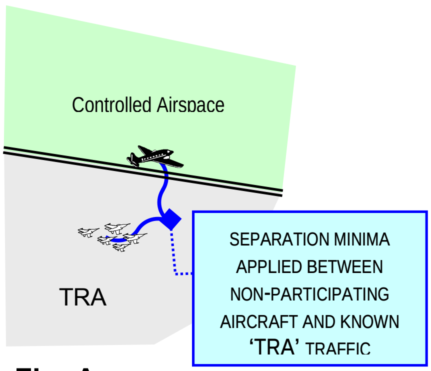


Fig. A

Fig. A applies when a direct controller-to-controller co-ordination is maintained between ATS units involved and a full knowledge of radar-controlled aircraft operating inside the area provided to both controllers.

Procedures should be established providing for the application of prescribed separation minima from known 'area' traffic. This permits non-participating aircraft to safely operate closer to the published limits of a reserved/restricted airspace.

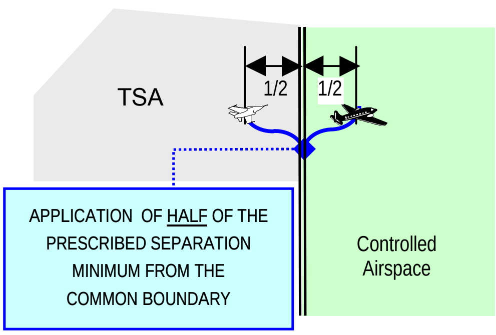


Fig. B

In some instances, when a direct controller-to-controller co-ordination cannot be maintained and/or information on radar-controlled aircraft operating inside the 'TSA' cannot be provided to both controllers, some States have prescribed that separation provision should be distributed equally on both sides of the common boundary as illustrated in **Fig. B.**

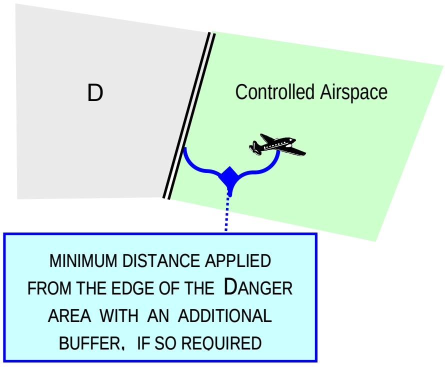


Fig. C

As illustrated in **Fig. C**, when the half of prescribed separation rule specified for Figure B cannot be used, a minimum distance should be applied from the published limits of an active area, including any additional buffer, where applicable.

1.5.5 Safety Assessment

1.5.5.1 When considering such tactical rules, Responsible Authorities should ensure that safety is assured in all circumstances through:

- the conduct of appropriate safety assessments;
- the definition, if required, of specific separation minima depending on the activities conducted in reserved/restricted airspace, with the addition of an adequate buffer;
- the implementation of robust LoAs between civil and military units involved; and
- the promulgation of the first usable IFR levels above/below an area in the definition of associated ATS routes, as appropriate.

1.5.5.2 ICAO Annex 11, paragraph 2.16.3, recommends that "*Arrangements shall be made to permit information relevant to the safe and expeditious conduct of flights of civil aircraft to be promptly exchanged between air traffic services units and appropriate military units”*.

Annex 1A

PRINCIPLES
FOR THE DESIGN OF AIRSPACE STRUCTURES

1st RESPONSIBLE AUTHORITIES	***A responsible authority will be determined by each State in regard to:*** ♦ ***airspace design;*** ♦ ***type of Air Traffic Service provision; and/or*** ♦ ***any other activity carried out in specified airspace structures.***
2nd DESIGN EFFICIENCY	***The dimensions of airspace structures should be established to encompass the absolute minimum airspace necessary to contain operations.***
3rd CONTAINMENT OF OPERATIONS	***The published limits should contain enough airspace to ensure that activity in that airspace structure will not endanger non-participating aircraft operating at or near its published limits.***
4th PROTECTED AIRSPACE	***Airspace structures should be established in such a way that associated protected airspaces do not overlap.***
5th BOUNDARIES	***Distinct/individual boundaries should preferably be defined for activities in adjacent airspace. However, where it is necessary to define a common boundary, appropriate measures governing operations in the proximity of the common boundary should be established.***
6th PUBLISHED LIMITS	***The published limits of any airspace structure will be described in accordance with ICAO provisions stated in Annexes 4 & 15 and Doc 8126.***
7th RULES OF USE	***The Responsible Authority bears the obligation for ensuring that rules of use are established, published and complied with for the airspace structure within its area of responsibility.***

SECTION 1

GENERAL GUIDELINES FOR THE ESTABLISHMENT OF AIRSPACE STRUCTURES

FINAL PAGE

SUGGESTION - COMMENTS

To report any errors, or to propose a modification to the present Section 1 "General Guidelines for the Establishment of Airspace structures", please contact:

Mr Jean-Paul Lemaire
EUROCONTROL
Airspace & Flow Management and Navigation Business Division (AFN)
Rue de la Fusée, 96
B-1130 BRUSSELS
(E-mail: jean-paul.lemaire@eurocontrol.int)

SECTION 1 - SPONSOR: AIRSPACE MANAGEMENT SUB-GROUP

Whenever material received, in accordance with the above procedure, makes it apparent that an amendment of the present Section 1 is required, such amendment will be first discussed within the Airspace Management Sub-Group (ASM-SG) and then circulated for consideration by the Route Network Development Sub-Group (RNDSG) and the ATM Procedures Development Sub-Group (APDSG) before its adoption by the Airspace & Navigation Team (ANT).

PUBLICATION OF AMENDMENT

The agreed amendment will then be issued by EUROCONTROL in the form most convenient for its insertion in the Planning Manual.

SECTION 2

GUIDELINES FOR ATS AIRSPACE CLASSIFICATION

SECTION CHECKLIST

Page	Edition Amendment	Date
Section 2		
2-0	Amendment 1	17/01/05
2-1	Edition 2.0	22/10/03
2-2	Edition 2.0	22/10/03
2-3	Edition 2.0	22/10/03
2-4	Edition 2.0	22/10/03
2-5	Edition 2.0	22/10/03
2-6	Edition 2.0	22/10/03
2-7	Edition 2.0	22/10/03
2-8	Edition 2.0	22/10/03
2-9	Edition 2.0	22/10/03
2-10	Edition 2.0	22/10/03
2-11	Edition 2.0	22/10/03
2-12	Edition 2.0	22/10/03
2-13	Edition 2.0	22/10/03
2-14	Edition 2.0	22/10/03

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SECTION 2

GUIDELINES FOR ATS AIRSPACE CLASSIFICATION

2.1 INTRODUCTION

2.1.1 Backdrop

2.1.1.1 The initial goal of ICAO in implementing, in 1992, a new ATS Airspace Classification[1] was to simplify the designation of airspace and to standardise equipment and pilot requirements for IFR and VFR operations. The purpose was to eliminate the confusion between the characteristics of CTA, CTR, TMA and ATZ airspaces and to clarify the services provided to IFR and VFR flights in each class of airspace.

2.1.2 Current ICAO Requirements for Classification of ATS Airspace

2.1.2.1 According to ICAO Annex 11 - 2.5, when it has been determined that air traffic services are to be provided in a particular portion of airspace or in airspace associated with particular aerodromes, then those portions of the airspace shall be designated in relation to the air traffic services that are to be provided.

2.1.2.2 Airspace shall be classified and designated in accordance with the seven classes - A to G, defined in ICAO Annex 11 - 2.6. The requirements for flights within each class of airspace are defined in ICAO Annex 11 - Appendix 4, in terms of the type of flight allowed, the separation provided, the services provided, meteorological conditions, speed limitations, radio communication requirements and the ATC clearance required.

2.1.2.3 States shall select those airspace classes appropriate to their needs from the least restrictive Class G to the most restrictive Class A.

2.1.3 Differences Notified to ICAO

2.1.3.1 These ICAO provisions were interpreted in different ways by the ECAC States to best meet their own national requirements. Some States have therefore notified differences between their national regulations and practices and the corresponding International SARPS to ICAO. Other States have not yet introduced ICAO Airspace Classes.

2.1.3.2 Some ECAC States authorise VFR flights above FL 195, either by establishing Class B or C airspace, or by allowing VFR flights in Class A in accordance with specific conditions and/or with special ATC instructions. Some States relieve IFR flights from mandatory requirements for continuous two-way radio communication in Classes F & G. Other States do not permit IFR flights in Class G. Another State requires ATC clearances for IFR flights to operate in Class F airspace.

2.1.3.3 Most of the States have adapted VMC minima to their national conditions. Some States provide an ATC service to VFR flights or at least separation from IFR traffic.

[1] Reference: Third Meeting of the Visual Flight Rules Operations Panel [VFOP] (1986)

2.1.4 Need for a Simplified and Harmonised Airspace Organisation

2.1.4.1 The EUROCONTROL Airspace Strategy for the ECAC States has, accordingly, identified a lack of harmonisation in the current application of ICAO ATS Airspace Classes by the ECAC States.

2.1.4.2 Therefore, the Airspace Strategy calls for a uniform application of these Classes appropriate for the traffic operating in the airspace in order to avoid over and under classification. In addition, classifications should be as simple as possible and should also permit unambiguous rules and safe flight operations.

2.1.4.3 Direction for Change A of the Airspace Strategy identifies the strategic steps towards a simplified airspace organisation based on the proposed Traffic Environment Models N, K, and U. The first of 5 steps - Operational Improvement 1A (OI-1A), refers to the harmonisation of the existing ICAO airspace classifications in ECAC airspace starting with the common classification of the airspace above a common agreed level. The second step - OI-2A, refers to the simplification and harmonisation of the remainder of ECAC airspace to the surface.

2.2 AIR TRAFFIC SERVICES REQUIREMENTS

2.2.1 Requirements for Civil ATS Provision

2.2.1.1 To cope with the continuing increase in IFR traffic, ECAC States have progressively reduced the use of non-radar procedures by the introduction of appropriate radar and communications systems with a sufficient level of automation so as to improve ATC capacity and efficiency whilst at the same time enhancing safety.

2.2.1.2 Functional compatibility of the data exchanged between the airborne and the ground elements is essential to ensure the efficiency of the overall ATM system. An air traffic control unit should, therefore, be provided with information on the intended movement of the aircraft, or variations therefrom, and with current information on actual progress of the aircraft, so as to determine from the information received, the relative position of known aircraft to each other.

2.2.1.3 In order to meet the aspirations of the users of the airspace in the context of enhancing the flexibility of operations, whilst maintaining a safe and orderly flow of air traffic, the organisation of the airspace will need to evolve to an airspace structure based on the knowledge of traffic. The level of control will then be determined by the complexity of the traffic situation rather than on the current system of airspace classifications.

2.2.2 Requirements for Military ATS Provision

2.2.2.1 Military flying operations constitute a significant and important proportion of total airspace use. Therefore, the military authorities of some ECAC States have established their own "Operational Air Traffic" (OAT) Services in parallel with the "General Air Traffic" (GAT) Services in order to provide for their specialised operations such as air combat training, low-level missions, in-flight refuelling and high-energy flying activities which are incompatible with the normal application of the ICAO Rules of the air and air traffic services procedures.

2.2.2.2 As the co-existence of civil and military ATS systems has, in many cases, resulted in competition and an inefficient use of airspace, some States have decided to create an integrated ATS system to provide for both the civil and military needs. Experience gained by these States indicates that this solution offers promising results regarding the equitable and efficient sharing of airspace.

2.3 COMMERCIAL AIR TRANSPORT REQUIREMENTS

2.3.1 General Requirements

2.3.1.1 In respect of airspace organisation, the airline community seeks:

- Seamless services within airspace considered as a continuum;
- Simple and unambiguous rules, easy to implement and to follow;
- Freedom of movement to follow preferred and flexible flight profiles with minimum constraints;
- Pan-European harmonisation of airspace structure and legislation;
- Upper/Lower Airspace classification should be harmonised as soon as possible in order to enable the traffic to be operated within the airspace of a European network.

2.3.2 Requirement for a Clear Notification of Separation Responsibility

2.3.2.1 One of the critical issues identified with the lack of a harmonised application of ICAO ATS Airspace Classes is the limited awareness of aircrews regarding airspace classification. This results in confusion about the services offered and a lack of knowledge of the responsibility for separation, particularly at the lower levels, where the airspace classification is most varied throughout ECAC airspace.

2.3.2.2 For example, with radar services provided for the greater part of a flight throughout Europe, the flight crews operating on an IFR flight plan tend to assume that separation from all other traffic is always provided by ATC regardless of the class of airspace in which they are operating.

2.3.2.3 Because the safety of commercial air transport is of paramount importance, active control with separation of aircraft assured by ATC should be the rule for normal IFR operations.

2.4 MILITARY OPERATIONS REQUIREMENTS

2.4.1 General Requirements

2.4.1.1 Security in Europe may necessitate military operations undertaken by international organisations: UN, NATO or WEU, and for military aircraft to take precedence over civil aviation in some circumstances. It is, therefore, a fundamental principle that each ECAC State is able to train and operate its military air, sea and ground forces to enable them to discharge their responsibilities for security and defence. In order to carry out its operational tasks, military aviation seeks:

- freedom to operate in IMC/VMC at any time in all areas of ECAC airspace;
- special handling - in particular for priority flights and for time-critical missions, but also for military aircraft not fully equipped to the civil standard;
- to retain the possibility of operating uncontrolled VFR flights, including in "Controlled" airspace;
- temporary airspace reservations (TSAs), to contain activities which are incompatible with the normal application of the Rules of the Air;
- airspace restrictions for non flight-related activities such as protection of areas of national interest, gunnery, missile firing, etc....

2.5 GENERAL AVIATION & AERIAL WORK OPERATIONS REQUIREMENTS

2.5.1 General Requirements

2.5.1.1 General Aviation (GA) requires access to controlled airspace and airports at reasonable commercial cost. Where this activity increases it is likely to be largely centred on less congested airports. Aerial Work (AW) aviation needs to reserve airspace for particular operations, while recreation and sports aviation operating under VFR require a legitimate right of access to European airspace, although it may not be possible to fit to such aircraft the equipment required for flight in Controlled Airspace.

2.5.1.2 Although the majority of GA/AW flights operate in "Lower" Airspace under VFR rules, a sizeable amount (more than 10%) is IFR traffic. Therefore, the General Aviation & Aerial Work community seeks:

- to achieve maximum freedom of movement in all categories/classes of airspace;
- sufficient "Uncontrolled" airspace for its operations and VFR access to "Controlled" airspace, in particular for some gliders in the "Upper" Airspace;
- to maintain the right to change flight rules from IFR to VFR and vice-versa in the air, as well as before take-off or, at least, to receive special handling;
- to have the possibility of operating under VFR as long as weather conditions permit the application of the "see and avoid" rule.

2.6 TEST FLIGHTS & UAV OPERATIONS REQUIREMENTS

2.6.1 General Requirements

2.6.1.1 Test and Acceptance Flights for both civil and military purposes require special handling, but represent a relatively small airspace user community. The use of Uninhabited Aerial Vehicles (UAVs), formerly developed for military operations and recreation (model flying), has recently been extended to various civil aerial applications as a more cost effective solution than the use of conventional aircraft or helicopters.

2.6.1.2 No uniform regulatory framework for UAVs exists today, but it could be assumed that the Test Flights & UAVs community seeks mainly:

- accommodation of their operations, based on shared use of airspace, with sometimes a need for special handling, rather than on strict segregation;
- possibility of operating in the "Upper" Airspace;
- definition of standards for additional equipment capabilities so that UAVs can be designed to achieve compatibility with the airspace they are expected to operate in.

2.7 LIST OF POTENTIAL CRITERIA TO ESTABLISH CLASSIFICATION

2.7.1 General

2.7.1.1 In the course of the evolution of ECAC airspace towards a simplified organisation, as identified in Direction for Change A of the EUROCONTROL Airspace Strategy for the ECAC States, the different ATS Classes available for airspace classification will be limited to those defined in the harmonisation process in force at the time of publication of the present Edition/Amendment of the Planning Manual.

2.7.1.2 Until the harmonisation process is completed, where a choice of airspace classification still exists and as a result of the number of elements involved, it has not been possible to develop specific criteria to determine how to classify the airspace in a given area or at a given location. However, taking into account best practices in use in some ECAC States, the following decision-making criteria could be considered :

- Level of Air Traffic Services to be provided;
- Air safety-relevant incidents;
- IFR traffic volume;
- Mixed environment (IFR/VFR flights, different speeds and/or types of aircraft,...);
- Traffic concentration - Environmental Constraints;
- Particular operations (Military, GA, Test Flights, Aerial Work, Gliders, UAV,...);
- Meteorological conditions - Daylight/Night Operations;
- Flight Planning Issues;
- Cost-Benefit Analysis (Staff training, mandatory equipment, user charges,..)
- Principles or criteria already established for harmonised airspace.

2.7.2 Level of Air Traffic Services To Be Provided

2.7.2.1 Essentially, when the number and frequency of IFR flights have reached a level where the responsibility for the arrangements to maintain a safe and expeditious flow of traffic can no longer be left to the discretion of individual pilots, the provision of Air Traffic Control (ATC) will be required. This should apply in particular when IFR operations of a commercial nature are conducted.

2.7.2.2 The planning for, and the execution of, ATC is essentially a national responsibility. However situations may arise where States will be required to improve their services, not because there is an urgent national requirement to do so, but in order to ensure that the efforts of adjacent States to improve their ATS are not compromised.

2.7.2.3 It is, therefore, of prime importance that both the planning and execution of ATC is conducted in a manner that ensures that optimum uniformity is maintained to the greatest degree possible. Thus, the delineation of airspace, wherein ATC is to be provided, should be related to the nature of the route structure and/or the containment of IFR flight paths and the need for an efficient service rather than observing national boundaries (see Section 1).

2.7.3 Air Safety-Relevant Incidents

2.7.3.1 Even though the airspace classification should be established mainly as an enabling measure to facilitate the separation of aircraft by ATC, a local concentration of Air Safety-Relevant Incidents will require an immediate overall situational analysis which might lead to a change of classification of the airspace concerned.

2.7.4 IFR Traffic Volume

2.7.4.1 Categorisation of airspace surrounding aerodromes is mainly influenced by the volume of IFR traffic to be handled. As the number of IFR movements at an aerodrome increases, the necessity to protect IFR operations from other traffic by the implementation of a more restrictive ATS Class may be appropriate.

2.7.4.2 Change in airspace classification would therefore be considered primarily on the basis of the IFR traffic figures and trends registered over previous years and forecast increases or decreases at a given aerodrome. To that end, in order to simplify airspace organisation, modular airspace structures with a limited number of ATS Classes, in accordance with the Airspace Strategy, would be assigned to different categories of aerodromes in accordance with their annual IFR traffic volume.

2.7.5 Mixed Environment

2.7.5.1 A mixture of different types of air traffic (IFR/VFR) with aircraft of various speeds (light, conventional, jet, etc...) necessitates the provision of more advanced air traffic services and the establishment of a more restrictive class of airspace than, for example, the handling of a relatively greater density of traffic where only one type of operation is concerned.

2.7.5.2 Therefore, qualitative data on issues related to the handling of a mixture of traffic should be gathered to assess the best classification for a given block of airspace. The following parameters should be considered:

- the proportion of jet and/or heavy aircraft
- the amount and type of VFR operations
- training activities

2.7.6 Traffic Concentration - Environmental Constraints

2.7.6.1 Areas of intense activity, flight paths of both IFR and VFR traffic, traffic flows (*uni-, bi- or multi-diectional*), the relative situation of aerodromes in the vicinity, the proximity of big cities, etc... are other qualitative criteria which may influence the choice of an ATS Class in order to ensure the degree of control required to manage the situation.

2.7.7 Particular Operations

2.7.7.1 In determining an ATS Class appropriate to the main user of a block of airspace, care should be taken that unnecessary restrictions are not imposed on other traffic such as Military, General Aviation, Test Flights, Aerial Work, Gliders and/or UAV that wish to operate in this airspace.

2.7.8 Meteorological Conditions - Daylight/Night Operations

2.7.8.1 Meteorological conditions and/or Daylight/Night operations might have a substantial effect on the airspace classification of areas where there is a regular flow of IFR traffic, whereas similar or worse conditions might be less important for the classification of an area where such conditions would suspend the normal VFR traffic.

2.7.8.2 Most of the ECAC States have therefore adapted VMC minima to their prevailing national weather conditions. However, in view of the simplification and harmonisation of ATS Classification in Europe, adoption of common VMC minima for the entire ECAC region should be sought.

2.7.9 Flight Planning Issues

2.7.9.1 The flight plan is currently the only way by which the pilots/operators inform ATS of their intended operations and formally request air traffic services. From the flight plan ATS derives all the information of operational significance regarding the intended flight, such as equipment carried, route to be flown, requested flight level(s), departure/destination aerodrome, etc...

2.7.9.2 When it becomes necessary for ATC to have available all of this information on each individual aircraft operating within a given volume of airspace, a change in airspace classification may be required in order that the mandatory filing of flight plans is established.

2.7.10 Cost-Benefit Analysis

2.7.10.1 Change in airspace classification may have an impact on the numbers and training of qualified personnel (pilots & controllers), such factors require advance planning and therefore consideration during the decision-making process.

2.7.10.2 Change in airspace classification may also require the provision of additional facilities, especially for communication, navigation and surveillance.

2.7.10.3 Changes in airspace classification may, therefore, require a comprehensive Cost-Benefit Analysis.

2.8 GUIDANCE FOR ORGANISING THE "UPPER" PART OF ECAC AIRSPACE

2.8.1 Common Classification Above a Common Agreed Level

2.8.1.1 Within ECAC Airspace, the types and density of traffic above FL 195 require the provision of common procedures by ATC.

2.8.1.2 An ATS Route Network (ARN) has thus been established in ECAC Airspace, under the auspices of the EUROCONTROL Airspace & Navigation Team (ANT), for the purpose of flight planning and which facilitates the organisation of an orderly traffic flow by the Central Flow Management Unit (CFMU) (*see* Section 4).

2.8.1.3 Area control arrangements in place in most of ECAC States have the advantage that whenever traffic conditions and military activities permit, ATC may authorise specific flights under its control to deviate from the established route structure and to follow a more direct flight path or to fly in parallel with other flights without aircraft leaving controlled airspace and thus losing the benefit of ATC (see Section 1).

2.8.1.4 ECAC States have commonly agreed to provide, as from **27 November 2003**, an area control service in the entire ECAC airspace ***above FL 195 in ATS Class C***.

2.8.2 Common Process for ATS Airspace Classification above FL 195

2.8.2.1 ECAC States should designate the authority responsible for providing ATC services within the corresponding block of airspace under their sovereignty and for the territories over which they have jurisdiction.

2.8.2.2 In order to ensure a common ATS airspace classification within ECAC Airspace above FL 195 in accordance with the Airspace Strategy, ECAC States are required to ensure that the airspace above FL 195 and its associated traffic handling comply with the general agreements set out in paragraph 2.8.1.4. To that end, ECAC States will:

- enact this international agreement in corresponding national Regulations and/or Decrees;
- update accordingly their national AIP.

2.8.3 Common Conditions for VFR Access to Class C Airspace above FL 195

2.8.3.1 In addition to establishing Class C airspace as the ATS Airspace Class to be applied throughout ECAC airspace above FL 195, it will be necessary to introduce harmonised rules for access to this airspace by GAT traffic that may seek to fly en-route under VFR. Safety and airspace capacity considerations, and the understanding that there is almost no requirement for en-route GAT VFR flight above FL 195, require a general rule to be formulated:

- En-route GAT VFR flights above FL 195 will not be permitted.

However, there are various types of "special" GAT flight that will have to be accommodated, accordingly the general rule is amplified thus:

- GAT VFR flights above FL 195 and up to and including FL 285 will only be authorised in:
  - An airspace reservation [Temporary Segregated Airspace (TSA) or its equivalent] or
  - In accordance with specific arrangements agreed by the appropriate ATS authority
- GAT VFR flights above FL 285, within RVSM airspace, must be contained within:
  - An airspace reservation (TSA or its equivalent)

2.9 GUIDANCE FOR ORGANISING THE "MIDDLE" PART OF ECAC AIRSPACE

2.9.1 Need for a Known Traffic Environment above a common division level

2.9.1.1 TBD

2.9.2 Classification of a System of ATS Routes

2.9.2.1 TBD

2.9.3 Classification of a Control Area (CTA/TMA)

2.9.3.1 TBD

2.9.4 Special Handling of Particular Operations

2.9.4.1 TBD

2.9.5 Common Process for ATS Airspace Classification in "Middle" Airspace

2.9.5.1 TBD

2.10 GUIDANCE FOR ORGANISING THE "LOWER" PART OF ECAC AIRSPACE

2.10.1 Categorisation of Airspace Surrounding Aerodromes

2.10.1.1 TBD

2.10.2 Evaluation of VFR/IFR Traffic Mix and Concentration

2.10.2.1 TBD

2.10.3 Impact of Daylight/Night Operations and/or Weather Conditions

2.10.3.1 TBD

2.10.4 Classification of Terminal Airspace

2.10.4.1 TBD

2.10.5 Special Handling of Particular Operations

2.10.5.1 TBD

2.10.6 Common Process for ATS Airspace Classification in "Lower" Airspace

2.10.6.1 TBD

2.11 RATIONALISATION OF ATS AIRSPACE CLASSIFICATION TOWARDS TRAFFIC ENVIRONMENT MODEL - (see ANNEX 2A) -

2.11.1 Concept of iNtended Traffic Environment (Category N)

2.11.1.1 TBD

2.11.2 Concept of Known Traffic Environment (Category K)

2.11.2.1 TBD

2.11.3 Concept of Unknown Traffic Environment (Category U)

2.11.3.1 TBD

2.11.4 Separation Responsibility (ATC or Visual)

2.11.4.1 TBD

2.11.5 ATS Provision

2.11.5.1 TBD

2.11.6 Common Differences Notified to ICAO

2.11.6.1 TBD

2.11.7 Common Process for Airspace Categorisation in N, K, U

2.11.7.1 TBD

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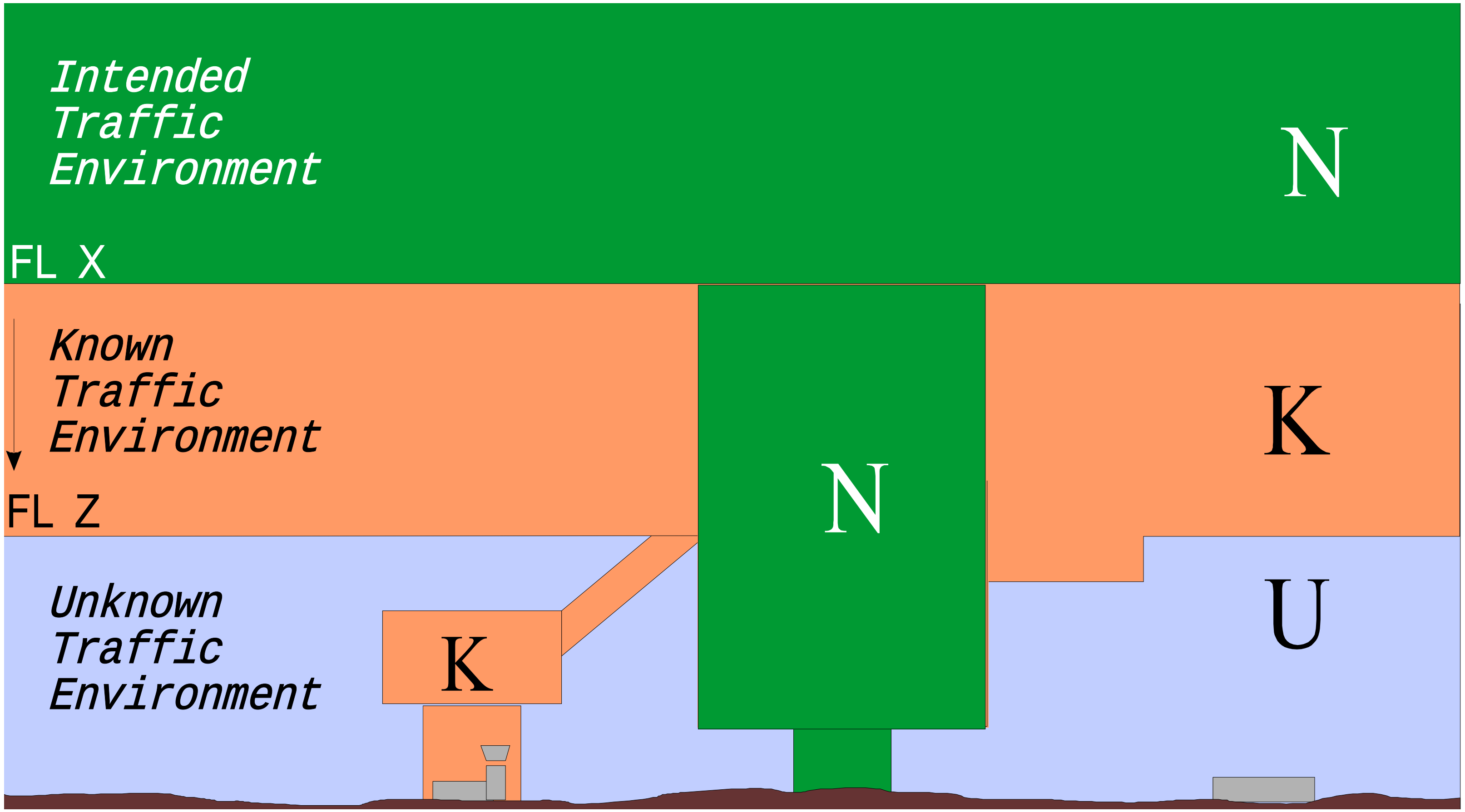
Annex 2A

RATIONALISATION OF ATS AIRSPACE CLASSIFICATION



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SECTION 2

GUIDELINES FOR ATS AIRSPACE CLASSIFICATION

FINAL PAGE

SUGGESTION - COMMENTS

To report any errors, or to propose a modification to the present Section 2 "Guidelines for ATS Airspace Classification", please contact:

Mr Bill Armit
EUROCONTROL
Airspace & Flow Management and Navigation Business Division (AFN)
Rue de la Fusée, 96
B-1130 BRUSSELS
(E-mail: bill.armit@eurocontrol.int)

SECTION 2 - SPONSOR: AIRSPACE MANAGEMENT SUB-GROUP

Whenever material received, in accordance with the above procedure, makes it apparent that an amendment of the present Section 2 is required, such amendment will be first discussed within the Airspace Management Sub-Group (ASM-SG) before its adoption by the Airspace & Navigation Team (ANT).

PUBLICATION OF AMENDMENT

The agreed amendment will then be issued by EUROCONTROL in the form most convenient for its insertion in the Planning Manual.

SECTION 3

AIRSPACE RESTRICTIONS & RESERVATIONS DESIGN

SECTION CHECKLIST

Page	Edition Amendment	Date
Section 3		
3-0	Amendment 1	17/01/05
3-1	Edition 2.0	22/10/03
3-2	Edition 2.0	22/10/03
3-3	Edition 2.0	22/10/03
3-4	Edition 2.0	22/10/03
3-5	Edition 2.0	22/10/03
3-6	Edition 2.0	22/10/03
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3-8	Edition 2.0	22/10/03
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3-12	Edition 2.0	22/10/03
3-13	Edition 2.0	22/10/03
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3-15	Edition 2.0	22/10/03
3-16	Edition 2.0	22/10/03
3-17	Edition 2.0	22/10/03
3-18	Edition 2.0	22/10/03
3-19	Edition 2.0	22/10/03
3-20	Edition 2.0	22/10/03

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SECTION 3

AIRSPACE RESTRICTIONS & RESERVATIONS DESIGN

3.1 INTRODUCTION

3.1.1 Flexible Use of Airspace Concept

3.1.1.1 The Concept of the Flexible Use of Airspace (FUA) endorsed at MATSE/4 in June 1994 and supported by the European Parliament on 27 September 1994 has been gradually implemented in the ECAC States as from the **28th March 1996**.

3.1.1.2 The basis for the FUA Concept is that airspace should no longer be designated as either military or civil airspace, but should be considered as one continuum and used flexibly on a day-to-day basis. Consequently, any necessary airspace reservation or segregation should be only of a temporary nature.

3.1.1.3 A more effective sharing of ECAC airspace and efficient use of airspace by civil and military users stemming from the application of the FUA Concept is realised through joint civil/military strategic planning and pre-tactical airspace allocation.

3.1.1.4 Airspace Management (ASM) procedures at the three levels; Strategic ASM Level 1, Pre-Tactical ASM Level 2 and Tactical ASM Level 3 are described in the EUROCONTROL Handbook for Airspace Management, whereas general guidelines for the establishment of airspace structures can be found in the Section 1 and planning considerations for ATS routes design including Conditional Routes (CDRs) in the Section 4 and for airspace restrictions and reservations design in the present Section 3.

3.1.2 Flexible Airspace Structures

3.1.2.1 The FUA Concept uses airspace structures that are particularly suited for temporary allocation and/or utilisation.

3.1.2.2 The different airspace structures; Conditional Routes (CDRs), Temporary Segregated Areas, (TSAs), Temporary Reserved Areas (TRAs), Cross-Border Areas (CBAs) or those Danger or Restricted Areas (D, R) subject to pre-tactical or tactical allocation under the Temporary Airspace Allocation (TAA) process, as well as Reduced Co-ordination Airspace (RCA) or Prior Co-ordination Airspace (PCA) procedures used for flexible airspace management are detailed hereafter.

3.1.2.3 In addition the present Section 3 provides elements for the information on any other activities of particular nature or for re-shaping the airspace to accommodate user-preferred trajectories for vectoring and in the future, free routing and/or autonomous operations.

3.1.3 National High-Level Policy Body Functions

3.1.3.1 In accordance with FUA principles, Strategic ASM at Level 1 consists of a joint civil and military process, within the high-level civil/military national body which formulates the national ASM policy and carries out the necessary strategic planning work, taking into account national and international airspace users requirements.

3.1.3.2 The permanent "National High-Level Policy Body" is required to establish a joint civil and military process to perform the following minimum functions:

a) formulate the national policy for airspace management;
b) reassess periodically the national airspace structures including ATS routes (see Section 4) and Terminal Airspace (see Section 5) with the aim of planning, as far as possible, for flexible airspace structures and procedures;
c) validate activities requiring airspace segregation and assess the level of risk for other airspace users;
d) plan the establishment of flexible airspace arrangements (CDRs, TSAs, CBAs, RCAs, PCAs, ..) and conduct, if required, associated safety assessment;
e) change or modify, if required and if practicable, Danger and Restricted Areas into temporary allocated airspace;
f) establish controlled airspace and ATS airspace classifications (see Section 2) taking into account the FUA concept;
g) publish in national AIP the airspace structures including ATS routes and ATS airspace under its jurisdiction;
h) co-ordinate major events planned long before the day of operation, such as large scale military exercises, which require additional segregated or reserved airspace, and notify these activities by AIS-publication;
i) periodically review the national airspace needs and, where applicable, cross-border airspace utilisation.

3.1.4 Need for National Airspace Planning Arrangements for Change Process

3.1.4.1 In order to ensure that airspace is utilised in a safe and efficient manner and that in the near future, a co-ordination process for airspace planning between neighbouring States will be properly set-up, there is a need first that all ECAC States establish formerly National Airspace Planning Arrangements.

3.1.4.2 Such National Airspace Planning Arrangements should clearly establish policies for the effective allocation and use of airspace and its supporting infrastructure and should define the process and responsibilities to ensure that proposed changes to airspace are initiated, considered, refined, approved and finally implemented in a safe and effective manner.

3.1.4.3 To that end, an outline of such airspace change process will be provided in the EUROCONTROL Handbok for Airspace Management to assist ECAC States in developing their National Airspace Planning Arrangements through which subsequent changes to the national airspace organisation could be made taking into account the needs of all stakeholders.

3.2 TEMPORARY AIRSPACE ALLOCATION (TAA) PROCESS

3.2.1 General Presentation of the TAA Process

3.2.1.1 Since the demands on the use of airspace are manifold, some of which are not compatible with civil aviation (e.g. rocket firing) and because there exist sensitive areas on the ground that need protection from possible disturbance by over-flying aircraft, it is recognised that there is a need for States to establish airspace restrictions of varying degrees of severity. In addition, there are aerial activities by specific users or user groups, which may require the reservation of portions of the airspace for their exclusive use for determined periods of time.

3.2.1.2 Whenever such restrictions and/or reservations have to be imposed, they invariably constitute a limitation to the free and unhampered use of that airspace with the associated effects on flight operations. It is therefore evident that the scope and duration of reservation/restriction established should be subject to very stringent scrutiny in order to keep undesirable effects to the minimum consistent with the reason causing their creation.

3.2.1.3 To achieve this and in order to improve efficiency and flexibility of aircraft operations, States will endeavour to use the "Temporary Airspace Allocation" (TAA) process summarised in a diagram at Annex 3A.

3.2.1.4 Definition of the TAA Process :

> *The **Temporary Airspace Allocation (TAA) Process** consists in the allocation process of an airspace of defined dimensions assigned for the temporary reservation (TRA/TSA) or restriction (D/R) and identified more generally as an "AMC-manageable" area.*

3.2.1.5 The TAA Process involves all AMC-manageable areas that are subject to allocation at ASM Level 2 & 3. These manageable areas are either formal structures established for the temporary reservation of airspace (see paragraph 3.2.3) or the temporary restriction of airspace (see paragraph 3.2.4) that are allocated at Level 2 & 3.

3.2.2 Validation of Activities Requiring Airspace Reservation/Restriction

3.2.2.1 General

3.2.2.1.1 In general airspace should only be reserved or restricted for specific periods of time which should stop as soon as the associated activity ceases. In practise, the TAA process includes all the AMC-manageable structures whenever their use can be linked to a daily allocation for the duration of a planned activity. Thus, when designating airspace volumes, States should establish, as far as possible, AMC-manageable structures.

3.2.2.2 Criteria governing the evaluation of national airspace needs and validation of activities

3.2.2.2.1 When States initiate their evaluation of short-term national airspace needs, or have to deal with a new airspace request, they should :

- ensure that the activities relating to the request for temporary reservation or restriction are valid and justify such action;
- consider the feasibility of avoiding any potential hazard and/or disruption to other airspace users, through appropriate civil/military co-ordination procedures, so that a joint use of airspace will be possible;
- if the joint use of airspace is not possible, determine the needs in terms of space, time and the conditions of use, that are required to confine the activities, to minimise the potential hazard and to minimise disruption to other airspace users;
- assess the level of risk for other airspace users and determine how a request can best be met with the least interference to other users.

3.2.2.3 Criteria governing the choice between Airspace Reservation and Restriction

3.2.2.3.1 Having assessed the need for an AMC-manageable area, where the activities are suitable for daily management and allocation at Level 2, States should :

- whenever possible, establish an airspace reservation using guidelines defined in Chapter 3.2.3;
- if not, - where either because of difficulty in the notification of airspace status to interested airspace users or because of national legal requirements - establish an airspace restriction (R or D) in accordance with guidelines defined in Chapter 3.2.4.

3.2.2.3.2 Finally, States should keep established airspace reservations and airspace restrictions under regular review so as to determine whether they are still required or whether modification may be necessary in the light of changed requirements.

3.2.3 Guidelines for the Establishment of Airspace Reservation

3.2.3.1 Activities Requiring Temporary Airspace Reservation

3.2.3.1.1 States should establish, whenever possible, an airspace reservation over their land and/or territorial waters :

- in response to an operational need to accommodate civil, military, R&D, training or test-flights which, due to the nature of their activities, must be temporarily "protected" from non-participating traffic;
- for military training activities conducted under positive control, when aircraft manoeuvres are unpredictable, sensitive to external interference, or difficult to alter without adversely affecting the mission;
- for civil and military activities where the level of risk is not permanently present and where a temporary airspace reservation or segregation for a period is manageable at Level 2.

3.2.3.1.2 States should clearly identify the activities for which the reservation/segregation of airspace is required from other activities and assess if they can be conducted simultaneously with traffic transiting together with their location in relation to the major traffic flows, in order to define the type of airspace reservation to be applied.

3.2.3.2 Different Types of Temporary Airspace Reservation (TRA, TSA)

3.2.3.2.1 While it is recognised that there exist legitimate reasons for establishment of airspace reservations, experience also indicates that depending on the activities, some "reserved" airspace may be transited by another airspace user under specific conditions and/or based on appropriate co-ordination procedures. For this reason, different areas can be established taking into consideration the activity that would take place associated with the transit possibility.

3.2.3.2.2 **Temporary Reserved Area (TRA)** is a defined volume of airspace normally under the jurisdiction of one aviation authority and **temporarily reserved**, by common agreement, for the specific use by another aviation authority and through which other traffic may be allowed to transit, under ATC clearance.

3.2.3.2.3 Any ATC clearance for crossing an active TRA will be subject to prior co-ordination requirements in accordance with appropriate co-ordination procedures established between civil and military ATS units concerned.

3.2.3.2.4 **Temporary Segregated Area (TSA)** is a defined volume of airspace normally under the jurisdiction of one aviation authority and **temporarily segregated**, by common agreement, for the exclusive use by another aviation authority and through which other traffic will not be allowed to transit.

3.2.3.2.5 In order to permit all airspace users and ATS providers to be fully aware of areas subject to temporary reservation/segregation, Temporary Reserved Areas (TRAs) and Temporary Segregated Areas (TSAs) will be published in the national AIPs.

Note: Pending results from consultation with ICAO on above definitions, the current TSA definition is maintained i.e. :

"***Temporary Segregated Area (TSA)*** *is an airspace of defined dimensions within which activities require the reservation of airspace for the exclusive use of specific users during a determined period of time".*

3.2.3.3 Procedures for a Joint/Shared Use of Airspace

3.2.3.3.1 In applying FUA principles, States should, before establishing any AMC-manageable areas, validate activities requiring airspace restriction/segregation and consider the feasibility of a joint or shared use of airspace, whenever possible, between General Air Traffic (GAT) and Operational Air traffic (OAT).

3.2.3.3.2 To that end, two procedures can be established in Letters of Agreement between the appropriate civil and military control units. These LoAs would need to specify the criteria required by the military authorities to permit or not GAT to fly "off-route" (e.g. radar performance, controller's workload, amount of OAT traffic expected).

3.2.3.3.3 The **Reduced Co-ordination Airspace (RCA)** procedure is used to allow GAT to fly "off-route" without requiring civil controllers to initiate co-ordination with the military controllers.

3.2.3.3.4 The RCA procedure is usually applied for a very large area such as the entire FIR/UIR, but also for critical ACC sectors which have different capacity figures according to the existence of military activity or not.

3.2.3.3.5 The **Prior Co-ordination Airspace (PCA)** procedure, as another way of booking airspace, involves a given block of controlled airspace within which military activities can take place on an ad-hoc basis with individual GAT transit allowed under rules specified in LoAs between civil and military units concerned.

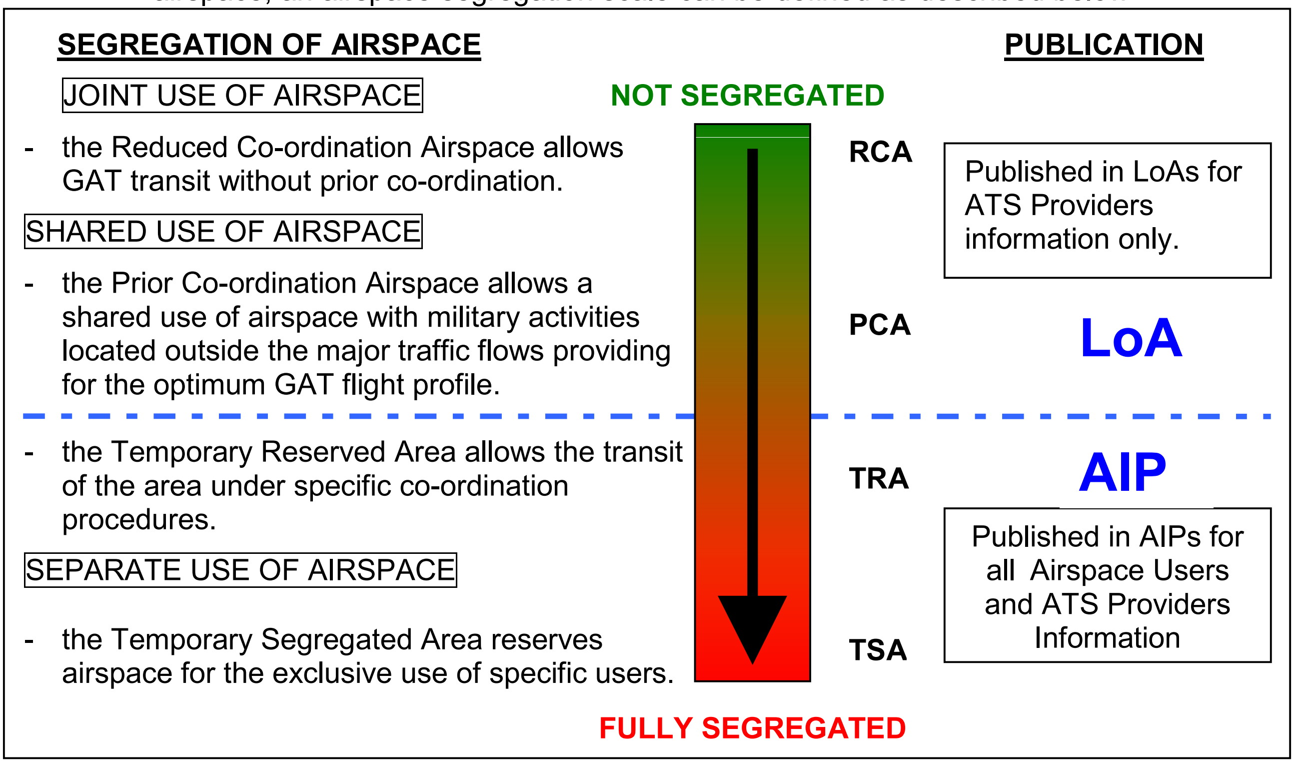
3.2.3.3.6 So as to minimise the need for individual off-route co-ordination, the PCA procedure will mainly be applied for airspace established outside the major traffic flows providing for the optimum GAT flight profile.

3.2.3.3.7 The airspace booking through the PCA procedure will be co-ordinated primarily between the ATS Providers concerned because they will be in the best position to put the reservation into effect. Therefore, Prior Co-ordination Airspace (PCA) will not be published in AIPs, but only in Letters of Agreement between the appropriate civil and military control units.

3.2.3.3.8 When the RCA procedure is in force, these Letters of Agreement should define the criteria required for the application of the PCA procedure with specific notice periods to allow the safe return of GAT flights to the ATS route network. Conversely, when military activities within a Prior Co-ordination Airspace (PCA) cease or decrease, the RCA procedure will be initiated.

3.2.3.4 <u>Degree of Airspace Segregation - Choice between RCA, PCA, TRA and TSA</u>

3.2.3.4.1 From the joint/shared use of airspace to the temporary reservation/segregation of airspace, an airspace segregation scale can be defined as described below.



3.2.3.4.2 AOs will normally use the permanent ATS routes established outside TSAs, TRAs and/or PCAs. However, if available, they will be allowed to file a CDR or even a direct track (not in case of a TSA) and will therefore be re-routed around an active PCA or TRA. When an area (TRA, TSA) is not active, the traffic may expect “short track” through it on the initiative of the ATS Provider.

3.2.3.5 Guidelines for the Establishment of Prior Co-ordination Airspace (PCA)

3.2.3.5.1 The RCA procedure (see Chapter 2.3.5 of the EUROCONTROL Handbook for Airspace Management) and PCA procedure will be implemented exclusively within controlled airspace in known traffic environment, and their use will be complementary according to co-ordination procedures laid down in associated LoAs to ensure a maximum joint use of airspace.

3.2.3.5.2 The purpose of PCA is to temporarily book an airspace, for the use of specific users, that is located outside the major GAT traffic flows. A PCA should be established within a controlled airspace in a known traffic environment, where en-route GAT VFR flights are not permitted (e.g. Class C above FL 195 - see Section 2) to guarantee that information on the airspace status will be provided to the required audience.

3.2.3.5.3 A PCA will mainly be used to separate general and commercial aviation operating in controlled airspace in a known traffic environment from high-speed military operations such as air combat training and formation flying.

3.2.3.6 Guidelines for the Establishment of Temporary Reserved Area (TRA) or Temporary Segregated Area (TSA)

3.2.3.6.1 When there is a need to inform in advance airspace users of any potential activity requiring to temporarily reserve/segregate an area and/or when such activity is located within a busy GAT environment, a TRA/TSA will be created and published in AIPs.

3.2.3.6.2 For cross-border activities, the same guidelines will be used for the establishment of a Cross-Border Area (CBA) either in a form of a TRA or a TSA. Specific elements which require to be taken into consideration for the establishment of such TRA or TSA across international boundaries are listed in the EUROCONTROL Handbook for Airspace Management – Section 3.

3.2.3.7 Criteria for pre-defining airspace reservation volumes (TRA/TSA)

3.2.3.7.1 TRA and TSA will be airspace of pre-defined dimensions but, if several activities are foreseen to take place in the area, they may be subdivided at Level 1 and published as such in AIPs. AMCs may then be able to allocate them fully or partially in accordance with national policy.

3.2.3.7.2 TRA and TSA are established as pre-defined volumes of airspace so as to safely encompass either pre-planned military-type missions within a specific area (e.g. combat manoeuvres, practice air intercepts,....) or activities in movement (e.g. aerial refuelling, en-route mass formations,....). TRA and TSA could also be required for civil activities such as special test-flights or even for radar vectoring within pre-defined areas of potentially very high density of traffic.

3.2.3.7.3 For the delineation of any reserved airspace volumes (TRA or TSA), the State 'Due Regard' obligation should be strategically observed so that activity in that airspace structure will not endanger non-participating aircraft operating at or near its published limits. Distinct/individual boundaries should preferably be defined for activities in adjacent airspace. However, where it is necessary to define a common boundary, appropriate measures governing operations in the proximity of the common boundary should be established (see Section 1).

3.2.3.7.4 The establishment of a common boundary should always be complemented by tactical rules. These can be part of the national air law and/or take the form of LoAs between units involved. Such rules should be as flexible as possible taking into account the following :

- Efficient airspace design and operation ensuring no waste of airspace;
- Radar vectoring in achieving efficient use of airspace.

3.2.3.7.5 In defining these tactical separation rules, States should ensure that safety is assured in all circumstances through:

- the definition, if so required, of specific separation minima depending on the activities conducted in reserved airspace, with the addition of an adequate buffer;
- the application of appropriate LoAs between civil and military units involved;
- the promulgation of the first usable IFR flight levels above/below an area in the definition of associated ATS routes.

3.2.3.8 Co-ordination of airspace reservation - TRA/TSA utilisation

3.2.3.8.1 For an efficient Temporary Airspace Allocation (TAA) process, ASM Level 2 requires the designation of an Approved Agency (AA) for the co-ordination of TRA/TSA utilisation and for the daily submission of corresponding airspace requests to the AMC the day before operations.

3.2.4 Guidelines for the Establishment of Airspace Restriction

3.2.4.1 Requirements for Airspace Restriction (Danger, Restricted or Prohibited Areas)

3.2.4.1.1 The FUA Concept recommends that where possible, D and R Areas are replaced by an airspace reservation (see Chapter 3.2.3 above) or modified by applying the TAA process when the airspace restriction is manageable at Level 2. However, States may have a continuing requirement to retain D and R Areas; e.g. Danger Areas over the High Seas (see Chapter 3.2.5).

3.2.4.1.2 Other D and R areas in some ATS classes of airspace may also not be suitable for replacement by an airspace reservation (TRA, TSA), either because of difficulty in the notification of airspace status to interested airspace users, or because of national and international legal requirements. For example a TSA, though managed as closely as possible to real-time requirements, may be more restrictive than existing D and R areas which can be penetrated by non-participating aircraft under specific and published conditions. Should the changing of some D and R Areas into TRA or TSA impose unreasonable constraints to users, States should retain these D and R Areas.

3.2.4.2 Criteria for pre-defining airspace restriction volumes (P/R/D)

3.2.4.2.1 For the delineation of any restricted airspace volumes (P, R or D), the State 'Due Regard' obligation should be strategically observed so that participating activity will not endanger non-participating aircraft operating at or near its published limits. Distinct/individual boundaries should preferably be defined for activities in adjacent airspace. However, where it is necessary to define a common boundary, appropriate measures governing operations in the proximity of the common boundary should be established (see Section 1).

3.2.4.2.2 The establishment of a common boundary should always be complemented by tactical rules. These can be part of the national air law and/or take the form of LoAs between units involved. Such rules should be as flexible as possible taking into account the following :

- Efficient airspace design and operation ensuring no waste of airspace;
- Radar vectoring in achieving efficient use of airspace.

3.2.4.2.3 In defining these tactical separation rules, States should ensure that safety is assured in all circumstances through:

- the definition, if so required, of specific separation minima depending on the activities conducted in restricted airspace, with the addition of an adequate buffer;
- the application of appropriate LoAs between civil and military units involved;
- the promulgation of the first usable IFR flight levels above/below an area in the definition of associated ATS routes.

3.2.4.2.4 The AIP would identify those D and R areas managed and allocated at Level 2. To that end, some States may add suitable qualifiers to these D and R designators to indicate the Level 2 management of these areas. The period and conditions of use of these AMC-manageable areas will be published in AUPs in the list "CHARLIE" of Temporary Airspace Allocation (TAA).

3.2.4.2.5 Other D and R areas, not suitable for Level 2 management, would be identified as such and completely defined in the national AIPs. Within these published times the activity will take place without any allocation by AMCs unless users and/or managers of these airspace restrictions are able to notify their activities for the following day.

3.2.5 Guidelines for the Establishment of Airspace Restriction/Reservation over the High Seas

3.2.5.1 <u>Establishment of Danger Areas over the High Seas</u>

3.2.5.1.1 The FUA Concept recommends that where possible, D and R Areas are replaced by an airspace reservation (see <u>Chapter 3.2.3</u> above) or modified by applying the TAA process when the airspace restriction is manageable at Level 2.

3.2.5.1.2 However, over the High Seas, regardless of the risk involved, only Danger Areas can be established.

3.2.5.2 <u>Activities over the High Seas manageable at ASM Level 2</u>

3.2.5.2.1 In general airspace should only be reserved or restricted for specific periods of time which should stop as soon as the associated activity ceases. In practise, the TAA process includes all the AMC-manageable structures whenever their use can be linked to a daily allocation for the duration of a planned activity.

3.2.5.2.2 Thus, when designating airspace volumes over the High Seas wherein an ECAC State has accepted the responsibility for providing ATS, that State should establish, as far as possible, "AMC-manageable Danger Areas" and allocate them in the same way as over land and/or territorial waters (see <u>Chapters 3.3.2 & 4.10</u> of the EUROCONTROL Handbook for Airspace Management related to ASM over the High Seas).

3.2.5.3 <u>Requirements for Danger Area Restriction over the High Seas</u>

3.2.5.3.1 In all other cases, according to ICAO recommendations, those who initiate danger area restrictions over the High Seas are under an increased moral obligation to judge whether establishment of the Danger Area is unavoidable and if it is, to give full details on the intended activities therein (see <u>Chapter 4.10</u> of the EUROCONTROL Handbook for Airspace Management related to ASM over the High Seas).

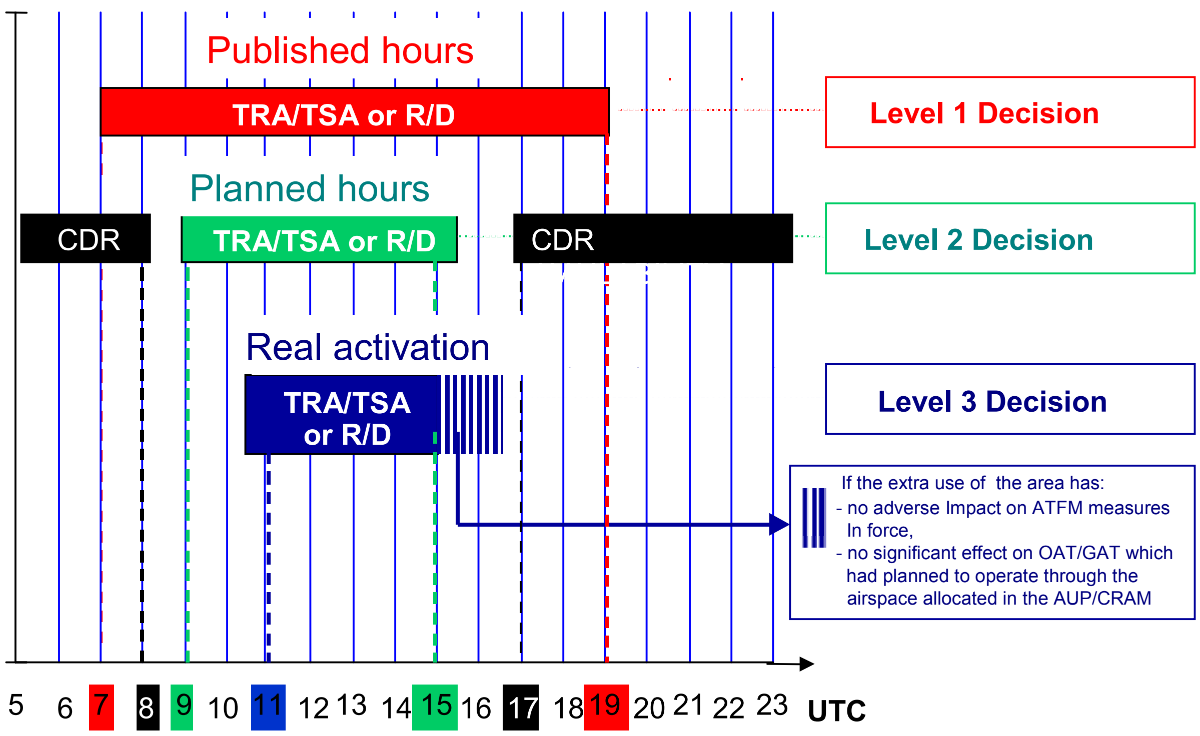
3.2.6 Activation Times Parameters

3.2.6.1 General

3.2.6.1.1 Activation times should be clearly stated in accordance with the following parameters :

- the "Published Hours" which would be the period of activation decided at Level 1 and published in AIP/NOTAM in a new column dealing with "Activation Hours". The Published Hours would cover the maximum possible activation time;
- the "Planned Hours" which would always take place within the Published Hours and would be decided at Level 2 by AMCs and published as such in AUPs;
- the "Real Activation Time" which would normally take place within the Planned Hours and would be the actual period of use of the area notified at Level 3 by appropriate means.

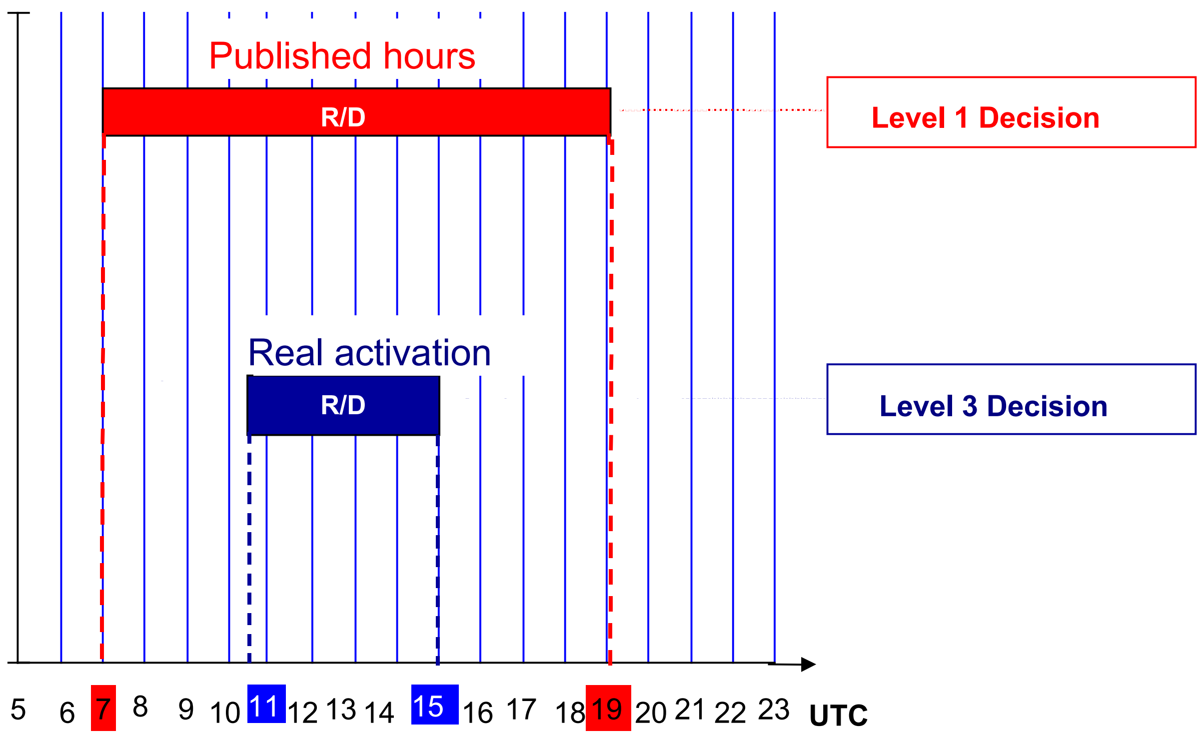
3.2.6.2 Activation times associated with the TAA Process – AMC-Manageable Areas



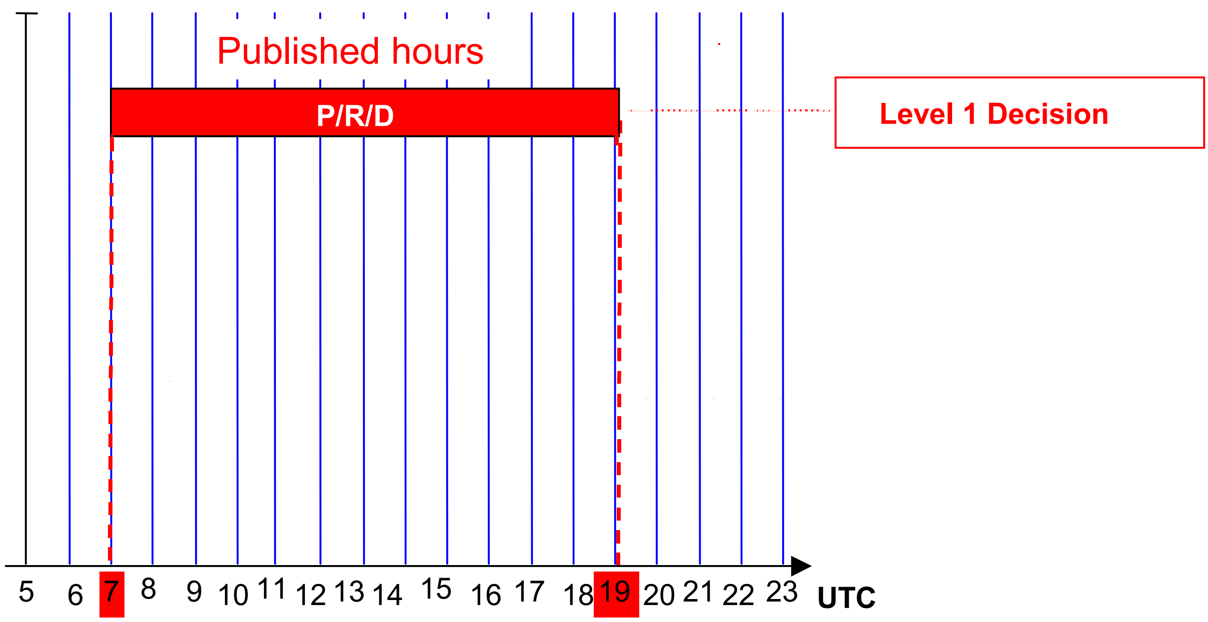
3.2.6.2.1 There is the possibility, after adequate Level 3 co-ordination, for the "Real Activation Time" of an area to be outside the "Planned Hours". This would require consideration of various issues, including :

- the control of access into the airspace in which the area is situated;
- any adverse impact on the ATFM measures in force;
- any significant effect on GAT/OAT which had planned to fly or operate through the airspace on the basis of related information in the CRAM/AUP.

3.2.6.3 Activation times associated with Airspace Restrictions Manageable at Level 3



3.2.6.4 Activation times associated with Airspace Restrictions NOT Manageable at all



3.2.7 Harmonised Publication of Airspace Restriction/Reservation

3.2.7.1 Publication of Restriction (P, R, D)

3.2.7.1.1 The ICAO AIS Manual (Doc. 8126) recommends that AIP RAC 5 lists all areas through which the flight of aircraft is subject to certain specified conditions and which have some permanency, including those which are activated from time to time. Doc. 8126 also requires that any such area should be designated a Prohibited Area (P), a Restricted Area (R) or a Danger Area (D).

3.2.7.1.2 A fictitious example of the harmonised publication in AIPs of Temporary Allocated Airspace (TAA) in the form of AMC-manageable R and D Areas is given in Annex 3B together with an explanatory note to be published in front of ENR 5.

3.2.7.2 Publication of Temporary Airspace Reservation (TRA, TSA)

3.2.7.2.1 Article 3 d) of the ICAO Convention requires Contracting States to have due regard for the safety of navigation of civil aircraft when issuing regulations for military aircraft. ICAO Annex 11 prescribes that any activity potentially hazardous to civil aircraft shall be co-ordinated with the appropriate air traffic services authorities. The co-ordination shall be effected early enough to permit timely promulgation of information regarding the activities in accordance with the provisions of ICAO Annex 15.

3.2.7.2.2 Under these circumstances, if an airspace reservation is formally established within controlled airspace, ECAC States, according to their own legislation, should publish the area as a TRA or a TSA in AIP ENR 5-2 (see Annex 3B). Nevertheless in all cases, States are required to establish LoAs, if needed, with direct communication between civil and military controlling/monitoring units concerned in order to allow an efficient co-ordination process.

3.2.7.2.3 As specified in the Doc. 8126, the description and graphic portrayal of TRA or TSA should include, as appropriate:

1) identification and name (if any) - lateral limits with geographical co-ordinates;
2) upper and lower limits;
3) type of restriction or nature of hazard;
4) remarks including the period of activity if the area is only “active” during certain periods.

The “risk of interception in the event of penetration” should also be noted in the remarks column defined in sub para 4) above.

3.2.7.2.4 As stated in para. 3.2.6.2, TAA activation time parameters encompass “Published Hours”, “Planned Hours” and “Real Activation Time”. The Published Hours would cover the maximum possible activation and should be published in the AIP in a new column or as a specific part of the “Remarks” column. In some cases, it could also be useful to publish in the “Remarks” column the “Operating Authority” and the “Penetration Conditions”, if any.

3.2.7.2.5 Information concerning Cross-Border Activities within a TRA or TSA established over international boundaries should be published in a similar way as a national TRA or TSA. However, such a “Cross-Border Area” must be given specific designators for publication in the AIPs of the States concerned, and the lateral limits of the area in each State.

3.2.8 Depiction on the ASM Planning Chart

3.2.8.1 General

3.2.8.1.1 Areas not suitable for allocation at Level 2 (Not AMC Manageable) and therefore not covered by the TAA Concept, can be split into two categories according to their handling at Level 3 (see paragraph 3.2.5.3 & 3.2.5.4 above).

3.2.8.1.2 Therefore, areas depicted on the ASM Planning Chart are subdivided into three categories according to their management possibilities as follows:

- in **plain light yellow** with orange outline, for the AMC-manageable areas subject to pre-tactical management on a daily basis (TAA Concept);
- in **medium pink border** with pink outline, for areas subject to tactical management, and for which real-time activity is known through appropriate means, and
- in **plain light pink** with pink outline, for areas not manageable at all (strategic definition only) or permanently prohibited (P) and for which no information on their actual activity can be retrieved.

3.2.8.2 Relationship between Airspace Reservation/Restriction and the FUA Concept

3.2.8.2.1 The table below summarises the relationship between the Airspace Reservation (TRA, TSA), Airspace Restriction (P, R, D) and the FUA Concept.

<table>
<tr><th colspan="2"></th><th>AIRSPACE RESERVATION</th><th>AIRSPACE RESTRICTION</th><th>Depiction on the ASM Planning Chart</th></tr>
<tr><td>AMC manageable, allocated at ASM Level 2</td><td>TAA
Concept</td><td>TRA
TSA</td><td>Restricted Area
Danger Area</td><td>Plain light yellow
TSA 1</td></tr>
<tr><td colspan="2">Not AMC manageable, but real-time activity notified at ASM Level 3</td><td></td><td>Restricted Area
Danger Area</td><td>Medium pink border
D 2</td></tr>
<tr><td colspan="2">Not suitable for Level 2 allocation nor for Level 3 notification</td><td></td><td>Prohibited Area
Restricted Area
Danger Area</td><td>Plain light pink
P 3</td></tr>
</table>

Relationship between Airspace Reservation/Restriction and the FUA Concept

3.3 RE-SHAPING AIRSPACE TO ACCOMMODATE EN-ROUTE USER-PREFERRED TRAJECTORIES

3.3.1 General

3.3.1.1 The general guidelines for the establishment and delineation of airspace structures, as defined in Section 1 and in previous Chapters, aim at finding a strategic compromise between conflicting demands made on the use of airspace by its many different users.

3.3.1.2 Once published, those airspace volumes need then to be used with full knowledge of the assumptions made for their establishment (Seventh Principle). However, tactical procedures should be established for the real-time use of those airspace in such a way that there is no waste of airspace (Fifth Principle) and a better utilisation of available airspace capacity.

3.3.1.3 In particular, control area initially established for structured routes can be used with new or adapted ATS airspace use procedures based on the provision of radar services to accommodate en-route user-preferred trajectories in different ways from less to full freedom of movement (*i.e. Bound to Fixed Route procedure up to Autonomous Operations*).

3.3.2 Introduction of New/Adapted ATS Airspace Use Procedures

3.3.2.1 Bound to Fixed Route (BFR) Procedure

- mandatory routing on centre lines of promulgated ATS routes;
- No direct routing offered;
- track-keeping responsibility to the air, with possibilities of radar monitoring or vectoring;
- separation responsibility to the ground.

3.3.2.2 Prior Co-ordination Airspace (PCA) Procedure - (see paragraph 3.2.3.5)

- mandatory routing on centre lines of promulgated ATS routes;
- direct routing offered after prior co-ordination with military controlling/monitoring unit concerned;
- track-keeping responsibility to the air, with possibilities of radar monitoring or vectoring;
- separation responsibility to the ground.

3.3.2.3 Reduced Co-ordination Airspace (RCA) Procedure - (see paragraph 3.2.3.3)

- mandatory routing on centre lines of promulgated ATS routes;
- direct routing offered without the need for prior co-ordination;
- track-keeping responsibility to the air, with possibilities of radar monitoring or vectoring;
- separation responsibility to the ground.

3.3.2.4 Parallel Tracks Application (PTA) Procedure

- mandatory off-set routing from centre lines of promulgated ATS routes;
- track-keeping always under radar monitoring or vectoring;
- separation responsibility to the ground.

3.3.2.5 Radar Vectoring Area (RVA)[5] Procedure

- mandatory routing on controller instructions;
- track-keeping always under radar vectoring;
- separation responsibility to the ground.

3.3.2.6 Random RNAV Area - Free Route Airspace (FRA)[6] Procedure - (see Section 7)

- free/random RNAV routing may be flight planned within specified areas (FRAs);
- track-keeping responsibility to the air, with possibilities of radar monitoring;
- separation responsibility to the ground.

3.3.2.7 Free Flight Airspace (FFA)[7] Procedure

- autonomous operations within specified areas (FFAs);
- track-keeping responsibility to the air, with possibility of radar monitoring;
- separation responsibility to the air.

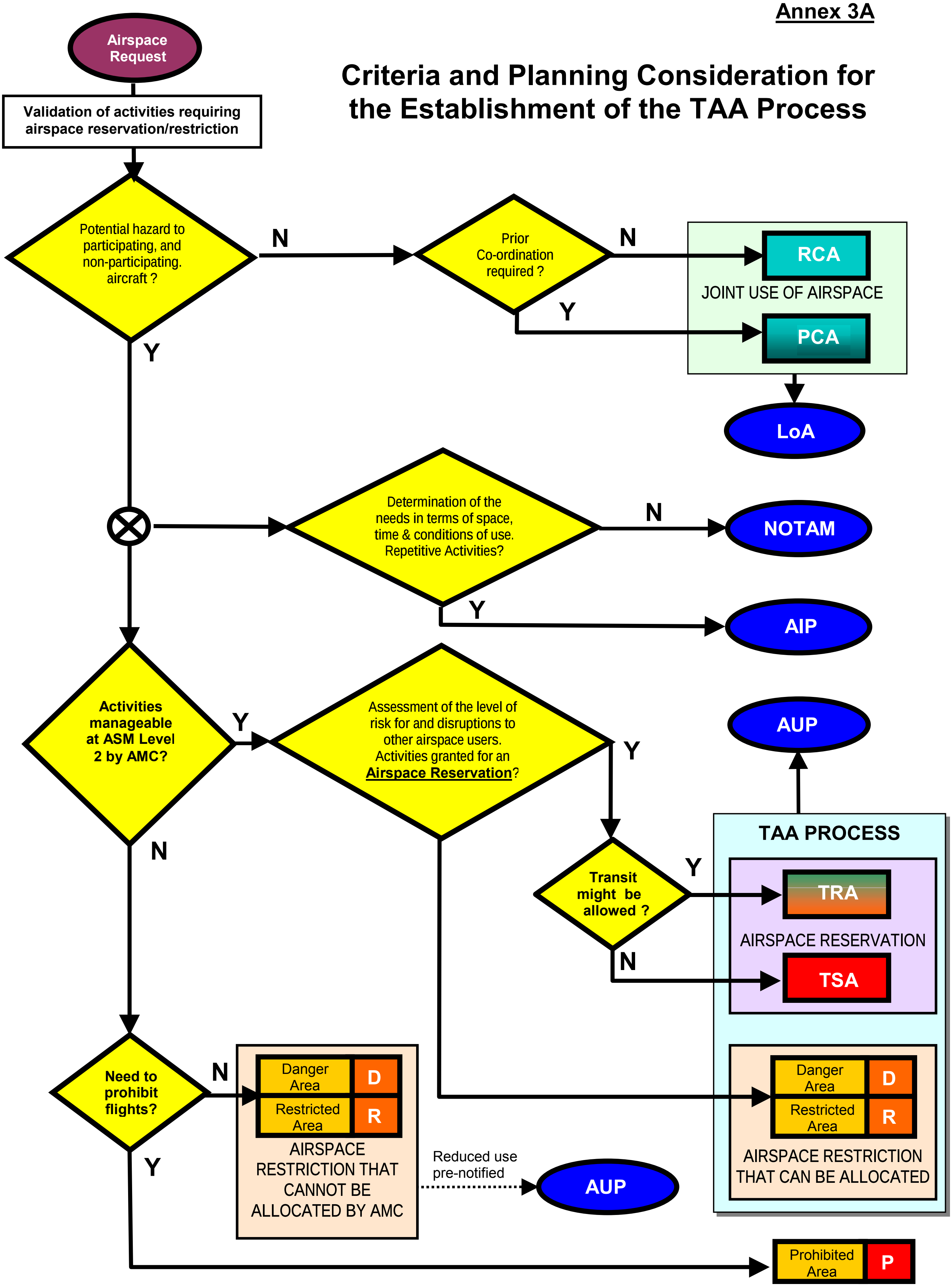
[5] A "Radar Vectoring Area" (RVA) would be seen as a kind of "civil TSA" to be strategically or dynamically (ad-hoc) established, after appropriate civil/military co-ordination, in area and during time of potential very high density of traffic to offer more flexibility to the controller than the use of fixed ATS routes, while ensuring temporary segregation of IFR flights from both OAT and VFR traffic.

[6] A "Free Route Airspace" (FRA) is a specific airspace within which users shall freely plan their routes between an entry point and an exit point without reference to the ATS route network. In this airspace, flights will remain subject to air traffic control.

[7] A "Free Flight Airspace" (FFA) is a specified volume of airspace within which autonomous operations will be allowed and the separation assurance responsibility will be fully transferred to the air.

Annex 3A

Criteria and Planning Consideration for the Establishment of the TAA Process



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Annex 3B

FICTITIOUS EXAMPLES OF PUBLICATION OF D & R (Manageable or not) IN AIP ENR 5.1

AIP *ENR 5-1-x*
xxxxxx *From 02 APR 98*

IDENTIFICATION NAME *Lateral Limits Coordinates*	Upper Limit Lower Limit	Activation Time Penetration Conditions	Remarks Type of Activity Operating Authority
1	2	3	
(EXAMPLE OF RESTRICTED AMC-MANAGEABLE AREA)			
XX-R 101 South 543045N 0131502E - 542830N 0111000E - .... - to point of origin	FL 310 FL 110	MON TO FRI 0830-1700 Planned hours specified in daily xxx AUP Real-time activity information and/or crossing clearance from:	**AMC-manageable area** Air-to-air firing ZZZZ Control FREQ: .... MHz
(EXAMPLE OF DANGER AMC-MANAGEABLE AREA OVER THE HIGH SEAS)			
XX-D 120 North Sea 534045N 0101502E - 532830N 0123005E - .... - to point of origin	FL 660 FL 195	MON TO FRI 0700-1600 Planned hours specified in daily xxx AUP Real-time activity information and/or crossing clearance from:	**AMC-manageable area** Air Combat Training YYYY Control FREQ: .... MHz
(EXAMPLE OF RESTRICTED AREA not suitable for AMC Management)			
XX-R 20 East Sector of an arc, 25 NM radius centred at 503045N 0031502E, from 270° GEO clockwise to 137° GEO.	FL 95 GND	MON TO FRI 0730-1700 (0630-1600) Real-time activity information and/or crossing clearance from:	Gunfiring XXXX TWR FREQ: .... MHz
(EXAMPLE OF DANGER AREA not suitable for AMC Management)			
XX-D 10 West A Circle, 20 KM radius centred at 504305N 0120002E.	FL 360 GND	MON TO FRI 1030-1700 (0930-1600)	Bombing exercise

Annex 3B – Page 2

FICTITIOUS EXAMPLES OF TRA/TSA PUBLICATION IN AIP ENR 5.2

AIP *ENR 5-2-x*
xxxxxx *From 02 APR 98*

IDENTIFICATION NAME *Lateral Limits Coordinates*	Systems/means of activation promulgation	Activation Time Upper/Lower Limits	Remarks Type of Activity Penetration Conditions
1	2	3	
(EXAMPLE OF TEMPORARY SEGREGATED AREA)			
XX-TSA 01 A NORTH EAST I 543045N 0131502E - 542830N 0111000E - .... - to point of origin **XX-TSA 01 B** NORTH EAST II 543145N 0121502E - 542830N 0111000E - .... - to point of origin	Planned hours specified in daily xxx AUP Real-time activity information from: ZZZZ Control FREQ: .... MHZ	MON TO FRI 0830-1700 FL 360-FL 230	**AMC-manageable area** Air Combat Training Penetration prohibited during Activation
(EXAMPLE OF TEMPORARY RESERVED AREA)			
XX-TRA 10 NORTH WEST ALPHA Sector of an arc, 25 NM radius centred at 503045N 0031502E, from 270° GEO clockwise to 137° GEO.	Planned hours specified in daily xxx AUP Real-time activity information from: XXXX TWR FREQ: .... MHz	MON TO FRI 0730-1700 (0630-1600) FL 245 - 700 M MSL	**AMC-manageable area** **Flying School Training** Rules of the air not always complied with Crossing clearance from : XXXX TWR

FICTITIOUS EXAMPLES OF PUBLICATION OF "Forewarning Areas" IN AIP ENR 5.3

AIP *ENR 5-3-x*
xxxxxx *From 02 APR 98*

IDENTIFICATION NAME *Lateral Limits Coordinates*	Systems/means of activation promulgation	Activation Time Upper/Lower Limits	Remarks Type of Activity Penetration Conditions
1	2	3	
(Example of Intense Aerial Activity outside Controlled Airspace)			
XX-F 250 BLUE ANGEL SOUTH 534052N 0151502E - 533830N 0150305E - .... -to point of origin	Information on activation and contact authority provided by NOTAM	Date, times and Upper/Lower Limits promulgated by NOTAM ten days in advance	SAR operations in VMC only

Annex 3B – Page 3

EXAMPLE OF EXPLANATORY NOTE ON AIRSPACE RESERVATION (TRA/TSA) IN FRONT OF AIP ENR 5

AIP *ENR 5-0-x*
xxxxxx *From 02 APR 98*

Purpose of Airspace Reservation (TRA or TSA)

The purpose of **airspace reservation** is to *temporarily reserve, by common agreement, a defined volume of airspace normally under the jurisdiction of one aviation authority for exclusive use by another aviation authority.* As some "reserved" airspace may be transited by another airspace user under specific conditions and/or based on appropriate co-ordination procedures, two different types of airspace reservation have been defined taking into consideration the activity that would take place associated with the transit possibility:

Temporary Reserved Area (TRA) is a defined volume of airspace normally under the jurisdiction of one aviation authority and **temporarily reserved**, by common agreement, for the specific use by another aviation authority and through which other traffic may be allowed to transit, under ATC clearance

Temporary Segregated Area (TSA) is a defined volume of airspace normally under the jurisdiction of one aviation authority and **temporarily segregated**, by common agreement, for the exclusive use by another aviation authority and through which other traffic will not be allowed to transit.

The Temporary Airspace Allocation (TAA) Process

The **Temporary Airspace Allocation (TAA) Process** consists in the allocation process of an airspace of defined dimensions assigned for the temporary reservation (TRA/TSA) or restriction (D/R) and identified more generally as an "**AMC-manageable area**" in AIP ENR 5.

The TAA process permits activities requiring temporary reservation to be allocated on the day before operations so as to allow the Airspace Management Cell (AMC) to make available, if required, Conditional Routes (CDRs) established through them outside their planned hours.

Any remaining D, R and P areas that are not suitable for AMC management, remain unaltered in the AIP. The planned activity and conditions for the use of TRA/TSA and AMC-manageable D or R areas will be published daily in the national "Airspace Use Plan" (AUP).

TRA/TSA Activation Times Parameters

TRA or TSA activation times are defined in accordance with the following parameters:

1. **Published Hours**
   - "Published Hours" cover(s) the maximum possible activation time.
   - "Published Hours" are published in AIPs in the Activation Time Column.

2. **Planned Hours**
   - "Planned Hours" will be specified daily by AMCs and published in the national AUP.
   - "Planned Hours" will always take place within the "Published Hours".

3. **Real Activation Time**
   - "Real Activation Time" is the actual period of use of the area known from the Operating Authority.
   - "Real Activation Time" will normally take place within the "Planned Hours".

SECTION 3

AIRSPACE RESTRICTIONS & RESERVATIONS DESIGN

FINAL PAGE

SUGGESTION - COMMENTS

To report any errors, or to propose a modification to the present Section 3 "Airspace Restrictions & Reservations Design", please contact:

Mr Jean-Paul Lemaire
EUROCONTROL
Airspace & Flow Management and Navigation Business Division (AFN)
Rue de la Fusée, 96
B-1130 BRUSSELS
(E-mail: jean-paul.lemaire@eurocontrol.int)

SECTION 3 - SPONSOR: AIRSPACE MANAGEMENT SUB-GROUP

Whenever material received, in accordance with the above procedure, makes it apparent that an amendment of the present Section 3 is required, such amendment will be first discussed within the Airspace Management Sub-Group (ASM-SG) before its adoption by the Airspace & Navigation Team (ANT).

PUBLICATION OF AMENDMENT

The agreed amendment will then be issued by EUROCONTROL in the form most convenient for its insertion in the Planning Manual.

SECTION 4

ATS ROUTE AND SECTOR DESIGN

SECTION CHECKLIST

Page	Edition Amendment	Date	Page	Edition Amendment	Date
Section 4					
4-0	Amendment 1	17/01/05	4-22	Edition 2.0	22/10/03
4-1	Edition 2.0	22/10/03	4-23	Edition 2.0	22/10/03
4-2	Edition 2.0	22/10/03	4-24	Edition 2.0	22/10/03
4-3	Edition 2.0	22/10/03	4-25	Edition 2.0	22/10/03
4-4	Edition 2.0	22/10/03	4-26	Edition 2.0	22/10/03
4-5	Edition 2.0	22/10/03	4-27	Edition 2.0	22/10/03
4-6	Edition 2.0	22/10/03	4-28	Edition 2.0	22/10/03
4-7	Edition 2.0	22/10/03	4-29	Edition 2.0	22/10/03
4-8	Edition 2.0	22/10/03	4-30	Edition 2.0	22/10/03
4-9	Edition 2.0	22/10/03	4-31	Edition 2.0	22/10/03
4-10	Edition 2.0	22/10/03	4-32	Edition 2.0	22/10/03
4-11	Edition 2.0	22/10/03	4-33	Edition 2.0	22/10/03
4-12	Edition 2.0	22/10/03	4-34	Edition 2.0	22/10/03
4-13	Edition 2.0	22/10/03	4-35	Edition 2.0	22/10/03
4-14	Edition 2.0	22/10/03	4-36	Edition 2.0	22/10/03
4-15	Edition 2.0	22/10/03	4-37	Edition 2.0	22/10/03
4-16	Edition 2.0	22/10/03	4-38	Edition 2.0	22/10/03
4-17	Edition 2.0	22/10/03	4-39	Edition 2.0	22/10/03
4-18	Edition 2.0	22/10/03	4-40	Edition 2.0	22/10/03
4-19	Edition 2.0	22/10/03	4-42	Edition 2.0	22/10/03
4-20	Edition 2.0	22/10/03	4-43	Edition 2.0	22/10/03
4-21	Edition 2.0	22/10/03	4-44	Edition 2.0	22/10/03

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SECTION 4

ATS ROUTE AND SECTOR DESIGN

4.1 ESTABLISHMENT OF ATS ROUTES

4.1.1 General Considerations

4.1.1.1 Ideally, aircraft want to fly on the most direct route between their points of departure and their destination except when severe weather phenomena are encountered. However, because of conflicting demands from many different users, it is usually not possible to establish the most direct route and therefore it is necessary to find a compromise between the demands and the offers.

4.1.1.2 As a result, air traffic control services are required to manage effectively the demand with the aim of satisfying the requirement in the best possible way. It is therefore essential that the various individual intentions of those flights making up the traffic demand are presented to the controller in such a manner that they can be related to one another and possibly conflicting intentions.

4.1.1.3 Pre-defined routes of flight constitute one of the major elements used today to channel controlled air traffic mainly for the en-route part of the flight using an en-route network of ATS routes, but when necessary, in particular at the busier aerodromes, standard departures (SID) and standard arrivals (STAR) may also be established in accordance with guidelines provided in Section 5.

4.1.2 ATS Route Network Development

4.1.2.1 Today in Europe, the manner to handle large amounts of en-route traffic is through a pre-established ATS route network (ARN). For developing a new version of ARN, ICAO SARPS as per the Chicago Convention and Annexes thereto are complemented for ECAC States by agreed planning principles and criteria as defined in Chapters 4.2 & 4.3.

4.1.3 Free Route Airspace Development

4.1.3.1 The number of flights in European Airspace is still growing, whereas exploiting more airspace capacity by constantly adapting the route structures and ATC sectors has limitations. EUROCONTROL together with some ECAC States are looking for new techniques to expand capacity and increase flight efficiency. This drive for further improvements has led to a concept that makes more effective use of aircraft flight management and navigation capabilities (e.g. possibilities of Random RNAV routings), in combination with more sophisticated automation to support the controller, fewer airborne conflicts, increased airspace capacity and more direct aircraft routings which can be flight planned by operators. This new approach which exploits these improvements is termed the “Free Route Airspace Concept” and will be further described in Section 7.

4.1.4 RNAV Routes and Non-RNAV ATS Routes

4.1.4.1 With effect from **23 April 1998**, the carriage and use of B-RNAV equipment became mandatory for aircraft operating within specified parts of the Regional ATS Route Network[8] of ECAC airspace. B-RNAV is specified as a navigation performance requiring a track-keeping accuracy of +/- 5NM for 95% of the flight time. Operators of aircraft must hold operational approval from their appropriate State regulatory authority and obtain airworthiness approval in accordance with JAA Temporary Guidance Leaflet TGL-2 (or acceptable alternative).

4.1.4.2 In order to contribute to safety and capacity gains, B-RNAV routes should be established in such a manner that their vertical delineation is harmonised throughout the ECAC area so as to enable a continuum of RNAV environment.

4.1.4.3 In most ECAC States, the minimum useable flight level for RNAV Routes is set at FL100 (i.e. B-RNAV equipment required above FL95), but this is not yet standard across all ECAC States. However, so as to enable RNAV operations in Terminal Airspace, RNAV environment will continue to/from the lowest safe and feasible level.

4.1.5 Regional Routes and Non-Regional Routes

4.1.5.1 Where international operations constitute the majority of the traffic, the development of the ATS route network requires a cohesive and co-ordinated behaviour of all States concerned. Where national operations constitute the bulk of the traffic to be handled, there is still a need for a concerted approach with adjacent States.

4.1.5.2 Isolated actions by States in developing a national ATS route network are only possible with respect to ATS routes serving strictly national purposes. Such action will, in most cases, have direct and noticeable effects on the traffic beyond the area of responsibility of the States concerned.

4.1.5.3 In this context, following the ICAO European Region initiative and the ECAC en-route Strategy for the 1990's, a Route Network Development Sub-Group (RNDSG) under the auspices of the EUROCONTROL Airspace & Navigation Team (ANT) was created in May 1993 to act as the organiser and co-ordinator of planning and implementation activities aimed at improving and upgrading the ATS Route Network in the ECAC area of the European Region as mandated by ICAO (EANPG Conclusions 35/2 & 36/2).

4.1.5.4 All ECAC States are required to actively participate to this international work as the detailed establishment or review of individual ATS routes, forming the ATS route network, should now definitely proceed through the RNDSG from a "Top Down" approach taking an ECAC-wide view, based upon the need for enhancement of overall ECAC ATM capacity along the following lines :

a) First identify the foreseen major traffic flows within the ECAC area as well as those extending beyond and review the weak links in the current route and sector organisation;

b) Establish and review the Regional En-route Network and supporting sectorisation to accommodate the expected major traffic flows reducing the airspace structures complexity and balancing the ATC workload;

c) Integrate those routes required to provide access to the Regional En-route Network from and to locations not directly served by them, as well as those routes not permanently available required to alleviate the traffic load on the main ATS routes (e.g. Conditional Routes);

[8] States may still designate Non-RNAV routes outside the Regional ATS Route Network as available for aircraft not fitted with RNAV equipment

d) Ensure connectivity between the en-route network and routes to/from Terminal Airspace;

e) Establish an overall phased implementation programme to ensure consistency in individual State implementation.

4.1.5.5 States may still designate Non-Regional routes to satisfy those activities of a more local nature or of a specific user group (e.g. VFR routes, military low-level routes, night flying,..) and should determine if these local routes need to be integrated in the overall route network.

4.1.6 Lower ATS Routes and Upper ATS Routes

4.1.6.1 In the ICAO EUR Air Navigation Plan (Doc. 7754, Vol.I, Basic ANP – Table ATS-1), the description of the ATS route network is subdivided, for planning purposes, into Lower and Upper ATS Routes with a uniform plane of division established at FL 245 disregarding existing limits of the FIRS/UIRs in the EUR region.

4.1.6.2 In the present environment, however, the division between Upper and Lower airspace has no relevance for most of the ECAC Region. But, national publication of ATS routes in AIPs are still distinguishing Lower and Upper ATS routes from a national perspective adopting their own FIR/UIR division without considering adjacent vertical division.

4.1.6.3 Thus those States, still considering a need for making a distinction between Lower and Upper ATS routes which do not coincide, are required to take into consideration from an ECAC-wide perspective a common division level based only on the use of “area control” arrangements versus a system of airways.

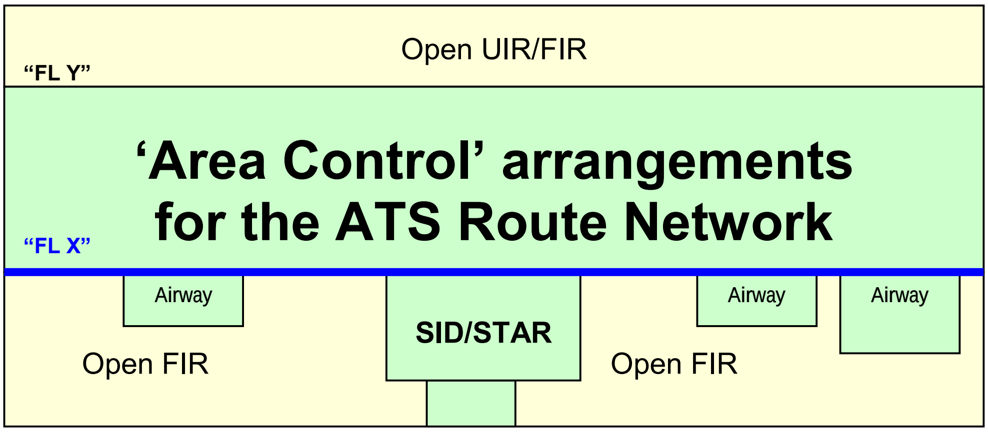
4.1.7 ‘Area Control’ Arrangements and Airways

4.1.7.1 “Area Control” arrangements have the advantage that, whenever traffic conditions permit, a controller may authorise specific flights under his/her control to deviate from the established ATS route or route structure without aircraft leaving controlled airspace and thus losing the benefit of ATC.

4.1.7.2 However, within a Control Area (CTA), the protected airspace provided along ATS routes is not visibly published as all airspace around the routes is by definition a controlled airspace, which does not facilitate the delineation of adjoining airspace restrictions or reservations (see Section 3). Conversely, controlled ATS routes established in the form of corridors (Airways) have by definition a clear description of associated protected airspace within which controlled flights should remain.

4.1.7.3 Nevertheless, following the agreement for a common ATS airspace classification above a commonly agreed base level, ECAC States have agreed to progress towards an ‘area control’ service above such a common level and that a system of airways will only be used below it (i.e. FL "X" see Section 2).

4.1.7.4 In order to give more freedom to VFR flights operations outside airways and Terminal Airspace, the lower limit of the controlled airspace should be established so that flights not requiring air traffic control services are not unnecessarily restricted while IFR traffic requiring ATC services can remain within controlled airspace during departure, en-route and approach phases of flight. For instance, Standard Instrument Departures (SIDs) and Standard Instrument Arrivals (STARs) should be contained in associated Terminal Airspace and Control Area established above. In the vicinity of aerodromes, the establishment of the lower limit of controlled airspace should also take into account those portions of airspace which may be required by ATC to vector aircraft by radar (see Section 5).



Vertical ECAC Airspace Organisation for ATS Routes

4.1.8 ATS Routes Permanently Available and Conditional Routes

4.1.8.1 The majority of the ATS routes established will be permanently available, however there will be cases when or where non-permanent routes, defined for the ECAC area as Conditional Routes (CDRs) (see Chapter 4.4), should be established:

a) when routes are required for specific periods only or can be made available only during weekends or at night because they cross areas (e.g. TSAs) which, during the week or daylight, are usually reserved for other activities (i.e. CDR 1);

b) where routes whose use depends on pre-tactical co-ordination procedures (i.e. CDR 2) or can only be effected on an *ad hoc* basis for specific flights involved and depending on the circumstances as they prevail at that time (i.e. CDR 3).

4.1.8.2 Such Conditional Routes should also be included in the ATS route network, however with a clear indication of the limitations imposed on their use. Being non-permanent structures, CDRs should be reviewed at frequent intervals with a view to reconsidering their categorisation whenever the use made of them requires so. Such periodical review process will be made in accordance with ASM Level 1 functions defined in the EUROCONTROL Handbook for Airspace Management.

4.1.9 Route Width and Route Spacing

4.1.9.1 According to ICAO Annex 11 - 2.11, where ATS routes are established, a protected airspace along each ATS route and a safe spacing between adjacent ATS routes shall be provided. The spacing between parallel ATS route centre lines for which a Required Navigation Performance (RNP) is applied for en-route operation will be dependent upon the relevant RNP type specified by individual States and when applicable, on the basis of regional agreements. In Europe, the foreseen applications of each RNP type are indicated in the Guidance Material relating to the Implementation of Area Navigation in the ICAO EUR Region (EUR Document 001-RNAV/5) currently under review.

4.1.9.2 From this guidance material, reductions of the B-RNAV[9] Route spacing minimum, to somewhere in the order of 10-15 NM, are expected to be possible for the ATS Route Network by placing higher reliance on ATC Radar Monitoring and intervention capabilities.

4.1.9.3 The circumstances in which such a reduction of route spacing is applied, will need to be assessed on case by case basis in accordance with ICAO Doc. 9689, taking into consideration procedural or radar environments and associated controller workload. An example study will be outlined in the ICAO EUR Guidance Material.

[9] B-RNAV is specified as a navigation performance requiring a track-keeping accuracy of +/- 5NM for 95% of the flight time (see Chapter 4.1.4 above)

4.1.10 Amendment to ICAO EUR ANP and Phased Implementation Plan

4.1.10.1 The ICAO European Region Air Navigation Plan (Doc. 7754 - EUR ANP) presents in general terms the ICAO plan for the provision of facilities and services for international air navigation in the ICAO European region. The Vol.1 - EUR Basic ANP describes in particular the basic ATS route network in the lower and upper airspace of the EUR region in the form of tables and charts artificially split at FL 245.

4.1.10.2 In order to be consistent with current and foreseen requirements of international civil aviation, the table and charts ATS-1 "*Basic ATS route network in the Lower and Upper Airspace*" of the ICAO Doc. 7754 are regularly updated to reflect ECAC States agreement to implement a new ARN version established by the RNDSG.

4.1.10.3 However, due to the time constraints of the ICAO EUR ANP amendment process and in order to have a more accurate view of the status of implementation of a new agreed ARN version, the RNDSG is required to establish a common programme for a phased implementation of the new version of the ATS Route Network and associated sectorisation indicating intermediate evolutionary stages and appropriate target dates.

4.1.11 Harmonised Publication of ATS Routes

4.1.11.1 The ICAO AIS Manual (Doc. 8126) recommends that AIP - Part ENR 3 contains a list of all ATS routes established within the territory covered by the AIP, whether they form part of ICAO regional air navigation agreements or are for use by domestic traffic only.

4.1.11.2 As specified in Doc. 8126 – Appendix H (ENR 3. ATS Routes), a description should be included, where applicable, of the route(s), or portion(s) thereof, where special procedures are required. Additionally, an indication of the special procedures concerned should be given. Information relating to upper ATS routes should normally be listed separately in ENR 3.2.

4.1.11.3 In these circumstances, Permanent ATS routes and Conditional Routes (CDRs) should be listed together in so far as a single ATS route could contain both a permanent route portion and one or more segments of different categories of CDRs. Thus, there is no need to have additional designators for CDRs (see Chapter 4.4).

4.2 ATS ROUTE NETWORK DEVELOPMENT

4.2.1 General Approach

4.2.1.1 Since 1993 under the auspices of the Airspace & Navigation Team (ANT), the Route Network Development Sub-Group (RNDSG) has developed a planning process for versions of the ATS Route Network (ARN) which is "Top Down" and utilises a number of facilitating concepts and planning techniques which are described in the following sections.

4.2.2 A "Top Down" Approach

4.2.2.1 In developing versions of the ARN, the RNDSG has, as already mentioned, adopted a "Top Down" Approach which takes an ECAC wide view and is based upon the need for enhancement of overall ECAC ATM capacity. The process includes progression 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.

A schematic diagram of the Top Down Approach is given in <u>Annex 4C</u>.

4.2.3 Planning Principles (PP)

Versions of the ARN are developed on a number of agreed planning principles. They are:

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

4.2.3.2 **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.

4.2.3.3 **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.

4.2.3.4 **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.

4.2.3.5 **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.

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

4.2.4 Facilitating Concepts (FC)

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

Airspace planning should be based on a RNAV 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.*

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

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 as far as possible be supported by the generalisation of area type controlled airspace.

4.2.4.3 **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:

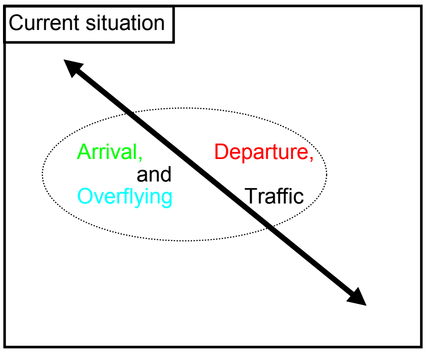
- when alignments of routes drawn independently of FIR boundaries determine the location of crossing points close to existing FIR/sector boundaries, in order to provide the controller with sufficient anticipation with respect to entering traffic;
- when alignments of routes affect an FIR airspace for 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.

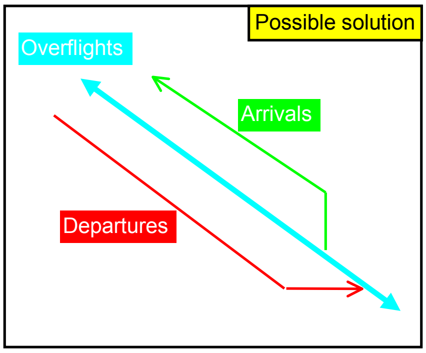
4.2.4.4 **FC 4 - As from Version 4, maximise the capacity enhancement potential of RVSM implementation on 24th January 2002.**

4.2.5 Planning Techniques (PT)

4.2.5.1 PT 1 - Establish specialised routes.

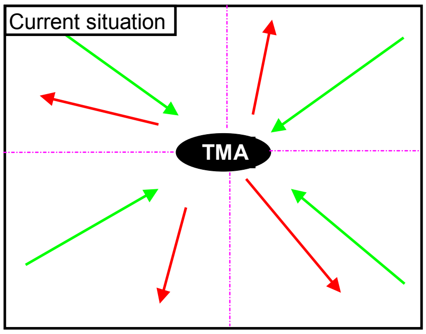
In dense areas, additional capacity can be gained by the segregation and deconfliction of arrival/departure routes and their separation from overflight routes. This structure should be applied for climbing and descending phases.

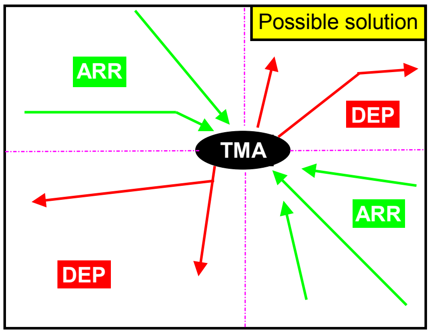




4.2.5.2 PT 2 - Establish specialised sectors.

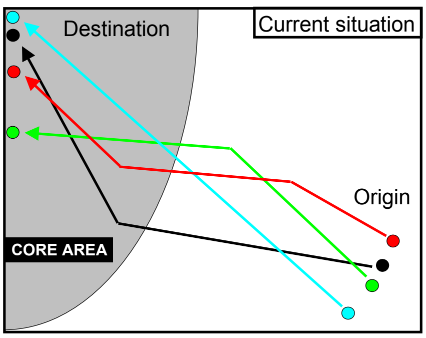
Based on the structure described above, specialised sectors should be established, grouping sets of routes of similar nature (arrival/departure; see illustration below), direction, and/or flight level series (odd level specialised sector, even level specialised sector). Where practicable, sectors should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

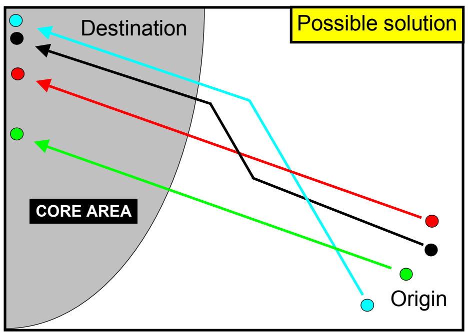




4.2.5.3 PT 3 - Organise any essential crossing of ATS routes carrying major traffic flows as close as practical to their origin.

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.





4.3 DEVELOPING A NEW VERSION OF THE ARN

4.3.1 General

4.3.1.1 In developing Version 3 of the ARN, the RNDSG produced a comprehensive list of criteria applicable to both route network and sector development. These were included in a separate document as a deliverable in the EATCHIP programme: Doc ASM.ET1.ST02.Del01. This deliverable was endorsed by the ANT in October 1997. As this work is still applicable in general terms to the development of routes and sectors, and as the time available to the RNDSG, did not allow a review of this work before the commencement of the development process for Version 4, it was agreed that the Version 3 criteria would continue to be the basis for Version 4, supplemented by specific criteria applicable in the context of RVSM Implementation.

4.3.2 Overview of Criteria used for Route Network and Sectorisation Development

4.3.2.1 The general criteria used for route network and sectorisation development, as drawn up for Version 3, are included as Annex A and Annex B. These general criteria are now complemented by the Guidelines developed as a result of the simulations and evaluations carried out to assess the impact of RVSM in an Airspace context. These EUR RVSM Implementation guidelines are summarised in Chapter 4.3.3.

4.3.3 Summary of Specific RVSM Criteria for Version 4

4.3.3.1 The implementation of RVSM will alter the vertical distribution of traffic as extra flight levels become available for use and the density of traffic on each flight level reduces. This should enable more aircraft to fly at, or close to, their optimum FL and permit a relaxation of the level capping restrictions on short haul city pairs. In order to manage this change in vertical distribution it will be necessary, where traffic levels dictate, to re-evaluate the Division Flight Level (DFL) between sectors based on 500ft intervals.

4.3.3.2 The criteria applicable to sector development are common to both core EUR RVSM and EUR RVSM Transition Airspace. Changes to the vertical dimension of sectors within Transition airspace are not considered necessary for RVSM implementation, but States may take this opportunity to evaluate the feasibility of introducing a DFL. In this case the possible increase in the climbing and descending traffic close to FL 290 should be taken into consideration.

4.3.3.3 Within the core EUR RVSM airspace the change in DFL should be based on operational needs and should:

- result from the ‘natural’ vertical traffic distribution rather than ‘force’ traffic to fit in with the vertical sector design.
- consider all airspace from ground to unlimited (including lower airspace) when planning the DFL.
- seek to balance the traffic loads between layers, avoiding unnecessary vertical co-ordination between the sectors.

4.3.3.4 The criteria for route network development includes specific guidance for Transition Airspace where route structure solutions involving uni-directional routes or Flight Level Allocation Schemes, ease the Transition Task in sectors where traffic levels warrant a structural solution. The increased use of uni directional and specialised routes for segregating and integrating departure traffic with overflying routes, is also valid in core EUR RVSM airspace.

4.3.3.5 The design and application of a FLAS is complex and the studies have shown that it should be designed using common planning principles, which avoid possible conflict over the choice of FLs on individual routes and permit extension if required. The selection of the preferred/blocked FLs should be kept to a minimum, be co-ordinated along the length of a route and be made according to a global rule in order to avoid frequent changes in FL. Although the FLAS options tested in the simulations were not advantageous to the ATS system as a whole there are instances where the controller workload can be reduced through its application. Therefore, it is recommended that the application of FLAS be restricted to major confluences and crossing points within EUR RVSM airspace and, when a route network solution cannot be found, to route segments close to the EUR RVSM/non-RVSM boundary in Transition Airspace.

4.4 ESTABLISHMENT OF CONDITIONAL ROUTES (CDR)

4.4.1 General Presentation of the CDR Concept

4.4.1.1 The Conditional Route (CDR) concept encompasses, by definition, all non-permanent ATS routes. CDRs are non-permanent parts of the published ATS route network that are usually established:

- through areas of potential temporary reservation (e.g. TRA or TSA), with CDR opening/closure resulting from associated military activities, and/or -
- to address specific ATC conditions (e.g. traffic restrictions or ATC sectorisation compatibility) with CDR opening/closure resulting from purely civil needs.

4.4.1.2 CDRs will be established by the Level 1, allocated at Level 2 by the AMC and utilised at Level 3 by ACCs. CDRs will usually be established and utilised as pre-planned routing scenarios. CDRs will permit the definition of more direct and alternative routes by complementing and linking to the existing ATS route network.

4.4.2 Criteria for the Definition of Routing Scenarios

4.4.2.1 CDRs should be planned to complement the ATS Route network and should lead to the development of flexible, but pre-defined routing scenarios (see examples in Annex 4D). Scenarios based on CDRs should take due account of the:

a) Expected traffic demand and nature of the traffic: *manoeuvring, overflying, arrival or departure*;
b) Foreseen period of CDR availability and the CDR Category (see paragraph 4.4.3.2.3 below and Annex 4E);
c) Expected impact on ATC Sector Capacity and flight economy resulting from CDR use;
d) Flexibility of an eventual change in ATC sectorisation configuration required for activation/de-activation of CDRs;
e) Existing national boundaries, airspace and route structure and TMA interface: *possibility of cross-border CDRs;*
f) Possible impact on ATS airspace classification: *the airspace class may be different when the change of area status from TSA to CDR leads to the provision of different air traffic services;*
g) Application of RNAV techniques;
h) Capability of the FPPS to activate the different routing scenarios;
i) Impact on OAT and GAT controllers' workload.

4.4.3 Criteria Governing the Categorisation of Conditional Routes

4.4.3.1 General

4.4.3.1.1 CDRs can be divided into different categories according to their foreseen availability, flight planning possibilities and the expected level of activity of the (possible) associated AMC-manageable areas (see Para 4.4.3.3.1). A CDR can be established at Level 1 in one or more of the three following categories:

a) Category One - Permanently Plannable CDR during the times published in AIPs;

b) Category Two - Non-Permanently Plannable CDR, and

c) Category Three - Not Plannable CDR.

4.4.3.2 CATEGORY ONE- Permanently Plannable CDR during the times published in AIPs

4.4.3.2.1 When a CDR is expected to be available for most of the time, it can be declared as permanently plannable for stated time periods and published as a Category One CDR (CDR 1) in AIPs. CDRs 1 can either be established on a H 24 basis or for fixed time periods.

4.4.3.2.2 CDRs 1 will form part of the strategic ATS route planning process and will complement the permanent ATS route network. Consequently, CDRs 1 are expected to be available for the time period declared in the AIP. Any closure of a CDR 1, which needs action to re-file the flight plan, has therefore to be published with appropriate advance AIS notice.

4.4.3.2.3 In the event of a short notice unavailability of a CDR 1, aircraft will be tactically handled by ATC at Level 3. Operators should consider the implications of such a possible re-routing and use of the alternate ATS routes published for each CDR 1 in the "Remarks" column of the AIP (see paragraph 4.4.3.2.4).

4.4.3.2.4 Therefore, when deciding on the categorisation of a Conditional Route as CDR 1, the impact of its unavailability on ACCs handling must be carefully assessed[10]. But, when national ATS route closure process can be transparent to the operators and has no impact on neighbouring States, CDR 1 unavailability will be managed by the AMC at Level 2 in a similar way as CDR 2 availability and be promulgated as such in Airspace Use Plans (AUPs) only for information to Approved Agencies (AAs) and ATS units concerned.

4.4.3.2.5 Any foreseen period of non-availability of CDRs 1 known or decided at pre-tactical level would if practicable, be promulgated for information to national AAs and ACCs concerned through national AUPs in the list "BRAVO" of Closed ATS Routes. In such cases, and considering the impact on RPL/FPL processing, the unavailability information is only for AAs and ATS units and will be handled at Level 3 which will then not require flight planning actions by AOs.

4.4.3.2.6 CDR 1 closures will therefore only be promulgated in the Conditional Route Availability Message (CRAM) as repetition for safety of the decision already published with appropriate advance AIS notice.

4.4.3.2.7 When establishing CDR 1, the national high level policy body should provide the Airspace Management Cell (AMC) with clear criteria for publication of its possible unavailability especially when the consequence on ACC Sector capacity and handling is very important e.g. during Peak Hours or weekends[10].

[10] *In the case of exceptional military activities, if this unavailability has to be applied to weekend routes, the re-routing of significant numbers of aircraft by ATC may not be feasible. In that case, AOs would be required to change their RPLs/FPLs in accordance with the CDR 1 closures published with appropriate advance AIS notice.*

4.4.3.2.8 When tactical re-routing is taking place due to a CDR 1 closure, any aircraft which experiences radio communication failure before receiving re-routing instructions will continue on the flight planned route. It could therefore penetrate an active Temporary Segregated Area (TSA). Planners must be aware of the need for ATC to be able to curtail activity in a TSA at very short notice to maintain safety.

4.4.3.2.9 When establishing a CDR 1, the national high level policy body should therefore ensure that procedures are established for the safe handling of flights which experience radio communication failure.

4.4.3.3 CATEGORY TWO - Non-Permanently Plannable CDR

4.4.3.3.1 Category Two CDRs (CDRs 2) will form part of pre-defined routing scenarios. CDRs 2 will be established and utilised with the aim of maximising one or more of the following benefits: - better traffic distribution, increase in overall ATC capacity and flight economy.

4.4.3.3.2 CDRs 2 availability can be requested to adjust traffic flow, when a capacity shortfall has been identified and after consideration of relevant ACC factors has been made by the FMPs/ACCs concerned.

4.4.3.3.3 Flights on CDRs 2 may be flight planned only when the CDR is made available in accordance with the appropriate AMC allocation listed in part “ALPHA” of the AUP and repeated in the CRAM.

4.4.3.4 CATEGORY THREE - Not Plannable CDR

4.4.3.4.1 Category Three CDRs (CDRs 3) are those that are expected to be available at short notice. Flights will be planned on the basis of the utilisation of the permanent ATS route network around the areas.

4.4.3.4.2 After co-ordination with the military unit(s) in charge of the associated TRA, TSA, R or D Area(s), the GAT controller may offer an aircraft a short-notice routing through the area using a pre-defined CDR 3.

4.4.3.4.3 CDRs 3 can be published in AIPs as CDRs usable on ATC instructions only. CDRs 3, not being subject to allocation the day before by AMCs, will not form part of the AUP nor the CRAM.

4.4.3.5 Guidelines for the Categorisation of CDRs - (see Annex 4E)

4.4.3.5.1 When States decide on the category to be applied to a CDR they should, in addition to their foreseen availability, take due account of the :

a) Possible complexity of co-ordination with the military units involved and the opening in real-time of CDR 3;
b) Possible Cross-Border aspects and harmonise with their neighbours to the greatest possible extent the categorisation, Flight Levels and intended availability of such routes;
c) Possible difficulties of re-routing, in real-time, all or some aircraft;
d) Need for the dissemination of the CDR availability the day before operations to all ATM users (ACCs, CFMU/IFPS/CADF, AOs, ...) or to confine such information to one or several ATC sector(s) within one ACC for tactical use only;
e) Possibility to form part of different routing scenarios (see paragraph 4.4.3.2.2);
f) Possible complexity of being used under more than one category and in particular harmonise with their neighbours the fixed period of “Weekend” routes as Category 1 and the intended availability as Category 2;
g) Expected impact on ATC sector management (grouping/degrouping).

4.4.3.5.2 In order to assist national Level 1 Route Planners in the Categorisation of ATS Route in Permanent Route or one of the three different categories of CDRs, guidelines based on eight (8) major questions related to ATFM, ATC and ASM requirements are proposed at Annex 4E.

4.4.3.5.3 A CDR can be established at Level 1 in more than one of the three categories. For example, two flight planning possibilities can be defined for a particular CDR e.g. a CDR used at week-ends can be plannable during a fixed period from Friday 17.00 to Monday 08.00 (Category One), or flight planned in accordance with AUPs at other times (Category Two).

4.4.4 Harmonised Publication of Conditional Routes

4.4.4.1 The possible partition of a CDR into different categories on a time and/or on vertical basis requires both the indication of the CDR category in the “Remarks” column in the AIP description of ATS routes, and the addition of an explanatory note at the front of ENR 3. A fictitious example of a harmonised publication of the three categories of CDRs is given in Annex 4F.

4.4.5 Depiction on the ASM Planning Chart

4.4.5.1 ICAO also requires the ATS route scheme to be displayed on a chart. For that purpose Permanent Routes and the three different categories of CDRs should have a distinct depiction style to indicate how operators should flight plan for such routes.

4.4.5.2 For airspace planners, EUROCONTROL produces (paper) ASM Planning Charts in different scales and an electronic map (Skyview). Both of them depict permanent routes in plain black lines, CDR 1 in dashed black, CDR 2 in dashed red, CDR 3 in dashed green and mixed categories CDR 1/CDR 2 in dashed purple.

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Annex 4A

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

1. GENERAL CRITERIA FOR ATS ROUTE NETWORK DEVELOPMENT

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 routings.

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.

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.

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.

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.

1.5 Extension of the FUA concept

Extension of the FUA concept to additional direct routings 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 routings which is today generally applied within one sector. The automated reprocessing of flight plans would facilitate the further application of this concept.

1.6 Network Architecture

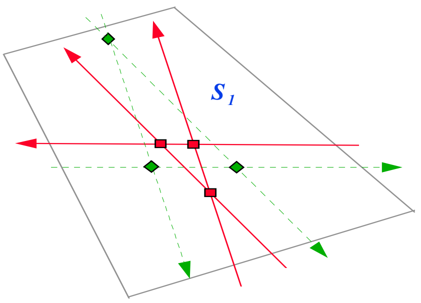
The definition of major traffic flows should include heavily loaded intra-European routes and/or segments which should be integrated in the overall structure at an early stage of the planning.

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

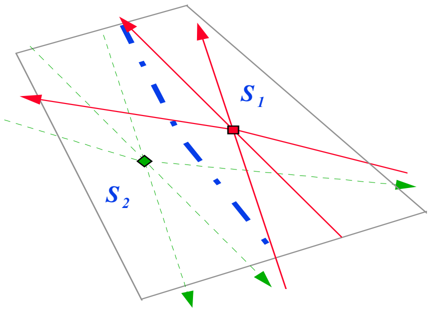
Efforts to eliminate specific traffic bottlenecks should include, as a first step, an in-depth analysis of the factors causing the congestion. In this regard, particular care should be taken to avoid worsening the situation in one area by attempting to improve it in the other.

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

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 should be kept to a minimum but should be in line with the traffic demand in respect of ATM capacity and most direct routing.

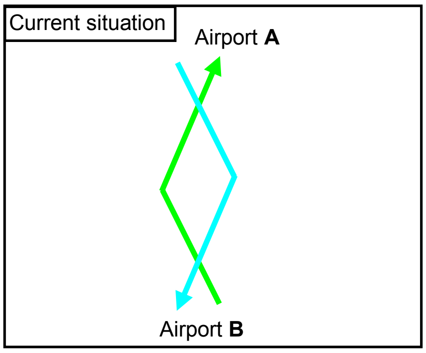
Although it is accepted that a large number of ATS routes can improve route capacity, it is also recognised that a large number of crossing points, especially in congested areas, can reduce sector capacity. Planners should optimise capacity by introducing new routes with as few crossing points as possible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

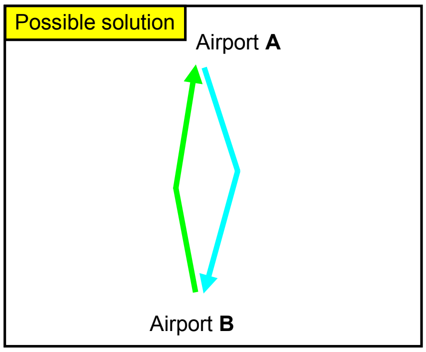
Whenever in the planning phase and based on forecast demand, an ATS route has been planned to accommodate a specific flow of traffic, its subsequent implementation should - if the traffic demand by that time is no longer met - be reconsidered. Redundant ATS routes should be deleted.

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.

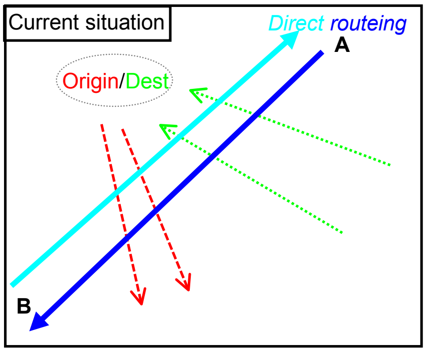
1.7 Planning of Routes

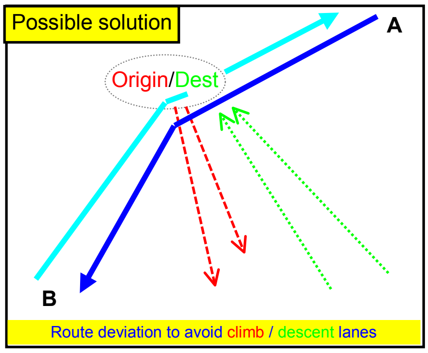
Planning should ensure that where dualised routes are used uni-directionally for opposite traffic flows, cross-overs are avoided as far as possible.



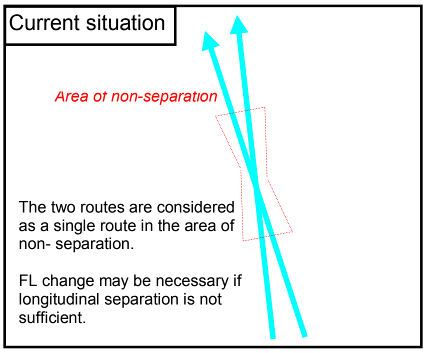


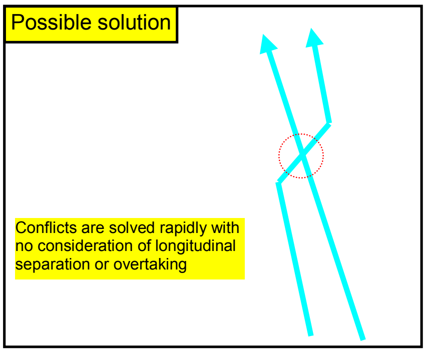
Crossing areas should not conflict with climb or descent lanes of major airports.



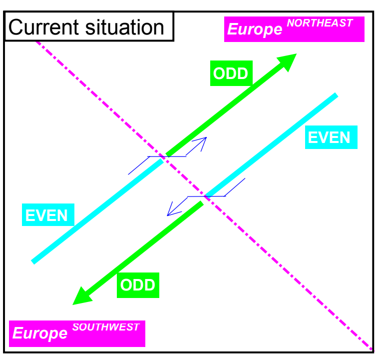


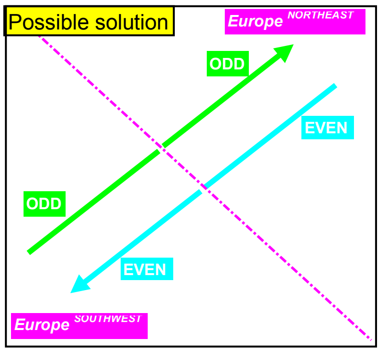
The extension of crossing areas between ATS Routes should be kept to a minimum (crossing at right angles).



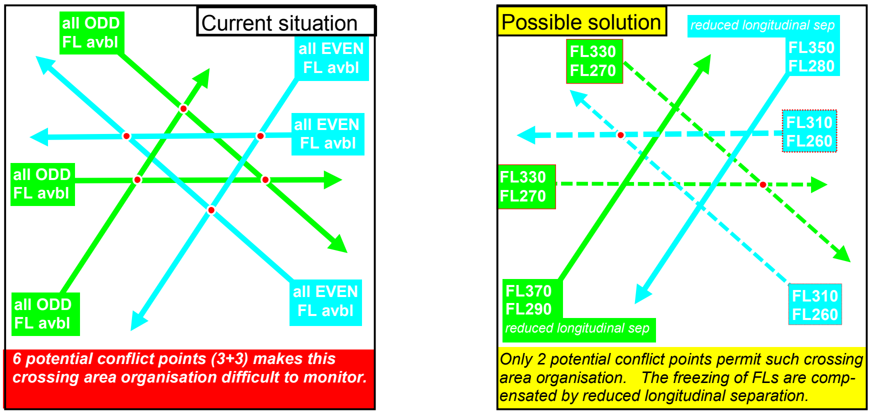


Currently two different applications of the ICAO table of cruising levels coexist in the EUR Region. This leads to a requirement for aircraft transiting the boundary between the two application areas to change flight levels. Consideration should be given to the possible increase of system capacity which 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.





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.



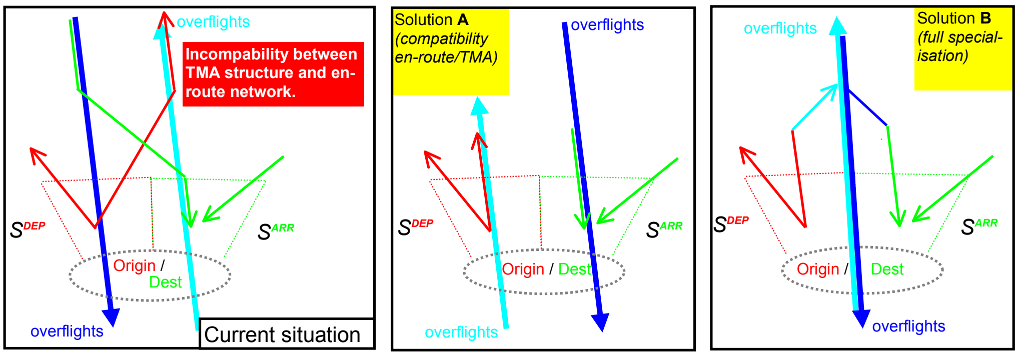
1.8 Shorthaul Routes and Levels

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

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.



Annex 4B

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

1 GENERAL CRITERIA FOR AIRSPACE SECTORISATION DEVELOPMENT

1.1 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.

1.2 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 affect 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 constrains the options for solutions, whereas the Top Down or Network-oriented approach (Appendix A.6 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.

Summary of method/rationale:

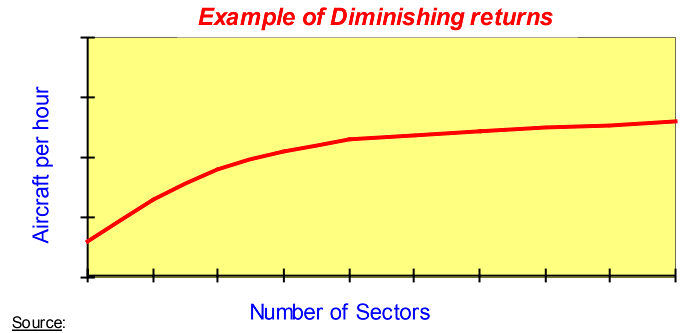
- Step 1: Route Network initial proposal
- Step 2: Examination of sectorisation viability
- Step 3: Harmonisation of outcome of step 1 and step 2

1.3 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 (conflicts) 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

1.3.1 Option 1: Additional Sectors

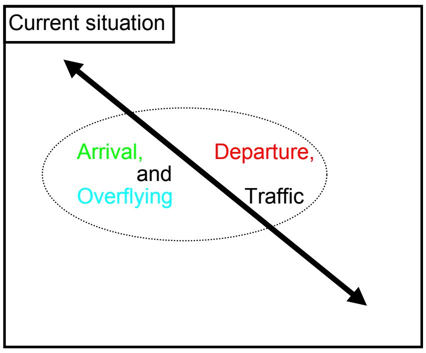
The provision of additional sectors is the classic method of increasing capacity. Although scope still exists for this in most of the ECAC airspace outside the core area or in the upper layers (vertical split), this is not always the most efficient method. Furthermore, in the core area the introduction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

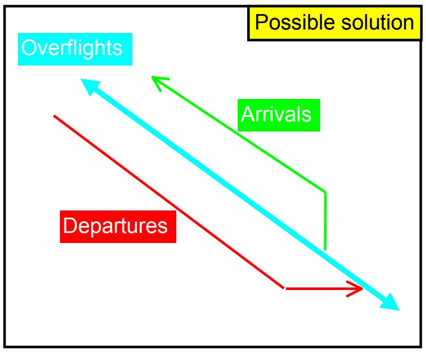
- limits are almost reached (diminishing returns)
- frequency shortage
- co-ordination burden (workload increases)
- short transit times
- complex network (within Lower Airspace, especially close to TMAs)

1.3.2 Option 2: Increased Sector Capacity

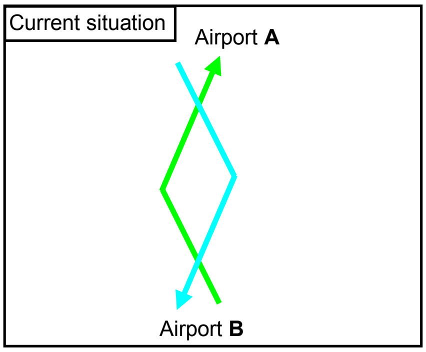
In the core area especially, therefore, the efforts of the RNDSG must be focused on increasing sector capacity. This objective can be facilitated, if airspace planners in the overall design of the route network bear in mind the need to reduce the complexity of ATS route structure and thereby control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

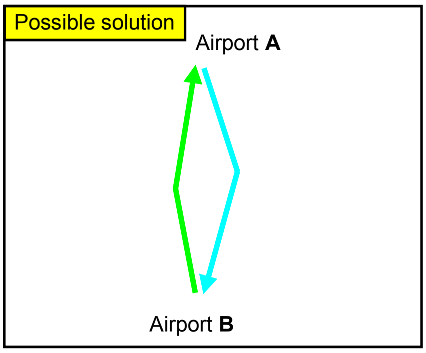
keeping the number of ATS routes controlled by a sector to a minimum
specialisation of routes (dualised routes/deconflicted ARR/DEP routes)



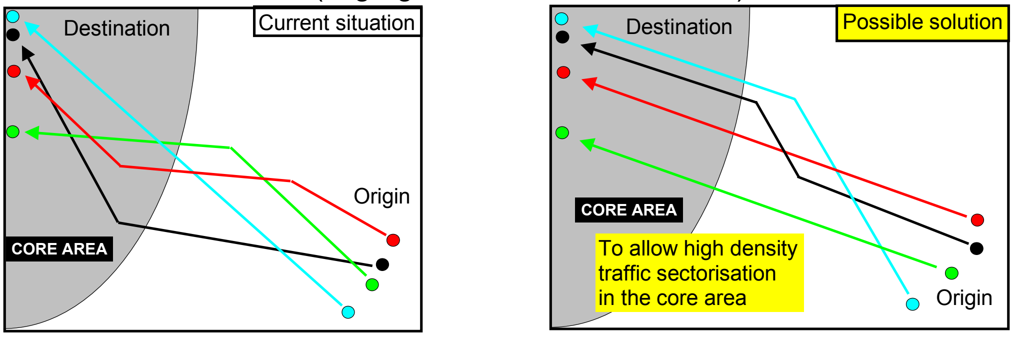


- deconfliction of traffic flows (elimination of unnecessary cross-overs)

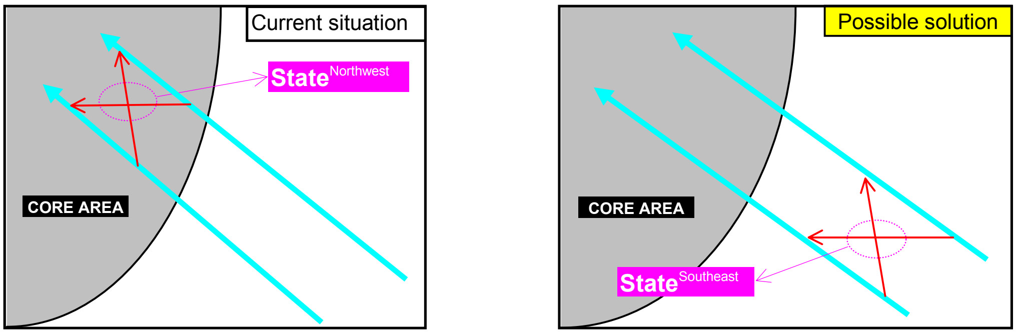




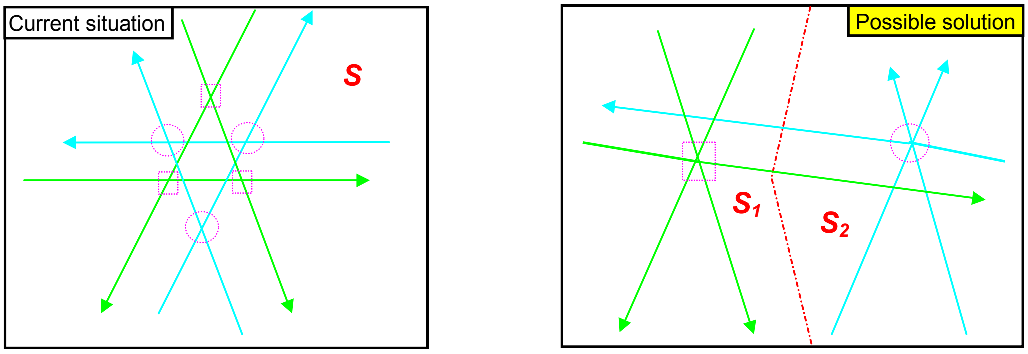
- organisation of traffic flows (segregation of main traffic flows)



- 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.

1.4 Criteria

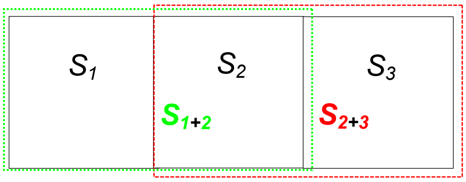
As a fundamental tool to ensure the relationship mentioned above, it is necessary to have standardised criteria developed by the RNDSG in order to establish, modify or validate en-route and Terminal sectors.

1.4.1 General Criteria Applicable to Sector Development :

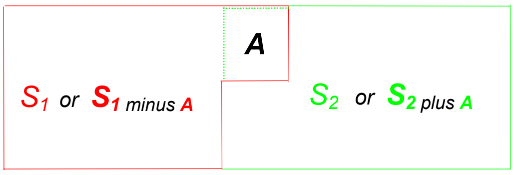
Sectorisation architecture should be:

- 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
- 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
- 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

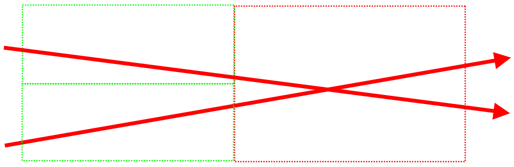
1.4.2 **Specific Criteria to Enhance Sector Capacity:**

I. Conflict Points:

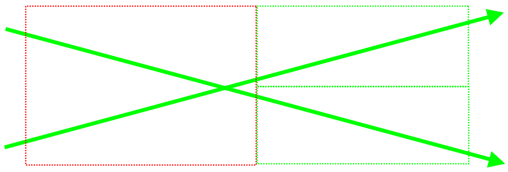
Sectorisation architecture should:

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

- 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)

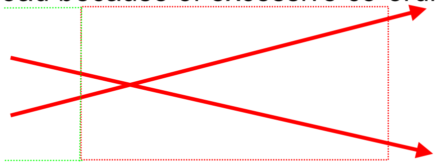


NO

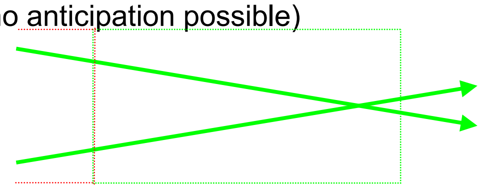


YES

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



NO



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 ⟷ 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
∗ tactical direct routings
∗ 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:

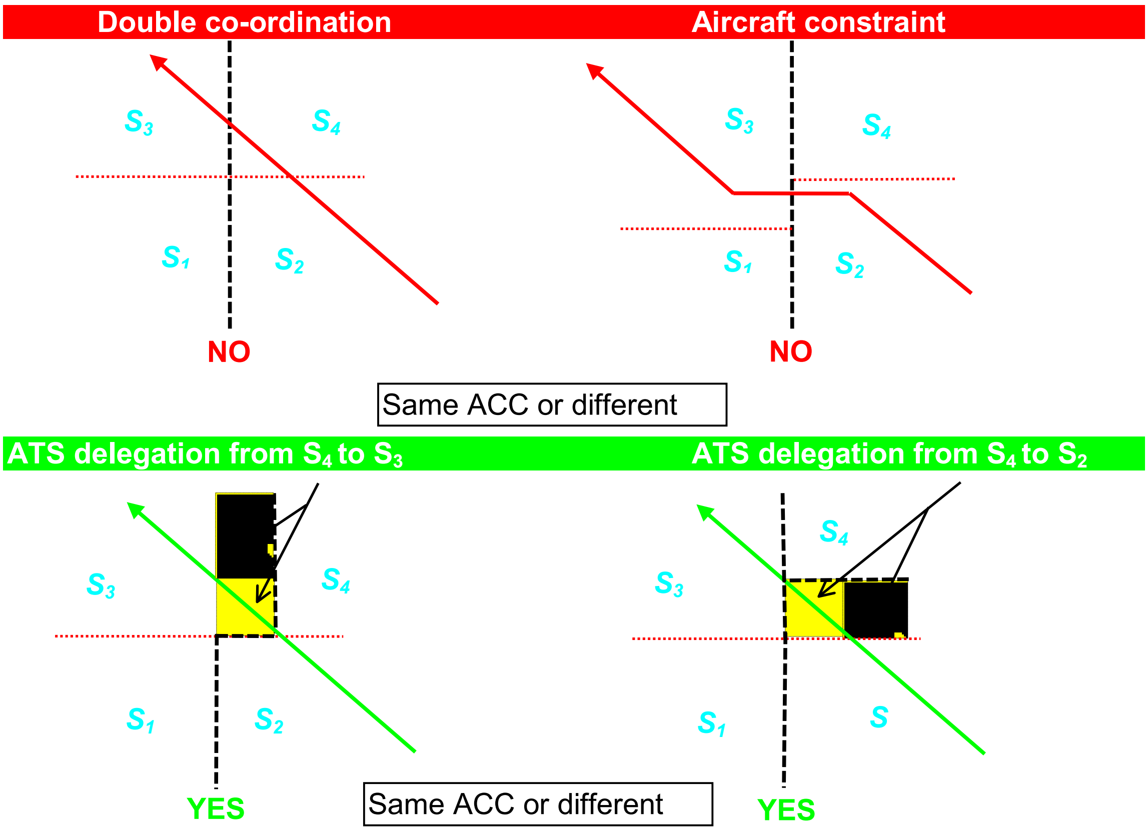
big sector	⟵ *versus* ⟶	**small sector**
better flexibility		better productivity
better anticipation		better efficiency through specialisation
more appropriate for varying flow demand		more rigid

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

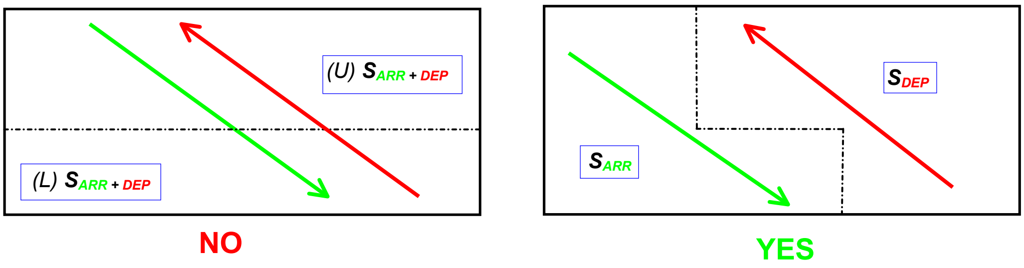
IV. Sector Boundaries/Sector Shape

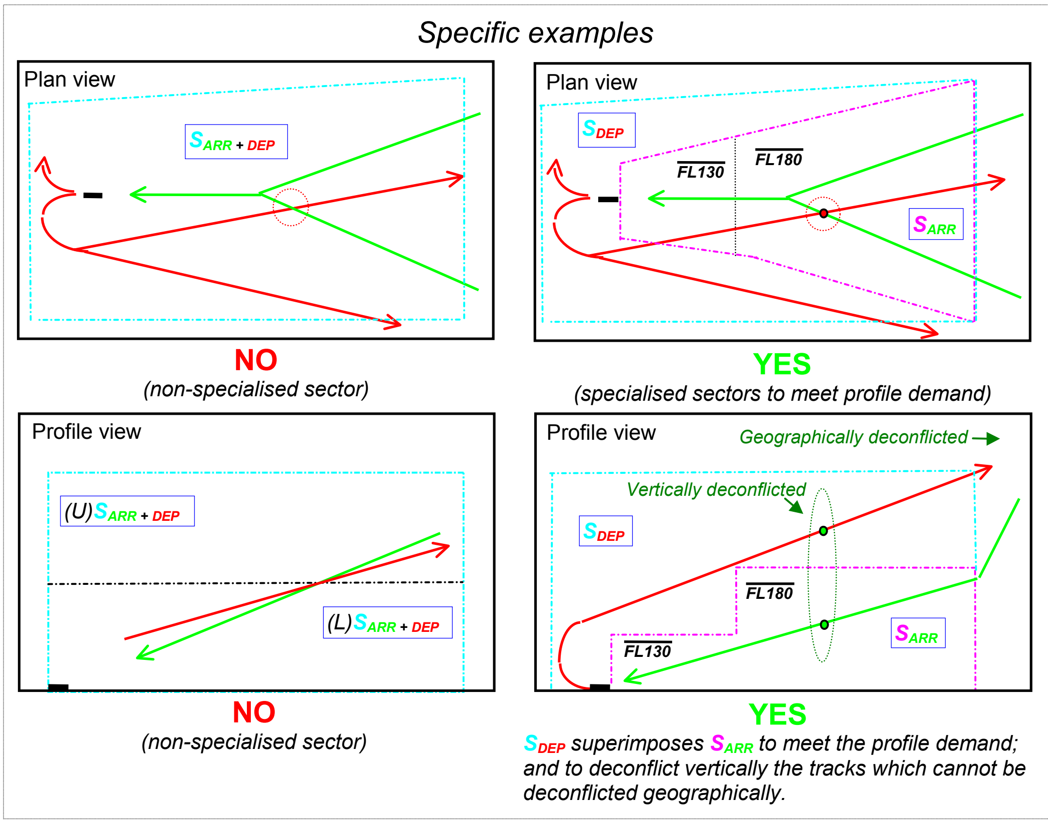
Sectorisation architecture should:

- 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)



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



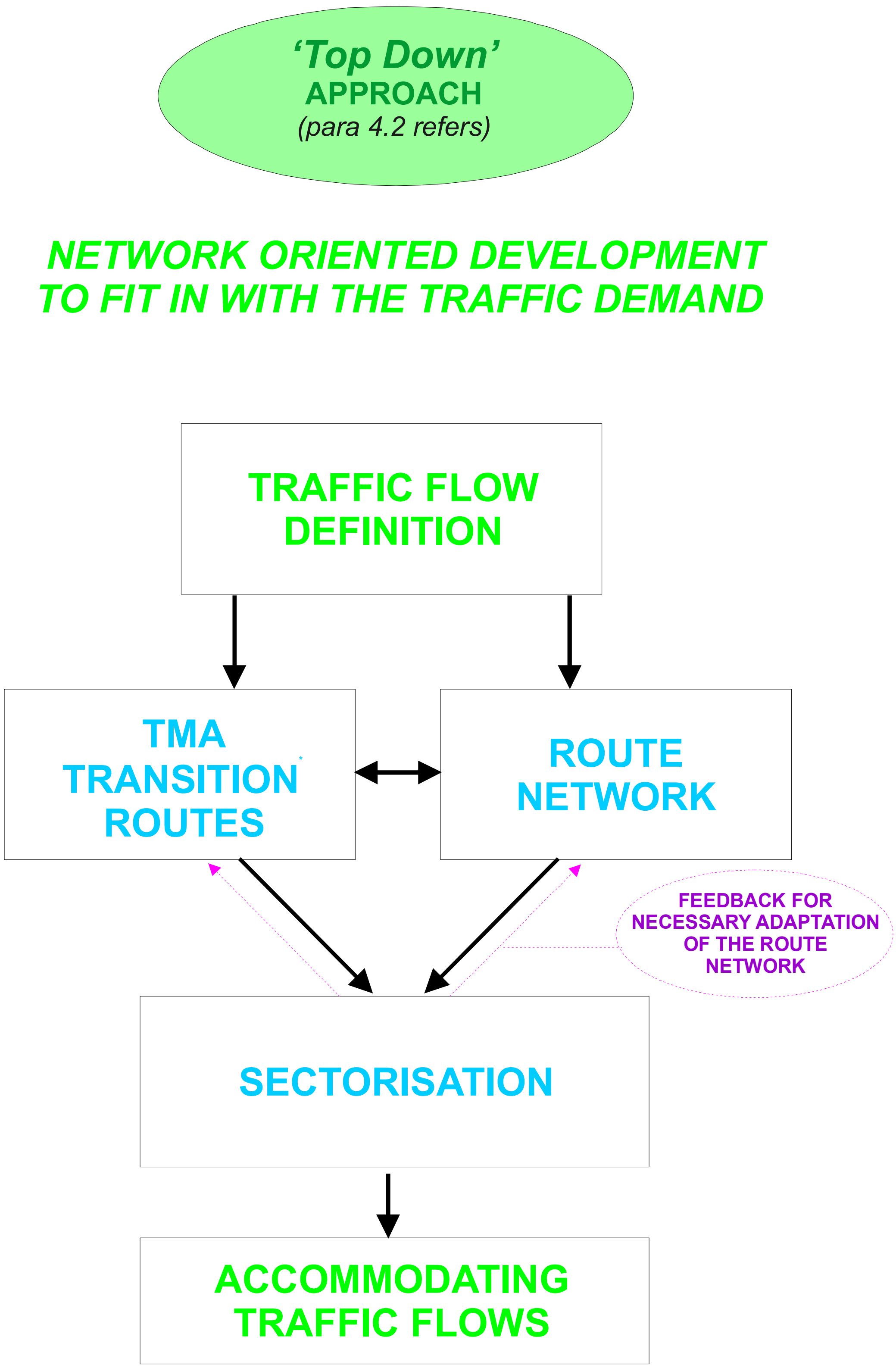


- promote overall system flexibility in support of fuel-efficient direct routes
- have varying division levels/level splits all over Europe depending on traffic patterns/source of traffic and the performance of aircraft (this means that a "standard" division FL 245 between Upper and Lower Airspace could 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)

1.5 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.

Annex 4C


'Top Down'
APPROACH
(para 4.2 refers)
NETWORK ORIENTED DEVELOPMENT
TO FIT IN WITH THE TRAFFIC DEMAND
TRAFFIC FLOW DEFINITION
TMA TRANSITION ROUTES
ROUTE NETWORK
FEEDBACK FOR NECESSARY ADAPTATION OF THE ROUTE NETWORK
SECTORISATION
ACCOMMODATING TRAFFIC FLOWS

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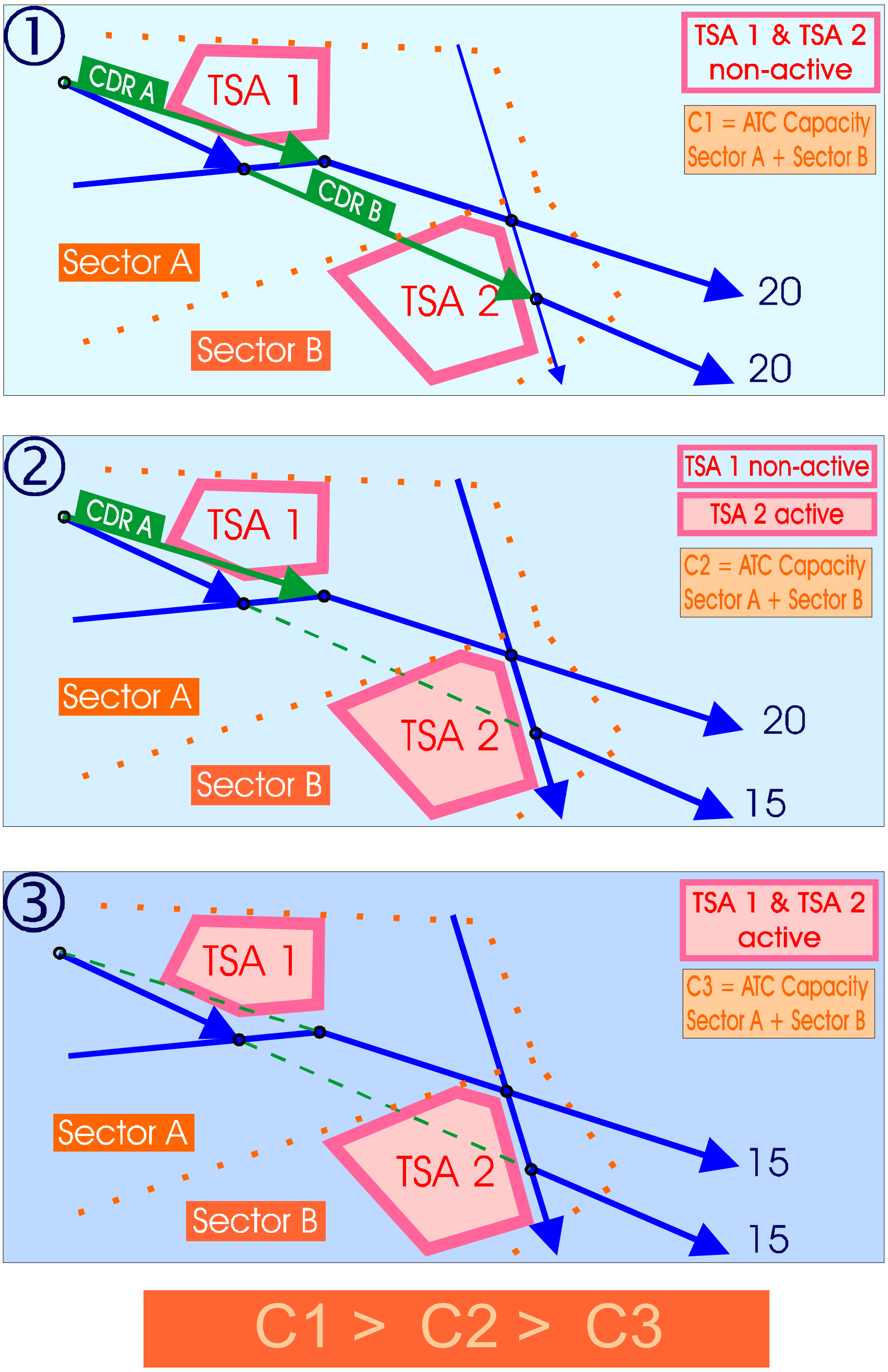
Annex 4D

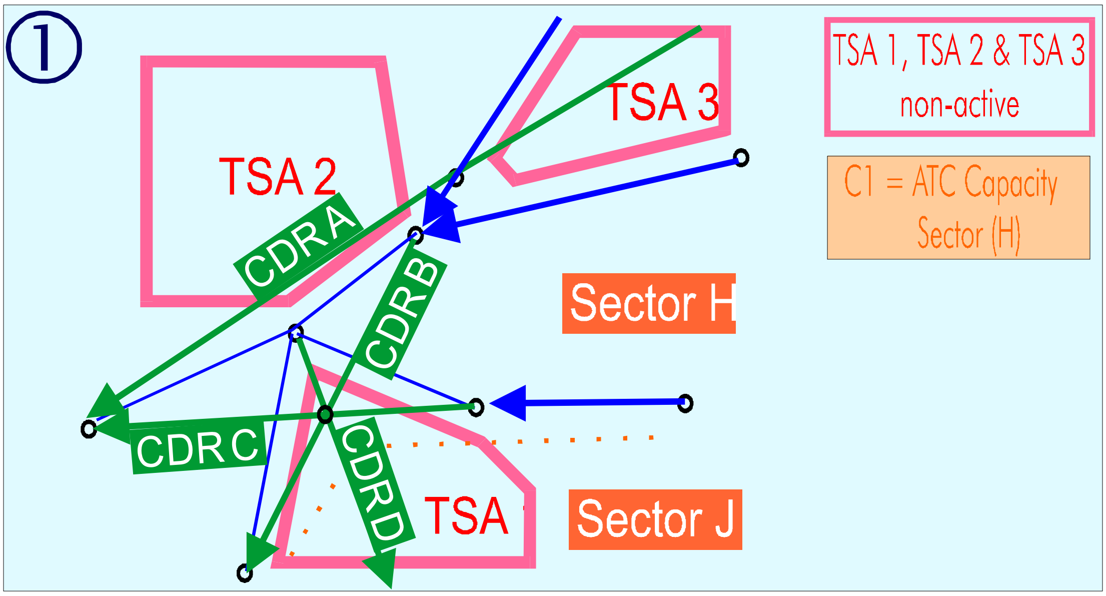
EXAMPLES OF CDR ROUTING SCENARIOS

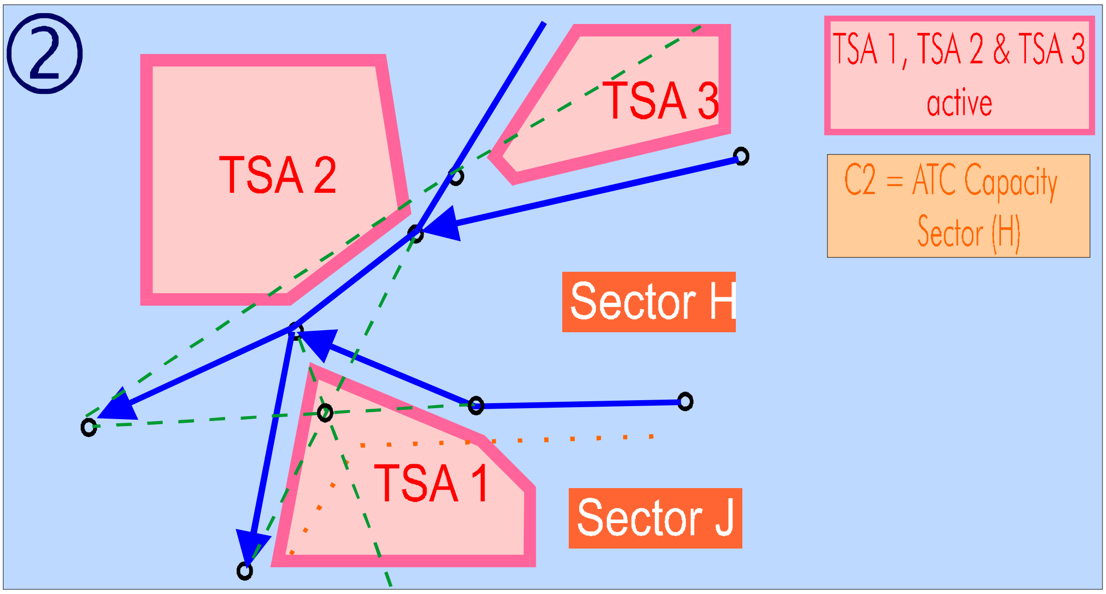
❶ SCENARIO 1



EXAMPLES OF CDR ROUTING SCENARIOS (cont'd)

❷ SCENARIO 2

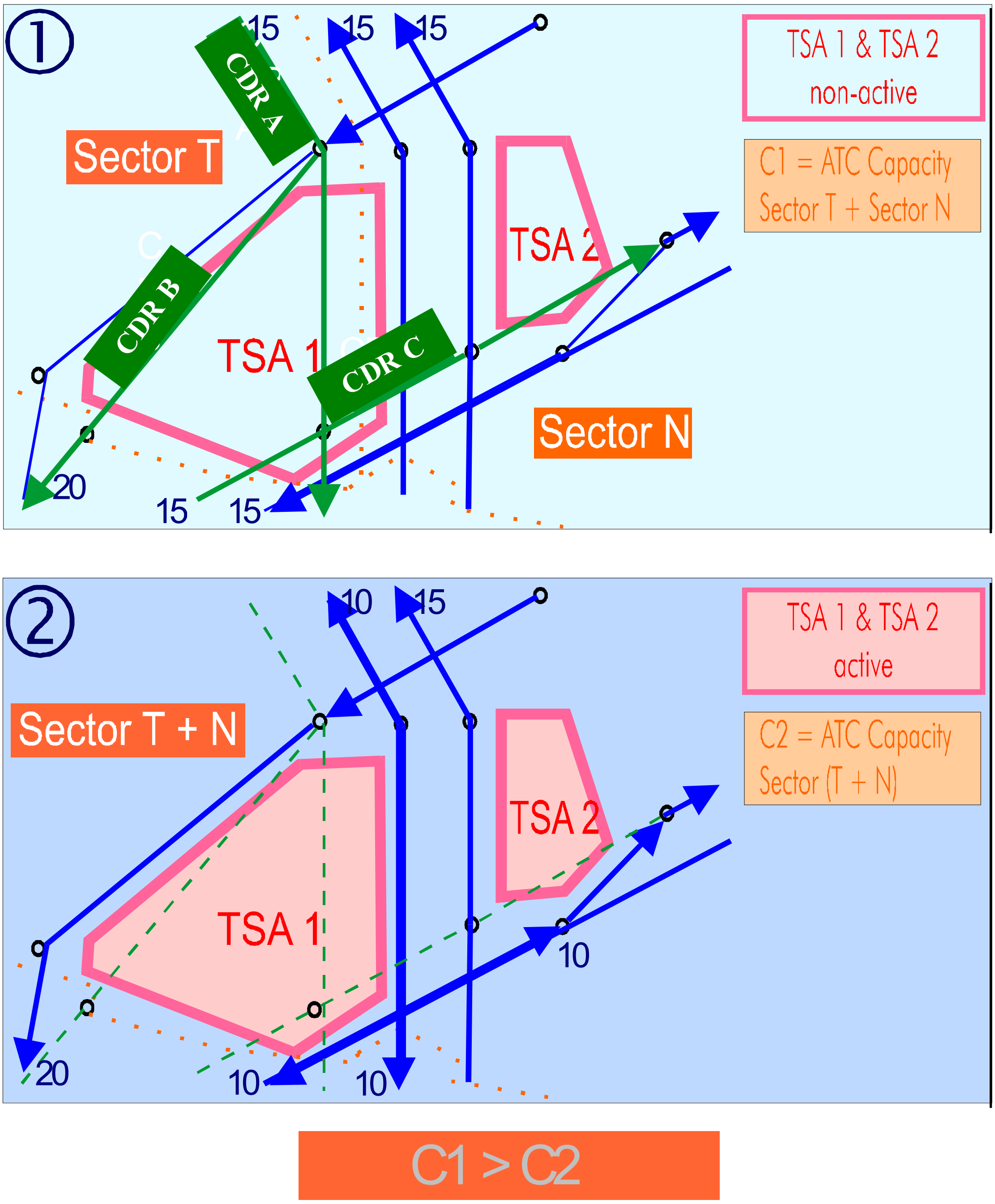




C1 = C2

EXAMPLES OF CDR ROUTING SCENARIOS (cont'd)

❸ SCENARIO 3



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Annex 4E

GUIDELINES FOR CDR CATEGORISATION

1. GENERAL

1.1 Guidelines for CDR Categorisation are based on the following eight major questions which should be read in conjunction with the diagram on page 4.

1.2 The expected rate of CDR availability would obviously be dependent on the foreseen usage of the associated TSA, but would only be one parameter amongst others used to determine the CDR category.

1.3 Thus, in order to profit from the daily pre-tactical co-ordination with 24H advance notice, the following requirements should be considered for the three ATM components:

- **ATFM**: allow the CFMU to manage potential gains in ATM system capacity;
- **ATC** : provide ATC with correct flight data without controller intervention;
- **ASM** : give enough stability and provision to ATM system and military activities.

2. DIFFERENTIATION BETWEEN PERMANENT ROUTE AND CDRs (*See* ◆ ➊)

2.1 The first question associated with ◆ ➊ is: would the proposed route be qualified as a “Permanent” Route or as a CDR?

2.2 Apart from other factors such as the existence or otherwise of associated AMC-manageable area(s), the decision would only be based on whether the route would be permanently available or not.

2.3 Any very rare route closure known sufficiently well in advance such that it could be published by appropriate AIS notice would be applicable to both Permanent Route and Category One CDR. This criteria would therefore not be used to differentiate a CDR from a Permanent ATS Route.

2.4 When the route would not be permanently available, it should be considered as a Conditional Route (CDR). The Conditional Route would either be expected to be available during fixed time period as for Category One CDR or could be daily managed by the AMC with 24H advance notice as for Category Two CDR or be declared (un)available at short notice and the associated re-routing be tactically handled by ATC at Level 3 as for Category One and Category Three CDRs.

3. ATFM REQUIREMENTS

3.1 Expected Impact on ATC Sector Management (See ◆ ❷)

3.1.1 The question associated with ◆ ❷ is: would the proposed route and its alternate be established in two different ATC sectors? If 'yes', progress to ◆ ❸, if not progress to◆ ❹

3.1.2 Consideration should be given in particular to the possibility of establishing the proposed route in a sector currently under utilised, or, to relieve an adjacent critical sector from frequent overloading, or, from imposing repeated delays.

3.2 Possible Demand/Capacity Imbalance (See ◆ ❸)

3.2.1 The third question associated with ◆ ❸ based on the expected demand/capacity imbalance is: should correct flight data processing be requested for ATFM Pre-Tactical measures? if the answer is 'yes', progress directly to◆ ❼**a**, if the answer is 'no' progress to ◆ ❺**.**

3.3 Increase in ATC Sector Capacity (See ◆ ❹)

3.3.1 The question posed in ◆ ❹ is: would the availability of the proposed route lead to a formal change in the sector capacity figure? The related ATFM actions having no direct impact in the CDR categorisation process, progress directly to ◆ ❺**,** if the answer is either 'yes' or 'no'.

Note: This means that the CFMU will react on sector capacity changes whatever category of CDR is involved.

4. ATC REQUIREMENTS

4.1 Correct FPLs Requested by ATC (See ◆❺)

4.1.1 The question posed in ◆ ❺ is: should correct FPLs be requested by ATC? If the answer is 'yes', progress to ◆ ❻. If the answer is 'no', progress directly to ❼**b.**

4.2 Correct Flight Processing Done Locally (See ◆ ❻)

4.2.1 The question posed in ◆ ❻ is: would local reprocessing of FPL be impossible? If the answer is 'yes', which means that FPLs **can't** be reprocessed locally, progress to ❼**a.** If the answer is 'no', which means that FPLs **can** be reprocessed locally, progress directly to ❼**b.**

Note: If the answer to ◆ ❺ or to ◆ ❻ is 'no', this means that in the event of short notice (un)availability of a CDR, tactical re-routing will be instructed by ATC.

5. ASM REQUIREMENTS

5.1 **Expected High CDR Availability for most of the time or during fixed time** (See ◆ ❼**a**)

5.1.1 The question associated with ◆ ❼**a**, based on expected high CDR availability, is: would the proposed route expected to be available for most of the time (i.e. H 24) or during fixed time period (e.g. at week-ends, nights or at peak hours) and any very rare long-term closure be published with appropriate AIS notice ? If the answer is ‘yes’, the route should be categorised as a CDR1. If the answer is ‘no’, progress to ❽.

Note: If the answer to ◆ ❼**a** is either ‘yes’ or ‘no’, this means that tactical rewriting being not possible, CDR (un)availability requires in any case action to refile the flight plan.

5.2 **Expected High CDR Availability for most of the time or during fixed time** (*See* ◆ ❼**b**)

5.2.1 The question associated with ◆ ❼**b**, based on expected high CDR availability, is: would the proposed route expected to be available for most of the time (i.e. H 24) or during fixed time period (e.g. at week-ends, nights or at peak hours) and in the event of short notice unavailability, tactical re-routing be instructed by ATC (See Note below ◆ ❺ and ◆ ❻)? If the answer is ‘yes’, the route should be categorised as a CDR1. If the answer is ‘no’, then the route proposal should be categorised as a CDR3.

5.3 **CDR 2 Availability Criteria** (*See* ◆ ❽)

5.3.1 The question associated with ◆ ❽, to confirm that a proposed route was eligible for categorisation as a CDR 2 is: would the minimum activation time of the route be two hours or more as defined in para. 4.5.4.i ? If the answer is ‘no’, it should be rejected for categorisation as a CDR altogether.

6. EXAMPLES OF CDR CATEGORISATION (*See next Pages*)

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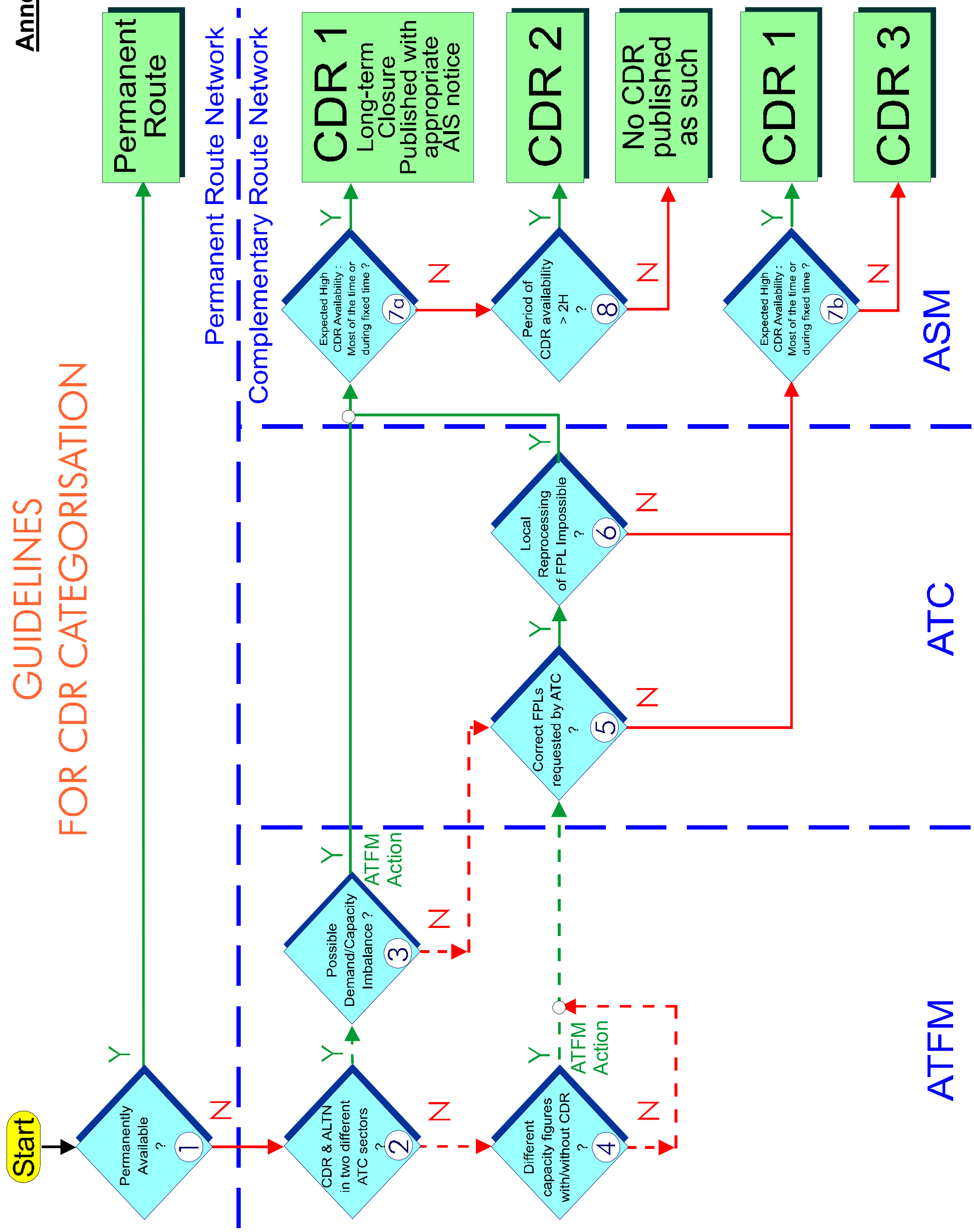
Annex 4E – Page 4



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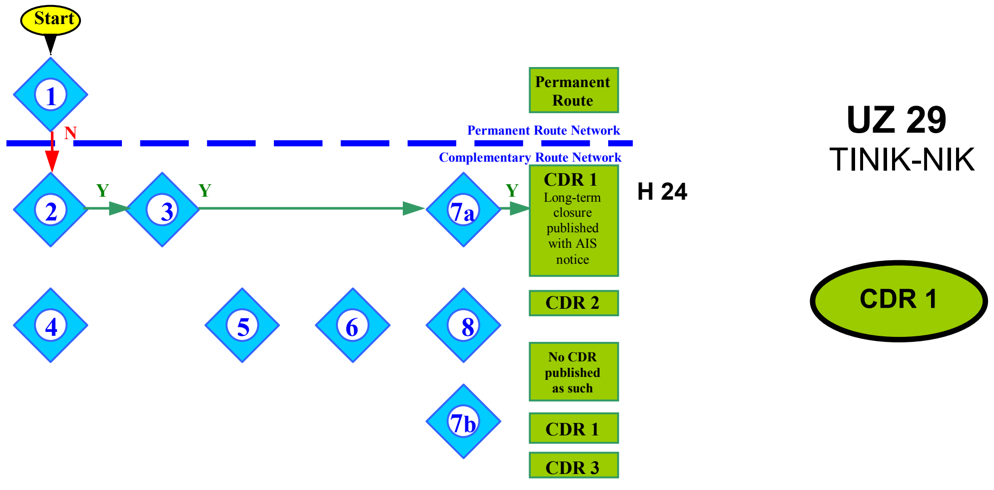
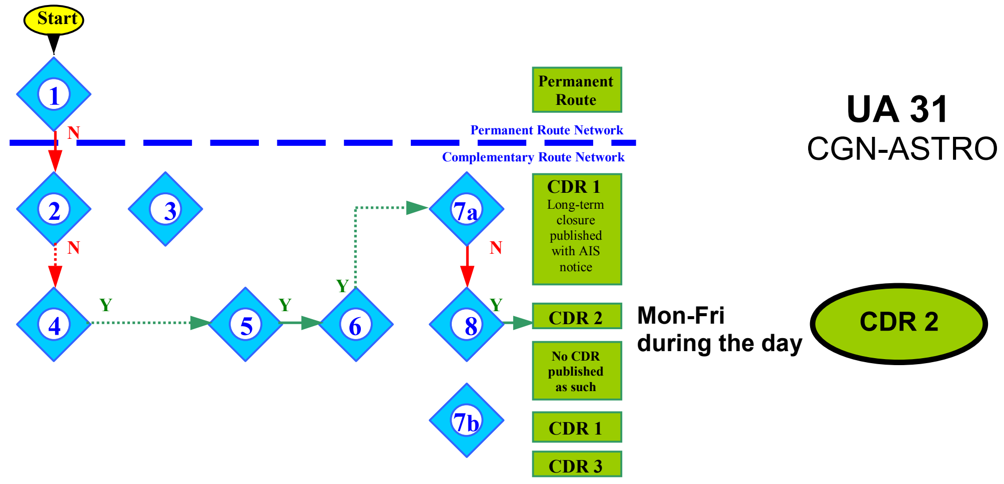
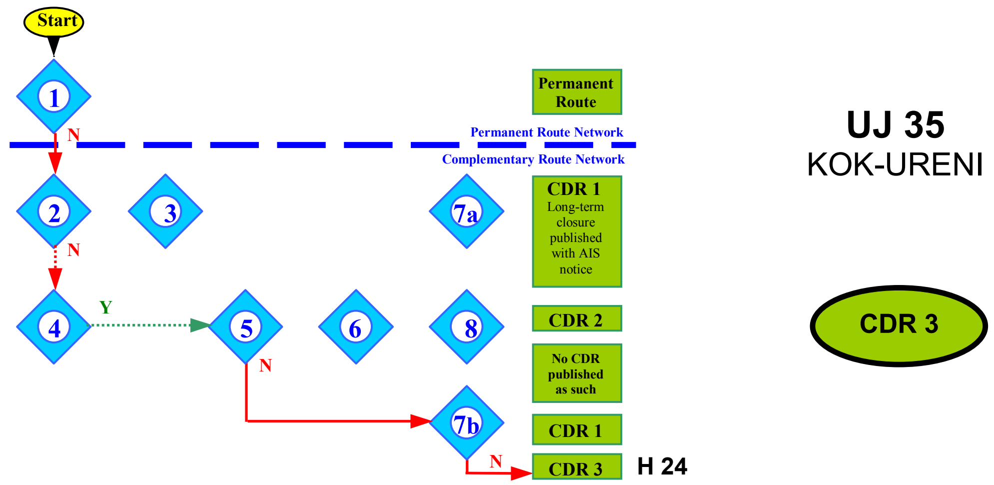
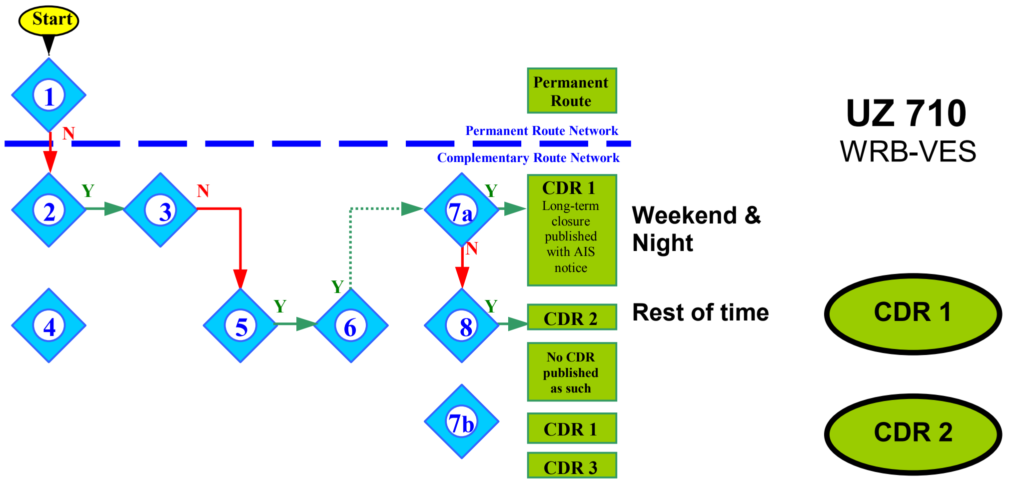
EXAMPLES OF CDR CATEGORISATION

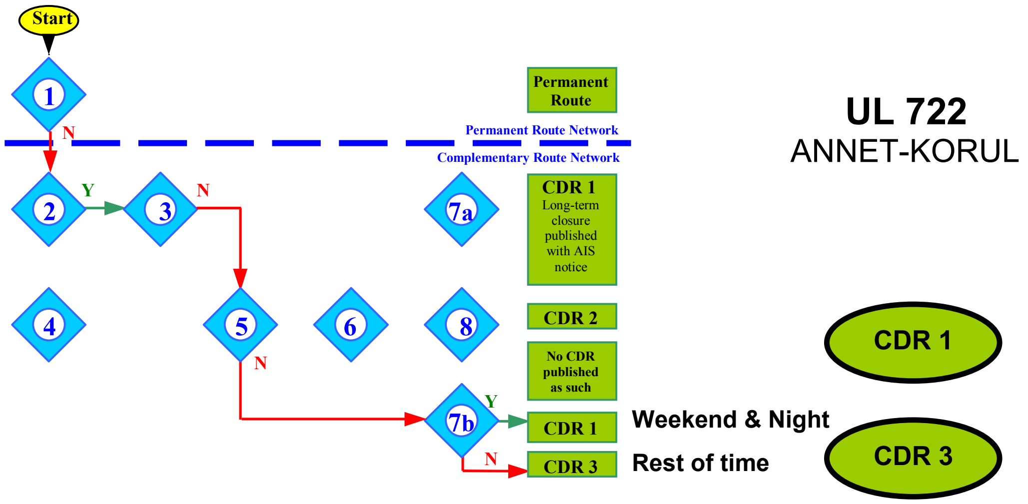


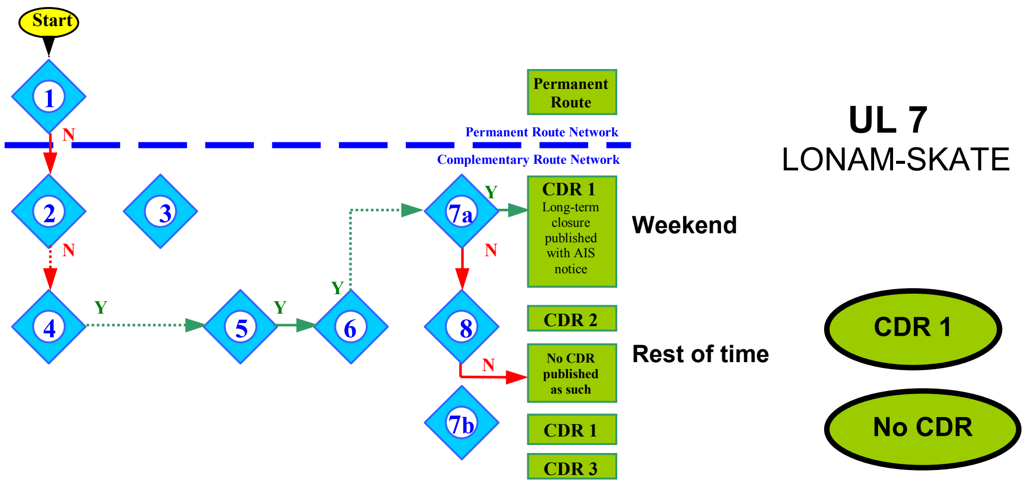




EXAMPLES OF CDR CATEGORISATION







Annex 4F

FICTITIOUS EXAMPLES OF CDR PUBLICATION

AIP *ENR 3-2-x*

xxxxxx *From 23 APR 98*

Route designator *(RNP type)* Name of significant points *Coordinates*	Track MAG VOR RDL DIST *(COP)*	Upper limits Lower limits *Airspace classification*	Minimum IFR cruising levels Direction Odd	 Even	Type Availability	Remarks Controlling unit Frequency
1	2	3	4		5	
UA 1 *(RNP 5)*	**(EXAMPLE OF CONDITIONAL ROUTE - CATEGORY ONE)**					
☐ BRAVO VOR (BBB)						
	012° 192° 69 NM	FL460 FL195 *Class A*	FL210 ↓	↑ FL200	CDR 1 H 24	TEMPO CLSD on UAC Instructions ALTN ROUTE: UA 7 Malmö UAC FREQ: ..MHZ
☐ CHARLIE VOR (CCC)						
UB 2 *(RNP 5)*	**(EXAMPLE OF CONDITIONAL ROUTE - MIXED CATEGORIES ONE & TWO)**					
☐ DELTA VOR (DDD)						
	036° 216° 56 NM	FL460 FL195 *Class C*	FL210 ↓		CDR 1 EV NGT FM 22 00 (21 00) TIL 06 00 (05 00)	TEMPO CLSD on UAC Instructions ALTN ROUTE: UA 8
☐ EEEEE						
	032° 212° 81 NM				CDR 2 EV DAY FM 06 00 (05 00) TIL 22 00 (21 00)	
☐ FOX VOR (FFF)						
	020° 200° 19 NM			↑ FL200		Berlin UAC FREQ: ..MHZ
☐ ICARD						
UG 3 *(RNP 5)*	**(EXAMPLE OF CONDITIONAL ROUTE - CATEGORY THREE)**					
☐ GOLF VOR (GGG)						
	056° 236° 66 NM	FL460 FL245 *Class A*	FL250 ↓		CDR 3 H 24	TEMPO OPN on UAC Instructions NML ROUTE: UB 9
☐ HHHHH						
	052° 232° 18 NM			↑ FL260		Bordeaux UAC FREQ: ..MHZ
☐ ICARD						

Annex 4F – Page 2

FICTITIOUS EXAMPLES OF CDR PUBLICATION (Cont'd)

AIP *ENR 3-2-x*
xxxxxx *From 23 APR 98*

Route designator *(RNP type)* Name of significant points *Coordinates*	Track MAG VOR RDL DIST *(COP)*	Upper limits Lower limits *Airspace classification*	Minimum IFR cruising levels Direction Odd	 Even	Type Availability	Remarks Controlling unit Frequency
1	↓2↑	3	4		5	
UR 4 *(RNP 5)*	**EXAMPLE OF MIXED CATEGORIES ONE & TWO - Night Route & Weekend Route**					
☐ VOR HIJ			FL210 ↓		CDR 1 EV NGT FM 22 00 (21 00) TIL 06 00 (05 00) & EV Week-end FM FRI 17 00 (16 00) TIL MON 07 00 (06 00) CDR 2 Rest of the Week	TEMPO CLSD on UAC Instructions ALTN ROUTE: UA 7
	089° 269° 92 NM	FL460 FL195 *Class A*				
☐ KLMNO						
	089° 269° 28 NM			↑ FL200		
☐ VOR OPQ						Geneva UAC FREQ: ..MHZ
UR 5 *(RNP 5)*	**EXAMPLE OF MIXED CATEGORIES ONE & TWO - Vertical Division**					
☐ VOR RST			FL250 ↓		CDR 1 H 24 FL 450 - FL 310 CDR 2 H 24 FL 290 - FL 250	TEMPO CLSD on UAC Instructions Wien UAC
	086° 266° 9 NM	FL460 FL245 *Class C*				
☐ MNMNM						
	085° 265° 58 NM			↑ FL260		
☐ VOR UVW						FREQ: ..MHZ
UG 6 *(RNP 5)*	**EXAMPLE OF PERMANENT PORTION FOLLOWED BY CONDITIONAL ROUTE - CATEGORY TWO**					
☐ VOR XYZ			FL250 ↓			
	019° 199° 162 NM	FL460 FL245 *Class A*			PERM H 24	London UAC FREQ: ..MHZ
☐ DDDDD						
	006° 186° 29 NM	FL460 FL245 *Class A*		↑ FL260	CDR 2 H 24	
☐ VOR YZX						

EXAMPLE OF EXPLANATORY NOTE ON CDR IN FRONT OF AIP ENR 3-2

AIP *ENR 3-2-x*
xxxxxx *From 23 APR 98*

Purpose of CDRs

"Conditional Routes" (CDRs) complement the permanent ATS route network. The purpose of CDRs is to allow flights to be planned on and to use ATS routes, or portions thereof, that are not always available. CDRs are established:

- through any potential areas of temporary segregation identified under the generic term "AMC-Manageable Areas" (TRAs, TSAs or R or D Areas), with CDR opening/closure resulting from associated military activities and/or
- to address specific ATC conditions (e.g. traffic restrictions or ATC sectorisation compatibility), with CDR opening/closure resulting from purely civil needs.

The conditions for the use of CDRs will be daily published in the national "Airspace Use Plans" (AUPs) and the "Conditional Route Availability Message" (CRAM).

Categories of CDRs

CDRs are divided into three different categories according to their foreseen availability and their flight planning potential. A CDR can be established in one or more of the three following categories:

1. **Category One** **(CDR 1)** - *Permanently Plannable CDR -* • Category One CDRs are CDRs expected to be available for most of the time. • Flights will be planned on Category One CDRs in the same way as planned for all permanent ATS routes. • Any re-routing around associated TRAs/TSAs will be made on ATC instructions only. • For the calculation of fuel consumption, alternate routes are published in the "Remarks" column.	Depicted on maps as follows : UR 80 (CDR 1)
2. **Category Two** **(CDR 2)** - *Non-Permanently Plannable CDR -* • Category Two CDRs are part of pre-defined routing scenarios which respond to specific capacity imbalances. • Flights will be planned on Category Two CDRs only in accordance with conditions daily published in the CRAM.	Depicted on maps as follows : UA 20 (CDR 2)
3. **Category Three** **(CDR 3)** - *Not Plannable CDR -* • Category Three CDRs are published as CDRs usable on ATC instructions only. • Flights will be re-routed on Category Three CDRs on ATC instructions as short notice routing proposals.	Depicted on maps as follows : UG 100 (CDR 3)

SECTION 4

ATS ROUTE AND SECTOR DESIGN

FINAL PAGE

SUGGESTION - COMMENTS

To report any errors, or to propose a modification to the present Section 4 "ATS Route and Sector Design", please contact:

Mr Alain Duchêne
EUROCONTROL
Airspace & Flow Management and Navigation Business Division (AFN)
Rue de la Fusée, 96
B-1130 BRUSSELS
(E-mail: alain.duchene@eurocontrol.int)

SECTION 4 - SPONSOR: ROUTE NETWORK DEVELOPMENT SUB-GROUP

Whenever material received, in accordance with the above procedure, makes it apparent that an amendment of the present Section 4 is required, such amendment will be first discussed within the Route Network Development Sub-Group (RNDSG) before its adoption by the Airspace & Navigation Team (ANT).

PUBLICATION OF AMENDMENT

The agreed amendment will then be issued by EUROCONTROL in the form most convenient for its insertion in the Planning Manual.

SECTION 5

GUIDELINES FOR TERMINAL AIRSPACE DESIGN

SECTION CHECKLIST

Chapter	Edition Amendment	Date	Chapter	Edition Amendment	Date
Section 5					
5-iii	Amendment 1	17/01/05	D-Ch01	Amendment 1	17/01/05
A-Ch01	Amendment 1	17/01/05	D-Ch02	Amendment 1	17/01/05
A-Ch02	Amendment 1	17/01/05	D-Ch03	Amendment 1	17/01/05
B-Ch01	Amendment 1	17/01/05	D-Ch04	Amendment 1	17/01/05
B-Ch02	Amendment 1	17/01/05	D-Ch05	Amendment 1	17/01/05
C-ChIntro	Amendment 1	17/01/05	D-Ch06	Amendment 1	17/01/05
C-Ch01	Amendment 1	17/01/05	D-Ch07	Amendment 1	17/01/05
C-Ch02	Amendment 1	17/01/05	D-Ch08	Amendment 1	17/01/05
C-Ch03	Amendment 1	17/01/05	E-Ch01	Amendment 1	17/01/05
C-Ch04	Amendment 1	17/01/05		Amendment 1	17/01/05
C-Ch05	Amendment 1	17/01/05		Amendment 1	17/01/05
C-Ch06	Amendment 1	17/01/05		Amendment 1	17/01/05
C-Ch07	Amendment 1	17/01/05		Amendment 1	17/01/05
C-Ch08	Amendment 1	17/01/05		Amendment 1	17/01/05
	Amendment 1	17/01/05		Amendment 1	17/01/05
	Amendment 1	17/01/05		Amendment 1	17/01/05

This section is divided into five Parts (A to E); each containing several chapters. As this is an entirely new Edition (2.0) to the Terminal Airspace Design Guidelines within the greater EUROCONTROL Airspace Planning Manual, this first checklist provides a list of chapters as opposed to pages and the footer on each page of this new Edition is marked Amendment 1, 17/01/05. When future amendments are made, the checklist will be expanded.

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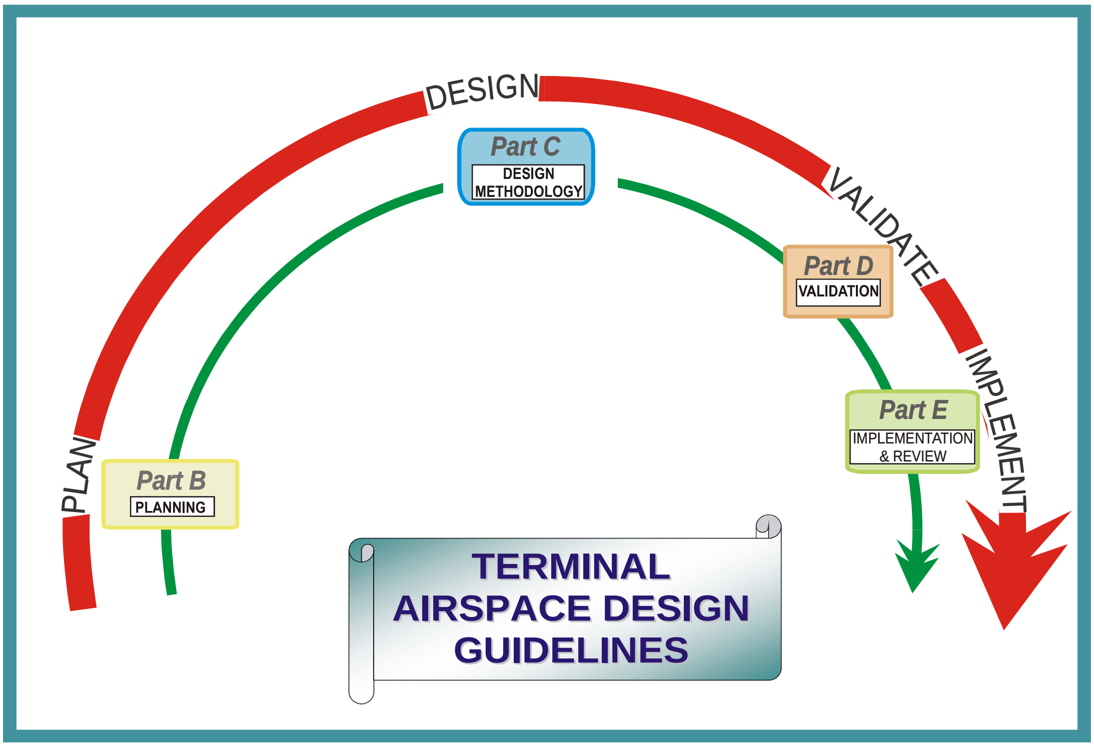
EUROPEAN ORGANISATION
FOR THE SAFETY OF AIR NAVIGATION

EUROCONTROL

EUROCONTROL AIRSPACE PLANNING MANUAL

SECTION 5

TERMINAL AIRSPACE DESIGN GUIDELINES



Edition Number	:	2.0
Amendment No	:	1
Amendment Date	:	17/01/2005
Status	:	Released Issue
Intended for	:	General Public

EUROPEAN AIR TRAFFIC MANAGEMENT

This 2ND edition of the *Terminal Airspace Design Guidelines (Eurocontrol, 2005)* replaces the first edition which was published in 1998 under the title *Terminal Airspace Design - Guidelines for an Operational Methodology*.

This document is also known as **Section 5** of the **Eurocontrol Airspace Planning Manual** (Amendment 1: 17/01/05)**.**

The electronic version of the full Eurocontrol Airspace Planning Manual can be downloaded from the ONE SKY web site by following this link.

http://www.eurocontrol.int/eatmp/fua/index.html

SECTION 5

GUIDELINES FOR TERMINAL AIRSPACE DESIGN

SECTION CHECKLIST

This document is divided into five Parts (A to E); each containing several chapters. As this first checklist constitutes a new Edition (2.0) to the Terminal Airspace Design Guidelines within the greater EUROCONTROL Airspace Planning Manual, this first checklist provides a list of chapters as opposed to pages and the footer on each page of this new Edition is marked Amendment 1, 17/01/05. When future amendments are made, the checklist will be expanded.

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C-Ch04	Amendment 1	17/01/05		Amendment 1	17/01/05
C-Ch05	Amendment 1	17/01/05		Amendment 1	17/01/05
C-Ch06	Amendment 1	17/01/05		Amendment 1	17/01/05
C-Ch07	Amendment 1	17/01/05		Amendment 1	17/01/05
C-Ch08	Amendment 1	17/01/05		Amendment 1	17/01/05
	Amendment 1	17/01/05		Amendment 1	17/01/05
	Amendment 1	17/01/05		Amendment 1	17/01/05

Note: The above checklist appears twice when the Terminal Airspace Design Guidelines are published as Section 5 of the Eurocontrol Manual for Airspace Planning

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APPENDICES

EXECUTIVE SUMMARY

Background

EUROCONTROL's Airspace Strategy for ECAC incorporates operational improvements to terminal airspace design. Even though it may be difficult and inappropriate to attempt to divide en-route and terminal airspace operations, an understanding of both is essential when designing a terminal airspace with a view to improving the capacity of the overall ATM system.

A document concerning the design of terminal airspace structures cannot be definitive because each structure has unique characteristics and evolves at a different rate. The development of a terminal airspace is also affected by a variety of parameters and these may vary to a large degree. These factors as well as differing policies adopted by States result in a multiplicity of design criteria. Nevertheless, there are many areas of commonality and these have provided a basis for this document.

Much material regarding terminal airspace design is available in several ICAO publications. This document neither repeats nor seeks to replace the ICAO material: it provides, instead, a complementary source of guidance from design conceptualisation to implementation for the European terminal airspace designer.

2nd Edition

This is the second edition of the *Terminal Airspace Design Guidelines* and it replaces Edition 1 of 1998 entitled *Terminal Airspace Design – Guidelines for an Operational Methodology*. This document is also identified as Section 5 of the EUROCONTROL Airspace Planning Manual and published as Amendment 1. Although these *Terminal Airspace Design Guidelines* are comprehensive, there may be aspects of the document which require amendment or expansion and any comments or suggestions would be welcome. These should be addressed to: ***EUROCONTROL (AFN-BD), Rue de la Fusée 96, B-1130 Brussels, Belgium.***

Likely users

This second edition was developed by the Terminal Airspace Task Force (TATF) of the Route Network Development Sub-Group (RNDSG) of the Airspace and Navigation Team (ANT). Building upon the foundations provided by the first edition, this document has been written for three audiences.

1. Primarily, ***Terminal Airspace Designers*** who are tasked with the designing a Terminal Airspace. With this in mind, the document provides comprehensive material relating to the entire design process in a format that allows the designer to 'start' the project at the beginning of the document, and 'conclude' it at the document's end.
2. ***Chief of ATC Operations*** (or equivalent person) bearing responsibility for all airspace design projects produced by airspace design teams.

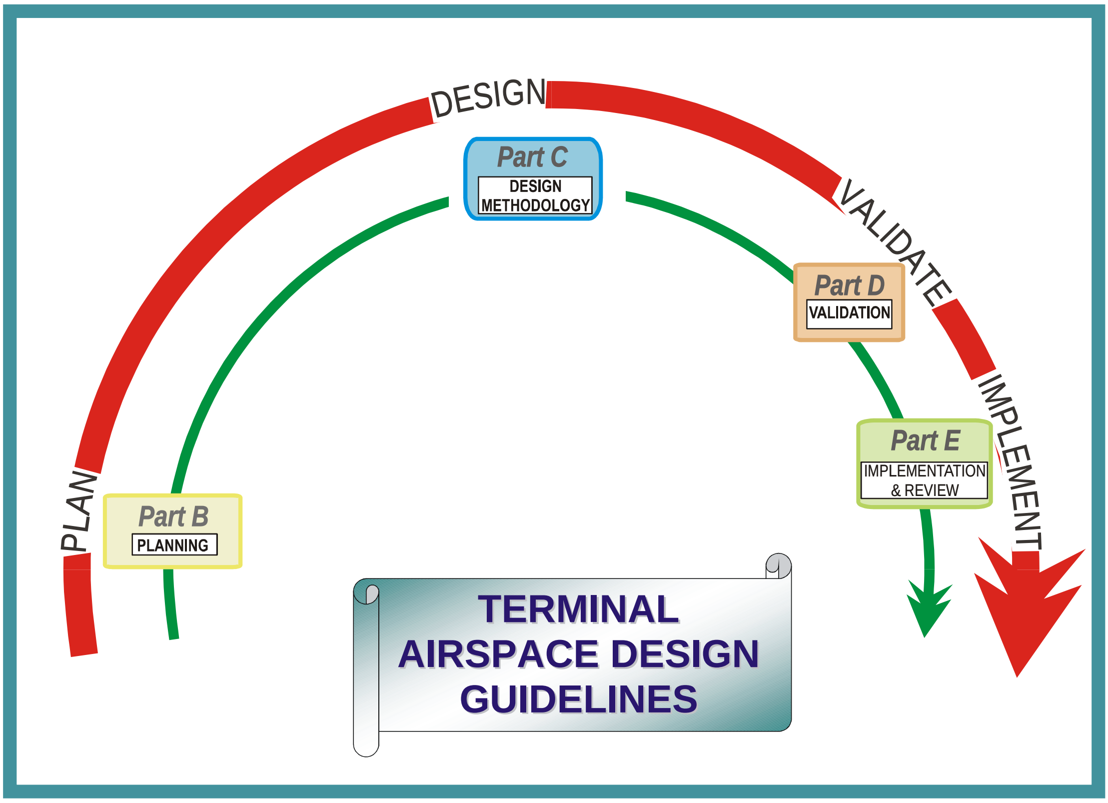
3. ***High-level ANSP Managers*** whose role is likely to include overseeing and coordinating large projects comprised of several sub-projects, one of which is the (re-)design of a Terminal Airspace. Because it cannot be assumed that these managers are familiar with Terminal Airspace operations, one of the aims of the document has been to provide an overview of the Terminal Airspace Design process.

Document Structure & Use

The document's structure and layout has been determined by the different needs of its intended users. In particular, the structure is aimed at providing a step-by-step user guide for use by Terminal Airspace designers. For this reason, this document is divided into five parts, the most detailed of which is Part C, *The Design Methodology,* intended for terminal airspace designers. It is hoped that this structure and layout clearly identifies the various phases of the design process from conceptualisation to implementation and review.

It is not intended that these guidelines be used as a stand-alone document. As previously stated, this document is a constituent part of the EUROCONTROL Airspace Planning Manual.

Furthermore, attention is drawn to the fact that these guidelines lay **considerable emphasis on the need for a co-operative and collaborative approach to Terminal Airspace design.** To this end, frequent guidance is contained in this document to follow a co-operative approach to terminal airspace design.



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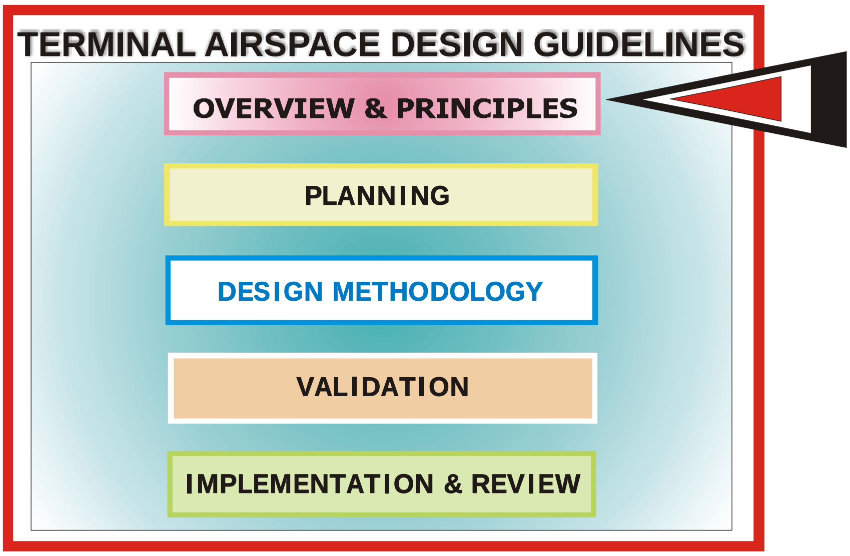
PART A

TERMINAL AIRSPACE OVERVIEW



CHAPTER 1

- INTRODUCTION -

1.1 THE CONCEPT OF TERMINAL AIRSPACE

There is a requirement to establish an airspace in the vicinity of certain airports to provide an adequate level of safety to aircraft operations. Generally this airspace is established with a view to the provision of an Air Traffic Control Service to aircraft operating under Instrument Flight Rules (IFR) and, where necessary, under Visual Flight Rules (VFR).

Due to the dynamic development of aviation, a complex system of terminology has evolved to describe this airspace established around an aerodrome. Some of these terms are defined by the International Civil Aviation Organisation (ICAO) and others are not. As a means of capturing the various airspace nomenclatures ascribed to such an airspace, this document uses the generic expression *Terminal Airspace.* This term is generic and it is intended that it be understood in a generic sense as it is used by the International Civil Aviation Organisation (ICAO)[1].

There are other reasons for using the expression Terminal Airspace.

One concerns a growing tendency for airspace planners responsible for ATS Routes and Control Areas (CTA) in 'en route' airspace and those responsible for Terminal Control Areas (TMA) to develop 'their' respective airspaces independently. Because of its generic meaning, the concept of Terminal Airspace discourages such division. Intentionally broad in meaning, *Terminal Airspace* both promotes and encourages the co-operative development of *all* airspace as a continuum.

Another reason for using the expression Terminal Airspace is the 'political' or 'lateral' equivalent of the reason cited above. Over time, it has become common-place for air traffic services airspace (ATS) such as a CTA or TMA to be confined within the sovereign airspace of a State. Despite the importance of airspace sovereignty[2], the broad and generic nature of *Terminal Airspace* intentionally discourages such 'automatic' sovereign divisions. Instead, the development of airspace as a continuum across state boundaries is encouraged. This view of ATS airspace can be traced to ICAO which allows one country to provide air traffic services in the (sovereign) airspace of another. Whilst examples of such arrangements already widely exist in the member states of the European Civil Aviation Conference (ECAC), there could be more such trans-national ATS airspace. Terminal Airspace 'boundaries' need not necessarily coincide with those of sovereign airspace.

1.2 DESIGN

Whilst Terminal Airspace ***design*** is frequently associated with the construction of IFR Procedures in accordance with obstacle clearance criteria prescribed in PANS-OPS (ICAO Doc. 8168), this document does not use *design* in that sense and therefore, obstacle clearance criteria are not included in this document.

In the context of this document, *design* has a broader meaning: it refers to the Terminal Airspace design **concept** and is concerned with the conceptual design of Terminal Airspace

[1] ATS Planning Manual (Doc. 9426)
[2] Chicago Convention at Article 1

routes, holds, airspace structure and ATC sectorisation in the greater airspace continuum. Consequently, *design* in this document, **precedes** and influences the PANS-OPS phase. That the *design* of a Terminal Airspace should be *planned* is one of the principle tenets of this document, as is the fact that this design should be properly assessed and validated prior to implementation. To this end, this manual provides guidelines on –

- conceptual design of arrival and departure routes, holding areas, the Terminal Airspace and ATC Sectorisation.
- qualitative assessment of the design concept; and
- quantitative assessment and design validation; and
- implementation planning and review.

Of necessity, the above implies that all of the above are to be completed before PANS-OPS procedure design is undertaken.

Given the above, this document seeks to ensure that the placement of **Terminal Routes and definition of the Terminal Airspace volume is driven by regulatory and ATC operational requirements** and not by exclusive reference to either -

- **mathematical obstacle clearance criteria contained in PANS-OPS** [thus Terminal Routes should *first* meet ATC objectives and PANS-ATM criteria (as well as environmental and user needs), and then be 'enabled' by PANS-OPS design criteria]; or.
- **technology** [thus Terminal Routes should seek to meet ATC objectives and PANS-ATM criteria *first,* and not be predicated upon a particular technology merely because it is available].

In summary, it can be said that *design* in this document promotes the view that the Terminal Airspace volume is the 'resultant' airspace created after the routes have been designed and other institutional requirements taken into account. Thus routes are designed to *first* support the objectives of air traffic control and facilitate the management of air traffic whilst ensuring the protection of IFR flight paths and obstacle clearance.

1.3 SAFETY

Airspace design plays an integral role in the safety of the totality of the air traffic management system. As such, design of a Terminal Airspace is aimed primarily at ensuring that safety is improved or at least maintained by the design of or changes to the design of Terminal Airspace. This requirement is embodied both in ICAO and EUROCONTROL text.

At a global level, ICAO places an obligation upon States to meet stringent safety requirements. These requirements, which are not exclusive to airspace design are stated in Annex 11 at para. 2.26 *ATS Safety Management* which reads in its first paragraph (at 2.26.1) that "*States shall implement systematic and appropriate ATS safety management programmes to ensure that safety is maintained in the provision of ATS within airspaces and at aerodromes.*"

From this 'starting point', flow many other requirements detailed variously in ICAO PANS-ATM (Doc. 4444), and, at European level, in the EUROCONTROL Safety and Regulatory Requirements (ESARRs 3 and 4).

From a strategic perspective, both global and regional strategies may be described as safety centred in that these strategies give weight to and support unequivocally the Safety objectives set at both global and regional level. In Europe, from an airspace design perspective, the EUROCONTROL ATM2000+ may be viewed as the ' parent' strategy which is detailed in the EUROCONTROL Airspace Strategy for ECAC.

1.4 THE TERMINAL AIRSPACE CHALLENGE

In the period to 2015, air traffic demand in the ECAC area is forecast to double to 15.8 million movements per annum.

Resolution of En Route-type delays:

Whilst many delays and bottlenecks have traditionally been generated by what is known as the en-route environment, this has not normally been associated with arriving and departure traffic flows for airports. However, as programmes for the enhancement of the en-route structure have been progressively introduced (e.g. Basic Area Navigation (B-RNAV) and Reduced Vertical Separation Minimum, (RVSM)), the percentage of delays occurring in the upper airspace is reducing and, increasingly, a higher percentage of delays will be attributed to airports and their associated Terminal Airspace infrastructure. It is anticipated that this focus will occur as early as 2005.

Competing interests

Even though it is tempting to consider traffic growth as the only challenge facing Terminal Airspace in the future, this view is incomplete. Indeed, the pressures placed upon Terminal Airspace in the future are likely to exacerbate an increasingly complex situation particularly when viewed together with the overriding requirement to ensure safety irrespective of air traffic increases. The challenges facing Terminal Airspaces of the future include:

- satisfying increasing demands made on the **air traffic services** to ensure that capacity is (at least) maintained, that delays are minimised and safety assured;
- satisfying increasing requirements to ensure protection of the **environment**[3];
- satisfying diverse requirements of various airspace **users** (which includes the increased use of regional airports to accommodate the proliferation of low-cost carrier operations);
- developing cost-effective technological **enablers** for air traffic control, environmental protection and airspace users to both support their respective needs and overcome any **constraints** that they might face;

Therefore, from a Terminal Airspace perspective, it is becoming increasingly important to ensure that the Terminal Airspace serving major airports actively address these emerging realities.

That the diverse interests of the Terminal Airspace 'participants' do not always coincide is a reality. Where, for example, ATC may prefer to use a particular runway in order to maximise capacity, flight paths to and from this runway may be considered unsatisfactory because of the environmental impact. Similarly, the preference of commercial air transport and airport operators for making continuous descent approaches to an airport – so as to minimise fuel burn and minimise environmental impact – these can be difficult for ATC to accommodate effectively in high-density Terminal Airspace where speed control limitations are frequently imposed upon arriving flights for traffic sequencing. Consequently, it is natural that tensions can and do arise as a result of the competing interests between these three groups – and that these need to be dealt with.

Added to this complexity is the reality that competing interests exist not only *between* the various Terminal Airspace 'participants' but *within* each of these groups. Examples are shown diagrammatically in Figure 1 - 1. From an ATC perspective, the 'triangular' interests of the Regulator, the air navigation service provider (ANSP) and social could refer to the challenges that may be encountered by any of the three 'parties' in meeting the requirements

[3] Traditionally, TMAs sought to address only the operational needs of **air traffic control.** This changed after the 1970s, when one of the effects of the oil crisis was to increase an awareness of the needs of, in particular, the commercial air transport airspace **user**. Most recently, in the years following the Kyoto Protocol, it has become incumbent on the aviation industry as a whole and on airports in particular to minimise adverse impact upon the **environment.**

of the other. Even when taken in isolation, internal 'tensions' may exist within any one of these three interested parties. For example, the 'social' part of the ATC triangle can be viewed in several ways

- difficulties experienced by ANSPs in obtaining personnel to staff remote areas;
- competition between different ANSPs within one State;
- tensions between staff from 'major' and 'minor' ATC stations or between en-route and terminal controllers (alluded to in para 1.1);
- competing interests of ATC, environmental interests and/or PANS-OPS designers (see para 1.2);

1.4.1 TERMINAL AIRSPACE DESIGN CHALLENGES

From the above, it is possible to create a (non-exhaustive) though quite specific list of the challenges facing the Terminal Airspace planner and designer in particular:

- increasing tendency of 'independent' or 'insular' airspace design on the part of 'specialist' en-route or Terminal airspace planners and States;
- tradition of PANS-OPS designers determining route placement without the necessary consideration for ATC operational requirements;
- tradition of confining Terminal Airspace within the sovereign airspace of a state; competing interests between air traffic control, environmental mitigation and the diverse requirements of airspace users;
- developing cost-effective technological enablers for air traffic control, environmental protection and airspace users to both support their respective needs and overcome any constraints that they might face.

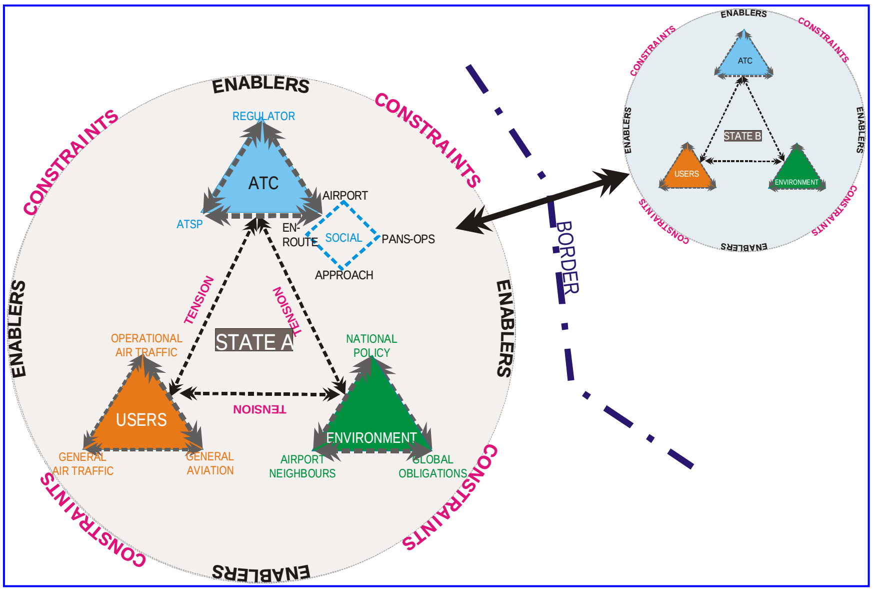


Figure 1 - 1: Challenges – Present and Future

1.5 MEETING THE CHALLENGE

Whilst the difficulties created by these challenges will certainly become more acute if action is not taken by airspace planners and designers and regulators – many of these difficulties can be overcome by meaningful **collaboration** and **co-operation**. This is not limited to Terminal Airspace planners and designers working their way through a checklist of things to be done; it suggests a willingness to undertake the design process as part of a multi-disciplinary team that will negotiate openly and adapt to meet each other's needs *without* compromising safety.

Collaboration and co-operation are the foundations upon which this document is built. As such, this document is intended to equip the Terminal Airspace designer with the means to successfully design a Terminal Airspace. The Terminal Airspace design 'toolkit' for air traffic controllers contained in this document is comprised of **–**

- **General Principles of Terminal Airspace Design** ***(Part A)***
- **Project Planning** ***(Part B),***
- **Design Methodology** ***(Part C)***
- **Assessment & Validation** ***(Part D)***
- **Implementation and Review *(Part E)***

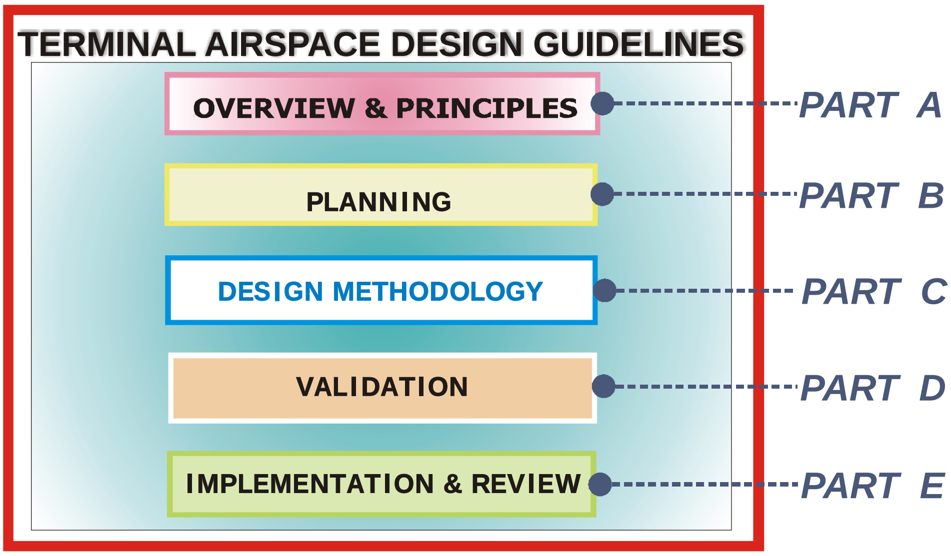


Figure 1 - 2: Terminal Airspace Design 'Toolkit

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CHAPTER 2

- GENERAL PRINCIPLES -

2.1 INTRODUCTION

Recognising that the design of Terminal Airspace is subject to many considerations which vary from location to location dependent upon local requirements, it is nevertheless possible to lay down broad principles of Terminal Airspace design which can be adopted as policy at STATE level. This chapter describes General Principles of design which may be viewed as providing the policy framework for Terminal Airspace design .

None of these principles should be viewed in isolation: inasmuch as a Terminal Airspace is part of the whole airspace continuum, each principle is also an integral part of the whole.

2.2 PRINCIPLES

Six General Principles can be viewed as the cornerstones of the Terminal Airspace design process. Of these principles, only Principle 1 (and its sub-principle P1.1) is prescriptive in that it stems from an ICAO Standard contained in Annex 11 (complemented by provisions in PANS-ATM Doc. 4444).

Listed below in shaded text, these principles and their sub-principles are elaborated upon in the paragraphs which follow.

P.1	**<u>SAFETY</u> SHALL BE ENHANCED OR AT LEAST MAINTAINED BY THE DESIGN OF (OR ALTERATION TO) A TERMINAL AIRSPACE. THIS PRINCIPLE INCLUDES A RECOMMENDATION TO-**
P.1.1	COMPLY WITH ICAO STANDARDS, RECOMMENDED PRACTICES AND PROCEDURES
P1.2	SUBJECT ANY TERMINAL AIRSPACE DESIGN (OR CHANGE) TO A SAFETY ASSESSMENT.
P1.3	ANALYSE, EVALUATE AND VALIDATE ANY DESIGN (OR CHANGE) TO TERMINAL AIRSPACE.

P.2	**TERMINAL AIRSPACE DESIGN SHOULD BE DRIVEN BY <u>OPERATIONAL REQUIREMENTS.</u> THIS INCLUDES RECOMMENDATIONS TO -**
P.2.1	BALANCE THE INTERESTS OF AIR TRAFFIC CONTROL AND AIRSPACE USERS IN ACCORDANCE WITH STATE POLICY (also see P.3.1);
P.2.2	PROMOTE THE USE OF THE FLEXIBLE USE OF AIRSPACE CONCEPT (FUA) WHERE APPROPRIATE.

P.3	**WITHOUT PREJUDICE TO PRINCIPLE P.1, WHETHER AND TO WHAT EXTENT CONSIDERATION SHALL BE GIVEN TO ENVIRONMENTAL IMPACT WHEN DESIGNING A TERMINAL AIRSPACE IS TO BE DECIDED BY <u>STATE POLICY</u>. THIS IMPLIES REQUIREMENTS FOR -**
P.3.1	STATE POLICY MAKERS AND REGULATORY AUTHORITIES TO PROVIDE GUIDELINES FOR ENVIRONMENTAL MITIGATION.

P.4	**THE DESIGN OF A TERMINAL AIRSPACE SHOULD BE UNDERTAKEN IN A COLLABORATIVE MANNER. THIS IMPLIES RECOMMENDATIONS THAT -**
P.4.1	TERMINAL AIRSPACE DESIGN PROJECTS SHOULD BE UNDERTAKEN BY MULTI-DISCIPLINARY PROJECT TEAMS WHICH INCLUDE REPRESENTATIVES OF AIRSPACE USERS, OPERATIONAL CONTROLLERS FROM ACROSS ATC DISCIPLINES AS WELL AS A PANS-OPS DESIGN SPECIALIST.

P.5	**TERMINAL AIRSPACE SHOULD BE DESIGNED, WHERE POSSIBLE, SO AS TO BE INTEGRATED INTO THE AIRSPACE CONTINUUM BOTH VERTICALLY AND LATERALLY WITHOUT BEING CONSTRAINED BY STATE BOUNDARIES**

P.6	**TERMINAL AIRSPACE SHOULD BE DESIGNED FOLLOWING A CLEAR DESIGN METHODOLOGY WITHIN THE GREATER CONTEXT OF A TERMINAL AIRSPACE DESIGN PROCESS.**

2.2.1 P.1 - SAFETY

P.1	**SAFETY SHALL BE ENHANCED OR AT LEAST MAINTAINED BY THE DESIGN OF (OR ALTERATION TO) A TERMINAL AIRSPACE. THIS PRINCIPLE INCLUDES A RECOMMENDATION TO-**
P.1.1	COMPLY WITH ICAO STANDARDS, RECOMMENDED PRACTICES AND PROCEDURES
P1.2	SUBJECT ANY TERMINAL AIRSPACE DESIGN (OR CHANGE) TO A SAFETY ASSESSMENT.
P1.3	ANALYSE, EVALUATE AND VALIDATE ANY DESIGN (OR CHANGE) TO TERMINAL AIRSPACE.

It is a fundamental premise that the design of Terminal Airspace should ensure, be conducive to and supportive of safe operations within the airspace. Furthermore, ICAO Annex 11 requires any design (or modification) of any aspect of an airspace to be subjected to a safety assessment. To these ends, ICAO PANS-ATM states (at Page 2-3):

2.6 SAFETY ASSESSMENTS

2.6.1 Need for safety assessments

2.6.1.1 A safety assessment shall be carried out in respect of proposals for significant airspace reorganizations, for significant changes in the provision of ATS procedures applicable to an airspace or an aerodrome, and for the introduction of new equipment, systems or facilities, such as:

a) a reduced separation minimum to be applied within an airspace or at an aerodrome;

b) a new operating procedure, including departure and arrival procedures, to be applied within an airspace or at an aerodrome;

c) a reorganization of the ATS route structure;

d) a resectorization of an airspace;

e) physical changes to the layout of runways and/or taxiways at an aerodrome; and

f) implementation of new communications, surveillance or other safety-significant systems and equipment, including those providing new functionality and/or capabilities.

Note 1.— A reduced separation minimum may refer to the reduction of a horizontal separation minimum, including a minimum based on required navigation performance (RNP), a reduced vertical separation minimum of 300 m (1 000 ft) between FL 290 and FL 410 inclusive (RVSM), the reduction of a radar separation or a wake turbulence separation minimum or reduction of minima between landing and/or departing aircraft.

Note 2.— When, due to the nature of the change, the acceptable level of safety cannot be expressed in quantitative terms, the safety assessments may rely on operational judgement.

2.6.1.2 Proposals shall be implemented only when the assessment has shown that an acceptable level of safety will be met.

Principle P.1.3 which speaks to the analysis, evaluation and validation of any design suggests that a **qualitative** analysis and evaluation be undertaken before **quantitative** analysis, evaluation and validation. The reason for recommending this sequence of action is as follows: a **qualitative analysis and evaluation** of an airspace refers to the process whereby it is determined to what extent the airspace designed meets international standards, recommended practices and Terminal Airspace design guidelines. At the most basic level, the **qualitative** phase may be described as the 'drawing board' stage where inconsistencies are detected and impracticable elements of the design are discarded by expert judgement of the airspace designers. As importantly, passing through this phase reduces the likelihood of resources being wasted at the **quantitative** stage normally undertaken by means of (expensive) real-time simulation. Furthermore, sound qualitative analysis and evaluation ensures that viable designs can be thoroughly analysed and evaluated at the quantitative phase.

2.2.2 P.2 - OPERATIONAL REQUIREMENTS

P.2	**TERMINAL AIRSPACE DESIGN SHOULD BE DRIVEN BY <u>OPERATIONAL REQUIREMENTS.</u> THIS INCLUDES RECOMMENDATIONS TO -**
P.2.1	BALANCE THE INTERESTS OF AIR TRAFFIC CONTROL AND AIRSPACE USERS IN ACCORDANCE WITH STATE POLICY (also see P.3.1);
P.2.2	PROMOTE THE USE OF THE FLEXIBLE USE OF AIRSPACE CONCEPT (FUA) WHERE APPROPRIATE.

This principle aims to undo the existing practice of the airspace design process whereby route placement within a Terminal Airspace is determined either exclusively by technology or driven (sometimes exclusively) by PANS-OPS design criteria. As such, this principle requires that consideration of the airspace concept forms part of the process whereby ATM/CNS enablers are identified, and that this conceptual phase <u>precedes</u> the PANS-OPS design stage.

2.2.3 P.3 - STATE POLICY

P.3	**WITHOUT PREJUDICE TO PRINCIPLE P.1, WHETHER AND TO WHAT EXTENT CONSIDERATION SHALL BE GIVEN TO ENVIRONMENTAL IMPACT WHEN DESIGNING A TERMINAL AIRSPACE IS TO BE DECIDED BY <u>STATE POLICY</u>. THIS IMPLIES REQUIREMENTS FOR -**
P.3.1	STATE POLICY MAKERS AND REGULATORY AUTHORITIES TO PROVIDE GUIDELINES FOR ENVIRONMENTAL MITIGATION.

This principle seeks to address the increasing challenge being presented to ATC and/or Airport Operators to minimise adverse Environmental impact. In many instances, these difficulties could be overcome were ANSPs to be provided with clear guidelines which have been decided by STATE policy makers at government level.

2.2.4 P.4 - COLLABORATION

P.4	**THE DESIGN OF A TERMINAL AIRSPACE SHOULD BE UNDERTAKEN IN A COLLABORATIVE MANNER. THIS IMPLIES THAT -**
P.4.1	TERMINAL AIRSPACE DESIGN PROJECTS SHOULD BE UNDERTAKEN BY A MULTI-DISCIPLINARY PROJECT TEAM MADE UP OF OPERATIONAL CONTROLLERS FROM ACROSS ATC DISCIPLINES AS WELL AS A PANS-OPS DESIGN SPECIALIST.
P.4.2	THE DESIGN TEAM SHOULD CONSULT WITH AIRSPACE USERS.

This Principle addresses one of the major challenges identified in Chapter 1 by advocating co-operation between the different ATM disciplines and between air traffic services and users (P2.1 and P2.2) during the Terminal Airspace design process. The stage at which consultation with airspace users is undertaken should be identified by the design team e.g. airspace users tend to be involved in the design process at an early stage when the operational requirements stem from the users, and at a later stage when the operational requirements are related to ATM.

The above requirement for collaboration is not limited to the ATS and Users: it extends to all interested parties referred to in Chapter 1, and therefore include but are not limited to:

- Air Traffic Services i.e.
  - ATC Planners and designers of the Terminal Airspace to be designed
  - ATC Terminal Airspace Planners from adjacent Terminal Airspaces
  - ATC En Route Airspace Planners
  - Aerodrome Control Planners
  - PANS-OPS designers;
- Users
  - Commercial air transport operators;
  - Military and civil
  - General Aviation (including VFR operations and recreational flying)
- Environmental (see P.3, above)
- Airport authorities
- Regional Authorities
- Controller Associations
- Authorities responsible for safety and environmental regulations.

2.2.5 P.5 - AIRSPACE CONTINUUM

P.5	**TERMINAL AIRSPACE SHOULD BE DESIGNED, WHERE POSSIBLE, SO AS TO BE INTEGRATED INTO THE AIRSPACE CONTINUUM BOTH VERTICALLY AND LATERALLY WITHOUT BEING CONSTRAINED BY STATE BOUNDARIES**

- Both vertically and laterally, Terminal Airspace should be viewed as part of the airspace whole. This means that the routes, airspace volume and sectorisation must be compatible with other routes, volumes and sectorisation schemes. Of necessity, this principle lends weight to the principle which promotes a collaborative approach to Terminal Airspace design (P.4).

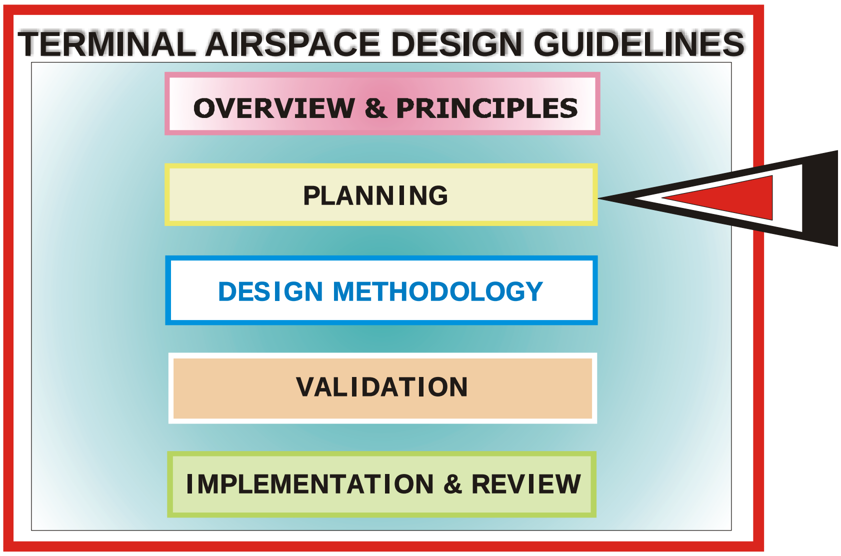
2.2.6 P.6 - DESIGN METHODOLOGY

P.6	**TERMINAL AIRSPACE SHOULD BE DESIGNED FOLLOWING A CLEAR DESIGN METHODOLOGY WITHIN THE GREATER CONTEXT OF A TERMINAL AIRSPACE DESIGN PROCESS.**

Whatever the Terminal Airspace Design Methodology, Design Guidelines or Project Management process used when undertaking a design of (or an alteration to) a Terminal Airspace, the Methodology, Guidelines and Process should be clear and easy to follow. An overview of this principle is explained in Part B.

PART B

PLANNING



CHAPTER 1
– WORKING ARRANGEMENTS –

Contents

INTRODUCTION

This Chapter constitutes the first of two chapters in Part B. It provides an introduction to Terminal Airspace design project planning by presenting examples of different working arrangements. To this end, various **sample managerial frameworks** within which Terminal Airspace projects may be developed are identified, as are the effects that these frameworks have on managerial structures. These samples have been selected because they are relatively common and generic. This said, however, they are only examples; other managerial frameworks can – and do – exist.

Note: Because this document neither attempts nor purports to be a project management handbook, the subject of project planning is provided in both chapters with a view to assisting the organisation and planning of Terminal Airspace design projects by the Terminal Airspace design team. With the design team in mind, these discussions cover managerial and planning aspects at various levels but emphasis is laid upon the Terminal Airspace design project and team.

1.1 MANAGERIAL FRAMEWORKS

As far as planning is concerned, it is necessary to recognise that Terminal Airspace design projects can be undertaken in various managerial 'frameworks'. Primarily, this is because design projects are undertaken for different reasons i.e. projects are triggered by different requirements. As a means of illustrating this reality – and to lay the foundations for the rest of this chapter – three ***sample*** '**types'** of managerial frameworks are distinguished in the context of Terminal Airspace Design projects. As previously stated, however, these framework 'types' are examples only – as are the names attributed to them:

- **Major infrastructure projects:** This management 'framework' of a Terminal Airspace design project envisages a situation where **the Terminal Airspace design project is one of several sub-projects being undertaken** to achieve a single goal such as the opening of a new runway at an airport. These sorts of projects are usually high profile and involve extensive planning and management of a multitude of aspects from calls for tender to budgets, contracts, implementation and review. These projects tend to span over several years.

  Characteristically, design projects undertaken within such a managerial framework are most frequently **initiated by a policy decision, usually at some level of government**, and these project are usually of considerable scale and duration.

- **External Directive projects:** This type of managerial framework involves situations where a Terminal Airspace design project is launched in response to requirements that are not strictly related to air traffic management or user requirements but rather to specific – and often politically loaded – requirements. The most typical example is where, for example, environmental mitigation measures are ordered by a court which results in a requirement to re-designed certain arrival and/or departure routes

  As with Major Infrastructure projects, these types of projects can also be high profile and on occasion, politically sensitive. This said, however, External Directive projects otherwise stands in complete contrast to major infrastructure projects. Most notably, External Directive projects tend to be 'high-speed and 'high-pressure' i.e. the interval between project start and end can (typically) be a matter of a few months. For their part, design projects undertaken within the External Directive managerial framework are characterised by the fact that the design team's actions have the potential to carry significant political implications.

- **ATM projects:** The narrowest managerial 'framework' is one where **a Terminal Airspace design project is launched as a direct consequence of an operational requirement which has been identified either by air traffic management or airspace users**.

  Typically, these requirements are related to safety and/or capacity. Significantly, these projects are not directed by a Project Steering Group (see para. 1.2), even though they may (exceptionally) span over several years.

Several remarks may be made at this stage:

[i] If the design of a Terminal Airspace is to be successfully and safely implemented, careful planning of a Terminal Airspace design project is a pre-requisite of *any* project, irrespective of the 'type' of managerial framework;

[ii] As will become evident in Chapter 2, as well as Part C (as per the Principles stated at Part A, Chapter 2), a collaborative approach to Terminal Airspace design is (increasingly) becoming mandatory in various States – and is very much encouraged from a pan-European perspective. This co-operation should not be exclusive e.g. limited to ATM or Airspace Users.

[iii] Irrespective of the managerial framework within which the Terminal Airspace design team is to work, changes to or the new design of a Terminal Airspace (particularly arrival/departure route and holding patterns) are becoming more difficult to implement due to environmental considerations.

1.2 MANAGEMENT STRUCTURES

It is natural that the differences between types of managerial framework be reflected in the management structure of different Terminal Airspace design projects. As a consequence, planning is also affected by the managerial structure which stems from a particular managerial framework.

For purposes of this discussion, three levels of management structure may be identified in the context of these managerial frameworks. They are called the ***Project Steering Group***, ***Operational Manager*** and the ***Terminal Airspace design team***.

Note: In this context, Operational Manager is a generic term. Depending on internal arrangements, the Operational Manager can be the Chief of he ATC Centre, Chief of Airspace Development, etc.

In the diagram on the next page, the following differences in reporting structure are shown:

With a Major Infrastructure project structure, the Terminal Airspace design team is accountable to the Operational Manager (e.g. Chief of ATCC, or Chief of Airspace Projects) who in turn acts as an interface between the Project Steering Group and the specialist design team.

In turn, with External Directive managerial structures the Terminal Airspace design team is usually accountable to the Operational Manager. As such, the managerial framework is usually as light as with ATM Projects, but such, 'accountability' often reaches beyond the ANSP.

Reporting structures associated with ATM Projects are usually lighter and two levels are envisaged i.e. Operational Manager and the Terminal Airspace design team.

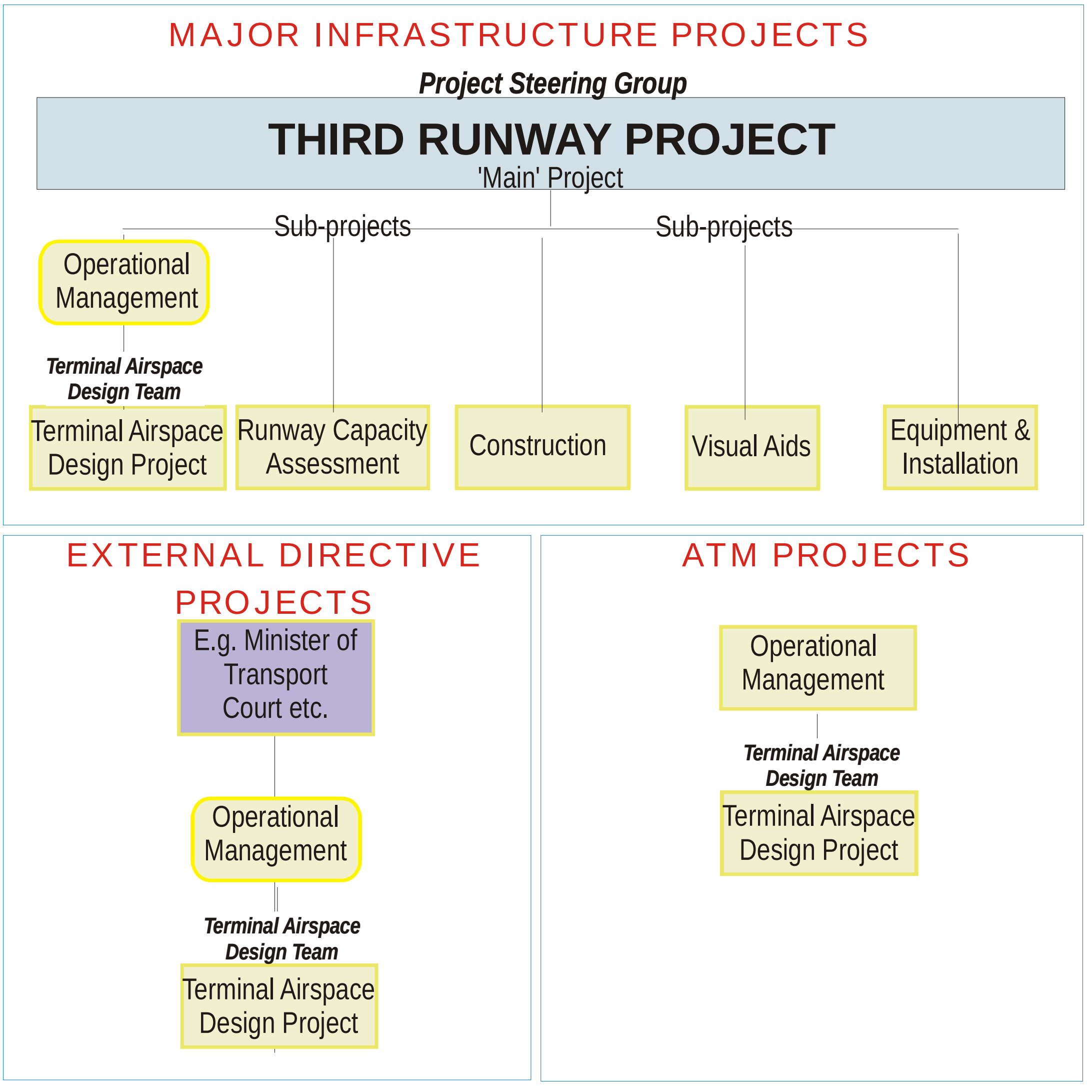


Figure 1 - 1: Sample Types of Managerial Frameworks

For completeness, the roles of the Project Steering Group, Operational manager and Terminal Airspace design team are briefly elaborated in the context of managerial frameworks. As will be seen, this impacts upon planning.

1.2.1 PROJECT STEERING GROUP

As far as the Terminal Airspace design team is concerned, the ***Project Steering Group*** associated with a Major Infrastructure project, may be considered to be the project's high-level overseer and prime mover. The Project Steering Group sets strategic objectives, identifies the necessary sub-projects, implementation time scales, ensures that project dependencies are identified and that the appropriate expertise is drawn together to work on the large-scale project. Amongst other things, the Project Steering Group sets up working arrangements. This includes 'delegating' responsibility for specialist work to specialist teams. In the case of Terminal Airspace design, the actual design activity is delegated to a Terminal Airspace Design Team.

1.2.2 OPERATIONAL MANAGER

The Operational Manager is most likely to lead the Terminal Airspace design team. Whereas the **operational manager** is at a level below the Project Steering Group in a Major Infrastructure project, the operational manager is most likely to lead the project in other instances. The extent of the Operational Manager's role alters according to the managerial framework: In a Major Infrastructure project, the Operational Manager ensures coherency between Strategic/Project Objectives (see next Chapter) set by the Project Steering Group and design objectives defined by the Terminal Airspace design team and also acts as interface between the Project Steering Group and the design team. In External Directive projects, the operational manager's role can be more demanding: with these projects, this manager may represent the design team in meetings that are politically charged, interprets the requirements of one group to the other whilst taking overall responsibility for ensuring that the final (design) result is safe.

1.2.3 TERMINAL AIRSPACE DESIGN TEAM

Central to this particular document is the ***Terminal Airspace Design team.*** In management and reporting terms, the Terminal Airspace design team bears responsibility for planning, development, validating and implementing changes to the airspace design. Nevertheless, the extent of the design team's managerial responsibilities and how the team operates is largely determined by the type of managerial framework of a particular project (this is usually a function of the way in which an ANSP is organised). For example –

In a **Major Infrastructure project** managerial framework it is the Project Steering Group that determines the time scales for implementation, the implementation date, general scope of the project and strategic objectives. Similarly, the PSG also sets up working arrangements, identifies (sub-) project teams, dependencies between them as well as a reporting structure and project milestones. In this managerial framework, the Terminal Airspace design team, while relieved of certain managerial functions, is also required to engage and co-ordinate with a wider range of expertise which can affect the schedule of the design team itself. Furthermore, it is incumbent on the design team to 'translate' the strategic and project objectives into their design equivalent which are called ***design objectives*** (See Part B, Chapter 2 for more details)***.*** At its specialist airspace 'level', the Terminal Airspace design team also needs to identify **project dependencies** e.g. other (En Route or Terminal) airspace projects being planned or developed

In **External Directive projects**, time scales for implementation, general scope of the project and strategic objectives are usually decided up the 'external' third party providing the 'trigger' for the launch of the project. In this managerial framework – again, without a Project Steering Group – the Operational Manager and Terminal Airspace design team bear a greater managerial responsibility. (The relationship between them is usually decided by internal procedure). Usually, depending on internal arrangements, it is the responsibility of the Operational Manager or the design team to identify the design objectives and scope. The responsible party also needs to ensure that project dependencies are identified, that working arrangements are set up to accommodate the project (e.g. with other airspace projects), and that the pre-defined implementation date is respected.

From one perspective, the **ATM Project** managerial frameworks which is 'lightest' in terms of reporting structure (there is no Project Steering Group), could be considered heaviest in terms of the responsibilities falling directly on the Terminal Airspace design team. One of the greatest advantages this type of managerial framework is, however, that it is usually possible for implementation time-scales to be decided only by the Terminal Airspace design team.

1.3 IMPACT OF TYPE DIFFERENCES

1.3.1 IMPACT OVERVIEW

It is not surprising that the differences between managerial frameworks can be substantial in terms of the project planning.

In order to appreciate the impact of these differences, a tabular overview is provided below followed by para. 1.3.2 which introduces the impact of Type differences on Project Planning – thus setting the scene for Chapter 2.

Note 1: Readers' attention is drawn to the fact that some of these differences will become clearer after reading the remainder of the Chapters in Part B.

DIFFERENCES AND SIMILARITIES BETWEEN SAMPLE PROJECT 'TYPES'

Terminal Airspace Project –	Major Infrastructure project	External Directive projects	ATM Project
(1) ...Initiated by	Policy by (national or regional) government, realised by Project Steering Group	Policy by (regional/municipal) government, or court ruling i.e. 'external' party	ATM operational requirements/ User requirements identified by/submitted to the Terminal Airspace design team
(2) .. Management Structure decided by	Project Steering Group	Operational Manager or Terminal Airspace Design team	Operational Manager or Terminal Airspace Design team
(3) ...Implementation date selected by	Project Steering Group in consultation with Policy makers, usually as a function of scope.	Decided at policy level/court ruling i.e. external party, enforced by Operational Manager (or equivalent), (often) despite the scope.	Decided by Terminal Airspace Design team as a function of Scope and objectives ***after*** scope and objectives set
(4) .. Strategic Scope & Objectives selected by	Project Steering Group.	'External' party.	Determined by the Terminal Airspace design team ***before*** deciding implementation date
(5) .. design objectives selected by	Terminal Airspace Design Team	Terminal Airspace Design Team	Terminal Airspace Design Team
(6) Dependencies with other projects Identified by	Project Steering Group, Operational Manager (and Terminal Airspace Design Team, at specialist level)	Operational Manager or Terminal Airspace Design Team	Operational Manager or Terminal Airspace Design Team
(7) Reference Scenario agreed by (Part C, Chapter 2)	Terminal Airspace Design Team	Terminal Airspace Design Team	Terminal Airspace Design Team
(8) Safety and Performance Criteria selected by (Part C, Chapter 3)	Terminal Airspace Design Team in accordance with Regulatory Requirements	Terminal Airspace Design Team in accordance with Regulatory- or external requirements	Terminal Airspace Design Team in accordance with Regulatory Requirements

Terminal Airspace Project –		Major Infrastructure project	External Directive projects	ATM Project
(9) Assumptions		Time Pressures, external to ATM Other airspace requirements	Requirement for common assumptions across several project teams is common.	can be affected by external requirements but otherwise selected by Terminal Airspace design team
(10) Constraints	(Part C, Chapter 4)	Potential for technical enablers being provided (usually because of project profile and ease of access to higher-level management)	Time Requirement for common assumptions can reduce design flexibility Increased co-ordination	Time Pressures, external to ATM Other airspace requirements
(11) Enablers		Greater spread of expertise readily available to Terminal Airspace Design team (from other projects); Greater likelihood of technical enablers being provided usually because of project profile and access to management	Greater spread of expertise readily available to Terminal Airspace Design team (from other projects); Greater likelihood of technical enablers being provided usually because of project profile and access to management	Potential for technical enablers being provided (usually because of project profile and ease of access to higher-level management)

Table 1- I: Comparison of Sample Project Types

1.3.2 IMPACT ON PLANNING

It has become evident that all Terminal Airspace design projects are undertaken in response to a particular requirement and that the source of a particular requirement largely determines the type of managerial framework for the project. Similarly – and quite predictably – these differences are also reflected in the extent and number of planning steps. Although this is dealt with fully in the next chapter, it is useful to consider what impact this has on planning. By way of introduction, the next diagram shows a sequence of sample planning steps and that the number of steps is dependent upon the managerial 'type'. In Figure 1-2, planning for-

- A **Major Infrastructure project** would commence at the rose-coloured dot (with the Project Steering Group) in the form of a **General Requirement** and the Terminal Airspace design team is created to undertake a specialist sub-project and to determine the **design objective** from the **project objective** defined by the Project Steering Group.
- An **External Directive project** would start at the mauve-coloured dot**.** In this case, the trigger for the project is handed to the Terminal Airspace design team as a **project objective.**
- An **ATM Projects** would commence at the green-coloured dot where a project has been triggered by either an ATM or User Requirement (known as an **Operational Requirement**) identified by the Terminal Airspace design team; from which **design objectives** are formulated.

These different levels of objectives are amplified in the next chapter.

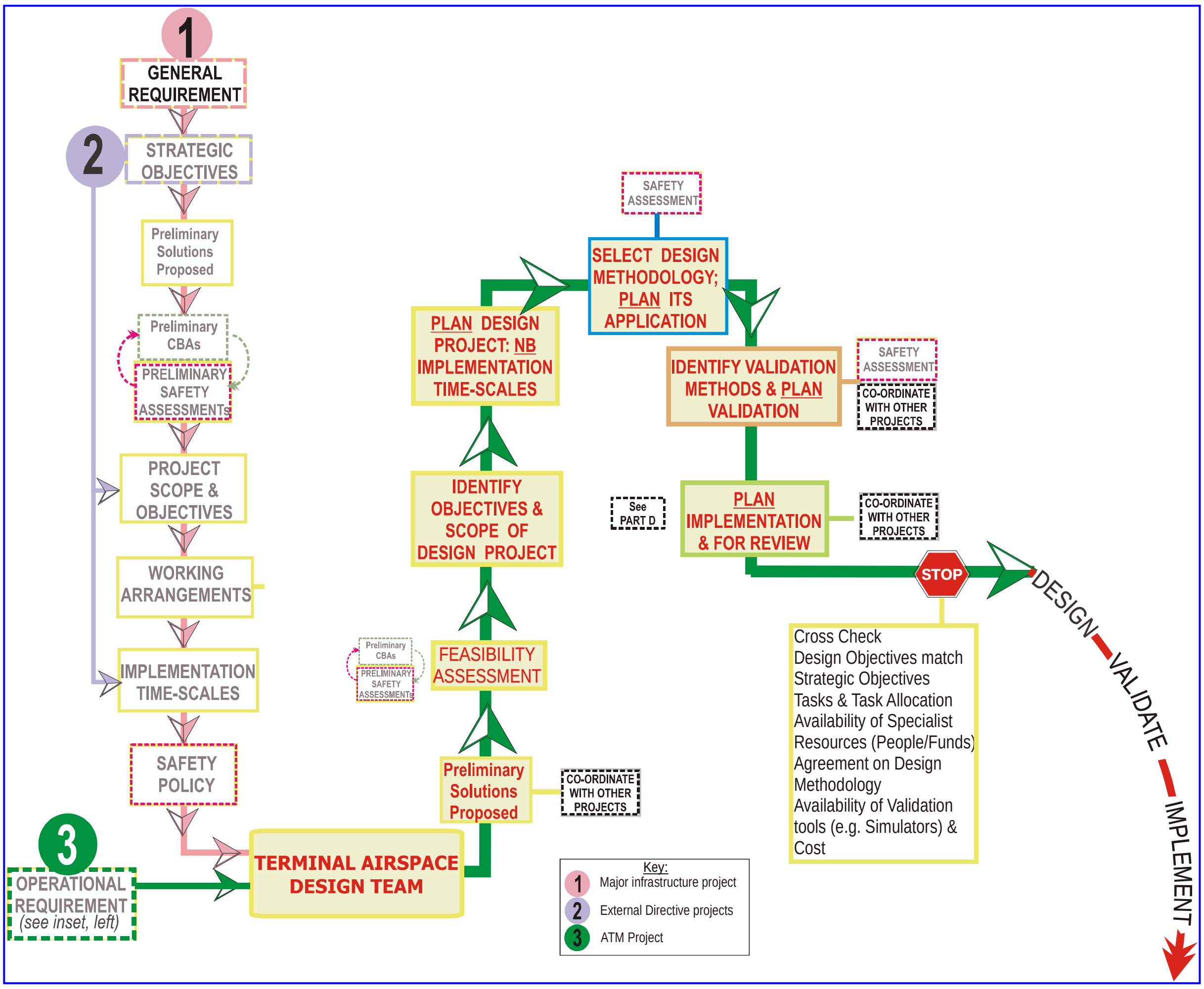


Figure 1 - 2: Different Planning Processes

1.4 SUMMARY

This Chapter has discussed working arrangements in the context of managerial framework 'types' in which Terminal Airspace design projects may be undertaken. Management structures that 'flow' from these managerial frameworks have also been explained and three (sample) 'levels' of management identified – the most significant, in the context of this document, being the Terminal Airspace design team.

Having laid these foundations in this chapter, the next chapter discuss Terminal Airspace design project planning.

CHAPTER 2
– PLANNING STEPS –

Contents

2.1 INTRODUCTION

This Chapter builds upon the foundations laid in Chapter 1; it amplifies aspects of project planning by providing a sequence of **sample** planning steps for a single Terminal Airspace design project. These planning steps could be used by a Terminal Airspace design team where an in-house process is not available.

That each of the three project 'types' (see previous chapter) are initiated differently, significantly impacts upon why and how the Terminal Airspace design team tackles its tasks. For this reason, this chapter first provides, for each managerial type, a brief (diagram-based) overview of sample project initiation process leading up to the point where a Terminal Airspace design team undertakes the re-/design of a Terminal Airspace. This is followed by a brief overview of setting up a Terminal Airspace design team which then leaves the bulk of this chapter to cover project planning by the Terminal Airspace design team (primarily within an ATM Project managerial framework).

Note 1: The Attachments to this chapter provide an overview of a sample planning process (in steps) which could be used as a the basis for a checklist by the Terminal Airspace design team.

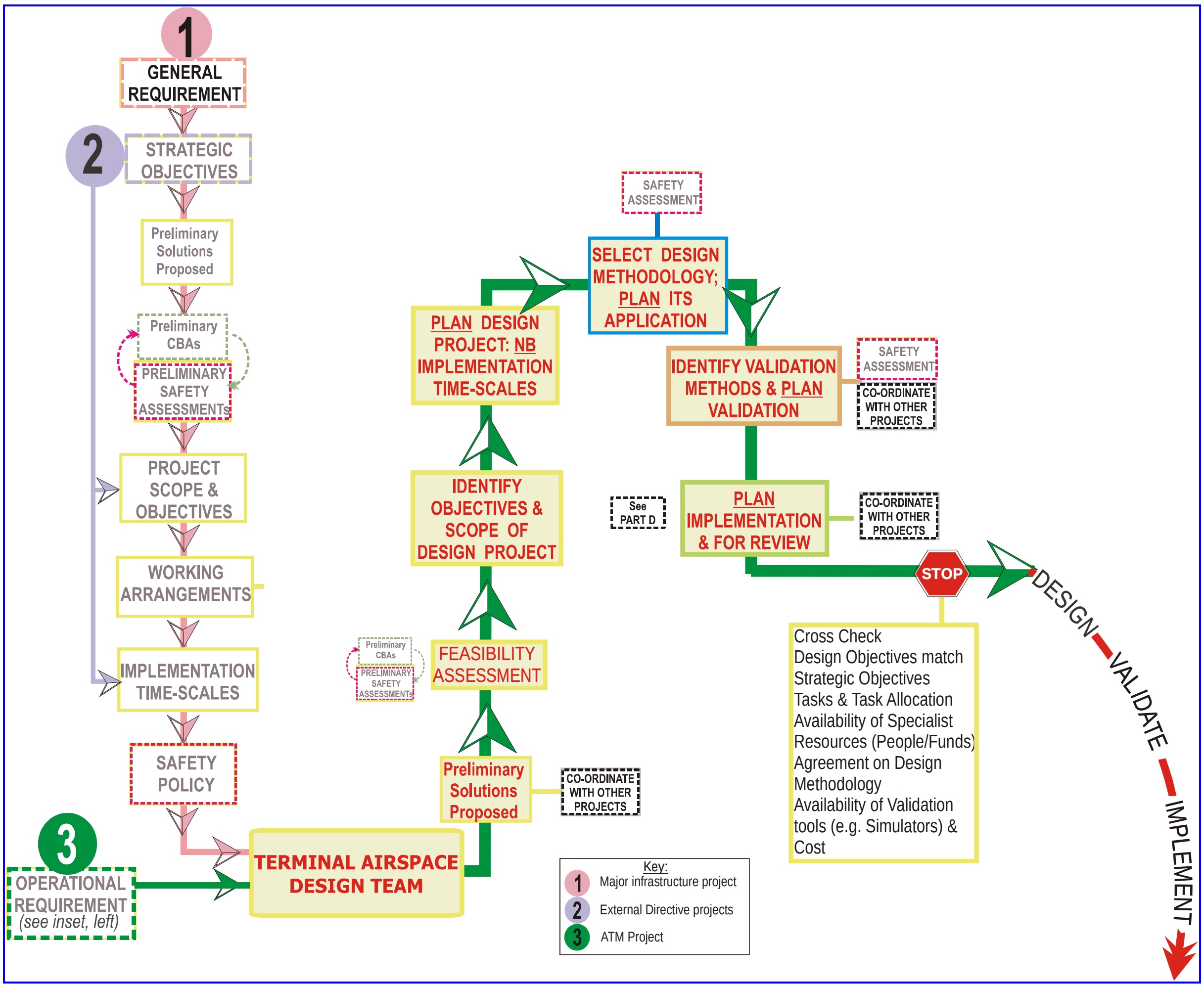


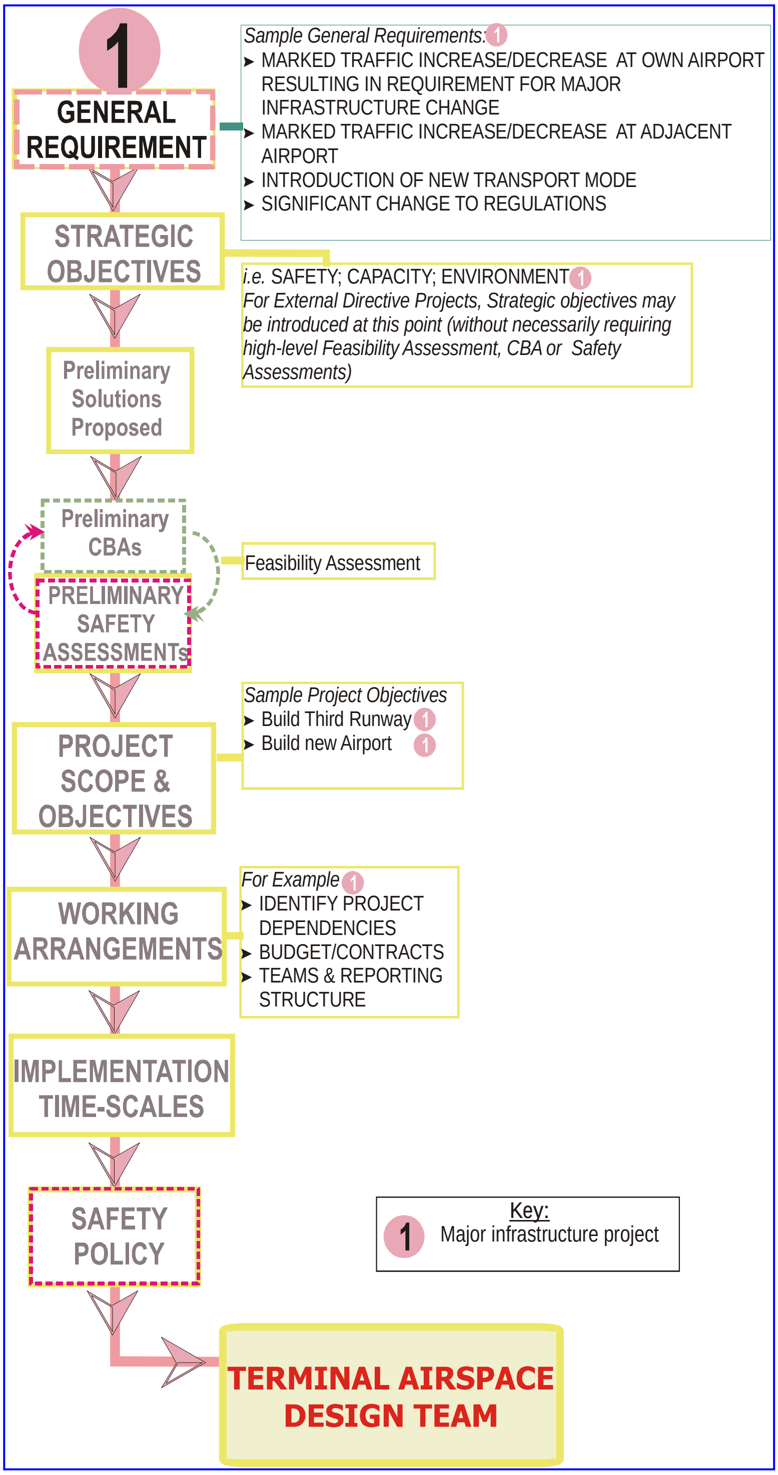
Figure 2 - 1: Overview – Sample Project initiation and Planning Steps

Depending upon the circumstances of a particular project, it is possible for 'start points' **1, 2 & 3 (above)** to be located elsewhere in the process chain.

2.2 SAMPLE PROJECT INITIATION

2.2.1 MAJOR INFRASTRUCTURE PROJECT

In this type of managerial framework, the project may be said to commence with **General Requirements** stemming from national policy.



- An example of a (high level) **General Requirement** is to ensure that sufficient capacity exists at Airport X, to accommodate forecast traffic increases.

In context, it is assumed that the Project Steering Group (PSG) is formed at this stage. One of its first tasks is to identify **Strategic Objectives** from the General Requirement**.**

- An example of a **Strategic Objective** stemming from the General Requirement could be to double the capacity at Airport X.

Note: Strategic Objectives generally relate to Safety, Capacity or Environment. Usually, more than one is selected.

Once strategic objectives are decided, the PSG then seeks to identify how these strategic objectives may be fulfilled. The 'solution' selected may be called the **Project Objective.**

- An example of a **Project Objective** could be to build a new parallel runway 18L/36R at Airport X.

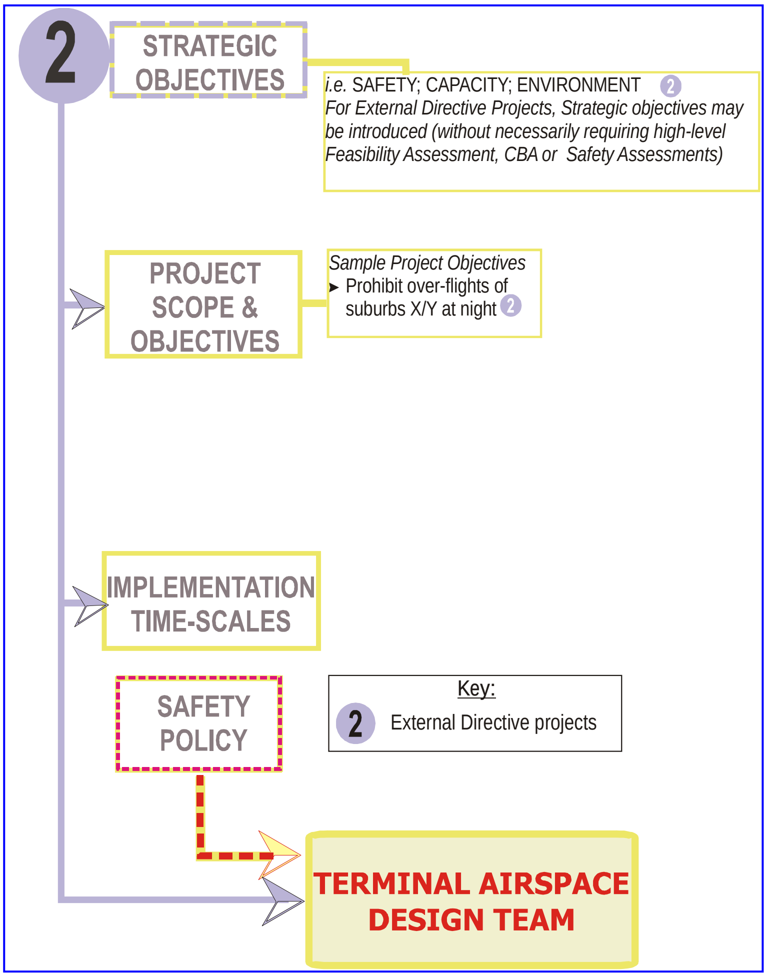
The Terminal Airspace design team would be included in the working arrangements to fulfil the project objectives. It would have to derive/determine **design objectives** compatible with the **project objectives.** (see para. 2.4.1 & 2.4.2)

Figure 2 - 2: Sample project initiation for a Major Infrastructure project

2.2.2 EXTERNAL DIRECTIVE PROJECT

This type of managerial framework is characterised by the fact that the project is 'started' by parties outside ATM/airspace users. Furthermore, these 'external' parties are usually in a higher authority e.g. within national government or the judiciary. These parties 'provide' the ANSP (and thus the Terminal Airspace design team) with ready-made **strategic** and **project objectives** in the form of a court order or ministerial directive/order.

As suggested previously, these projects tend to be politically charged, demanding quick results in a limited time period and most often, they relate to environmental impact and/or mitigation, especially noise.



- Examples of different levels of **'received' objectives** include –
  - Minimise environmental impact (**strategic objective)**;
  - Over-flight of suburbs X and Y prohibited between 2300-0530 (**project objective)**.

In such a case, The Terminal Airspace design team would be tasked to fulfil the (very specific and narrow) project objectives. To this end, it would have to derive /determine **design objectives** compatible with the **project objectives** (see para. 2.3).

Figure 2 - 3: Sample project initiation for External Directive project

2.2.3 ATM PROJECT

In contrast to the previous project 'types', ATM-type projects are usually initiated for ATM – related reasons by either the Terminal Airspace design team, operational air traffic controllers, airspace users etc. As such, these projects are initiated because some **operational requirement** has been identified. Examples of an operational requirement include:-

- Reduce the workload of Sector TX between 1000-1700 UTC on week-days.
- Increase the frequency of north-bound departures exiting the Terminal Airspace via point KODAP.

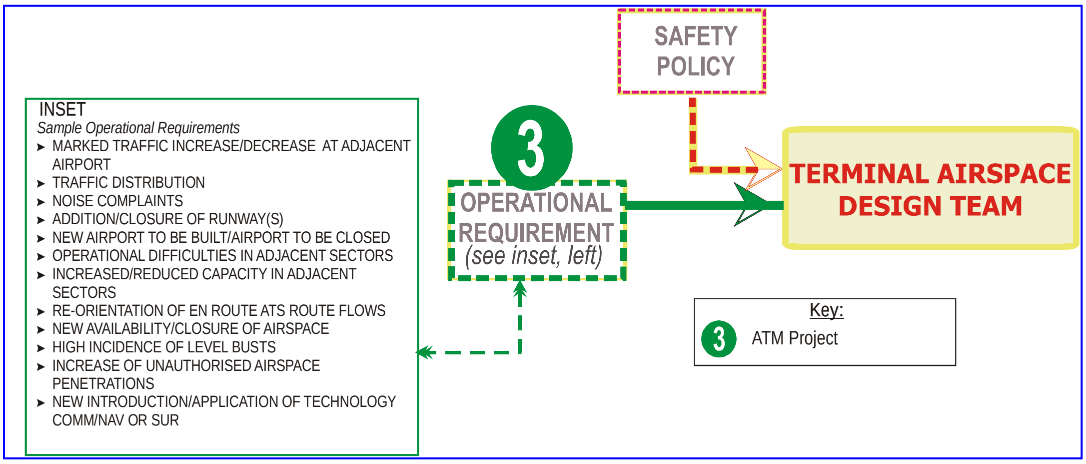


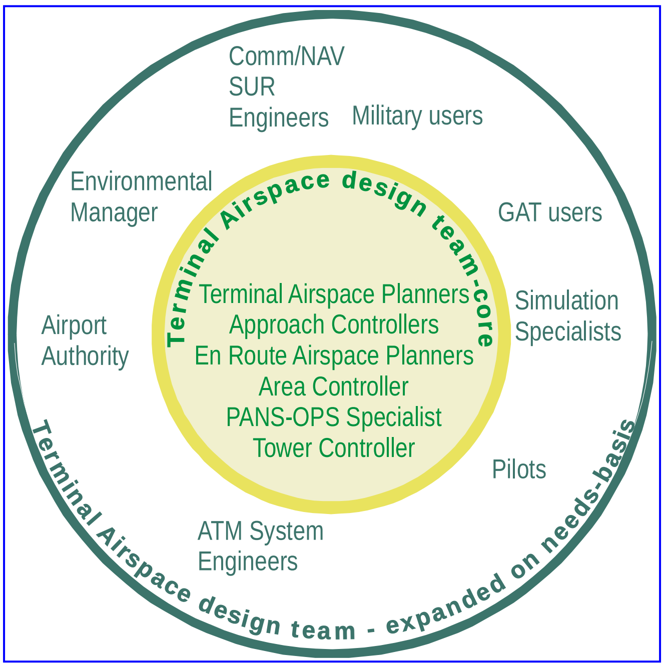
Figure 2 - 4: Sample Project initiation ATM Projects

It is then up to the Terminal Airspace design team to ‘translate’ or derive **design objectives** from these operational requirements by going through the process such as the example provided in para. 2.3.

2.3 FORMING THE TERMINAL AIRSPACE DESIGN TEAM

Irrespective of the managerial framework within which the Terminal Airspace design team operates, the Terminal Airspace design team is ideally made up of specialist airspace planners (where available), operational Approach Controllers, at least one operational Area controller, a Tower controller and a PANS-OPS specialist.

Whilst these members may be viewed as the core of the team, this is not the team’s limit. On a needs basis, the team will grow to include additional expertise such as pilots, engineering, simulation and safety specialists. If the decision to include such specialists is not taken when the project is launched, it is advisable to identify which specialists are needed once the objectives and scope have been formulated and tasks identified (see paras.2.4.1 and 2.4.2).



Depending upon the internal arrangements of a particular ANSP, the team may be led by the Operational Manager or a separate **team leader**. A Single focal point for the team is a useful way of ensuring that there is at least one individual whose most important task is to oversee, co-ordinate and ensure coherency of all the work being done. Other tasks of the leader include ensuring that schedules are kept, that communication occurs with relevant (dependent) projects and that the project’s development is consistent and coherent with the larger project.

Figure 2 - 5: Terminal Airspace design team

2.4 SAMPLE TERMINAL AIRSPACE DESIGN PLANNING STEPS

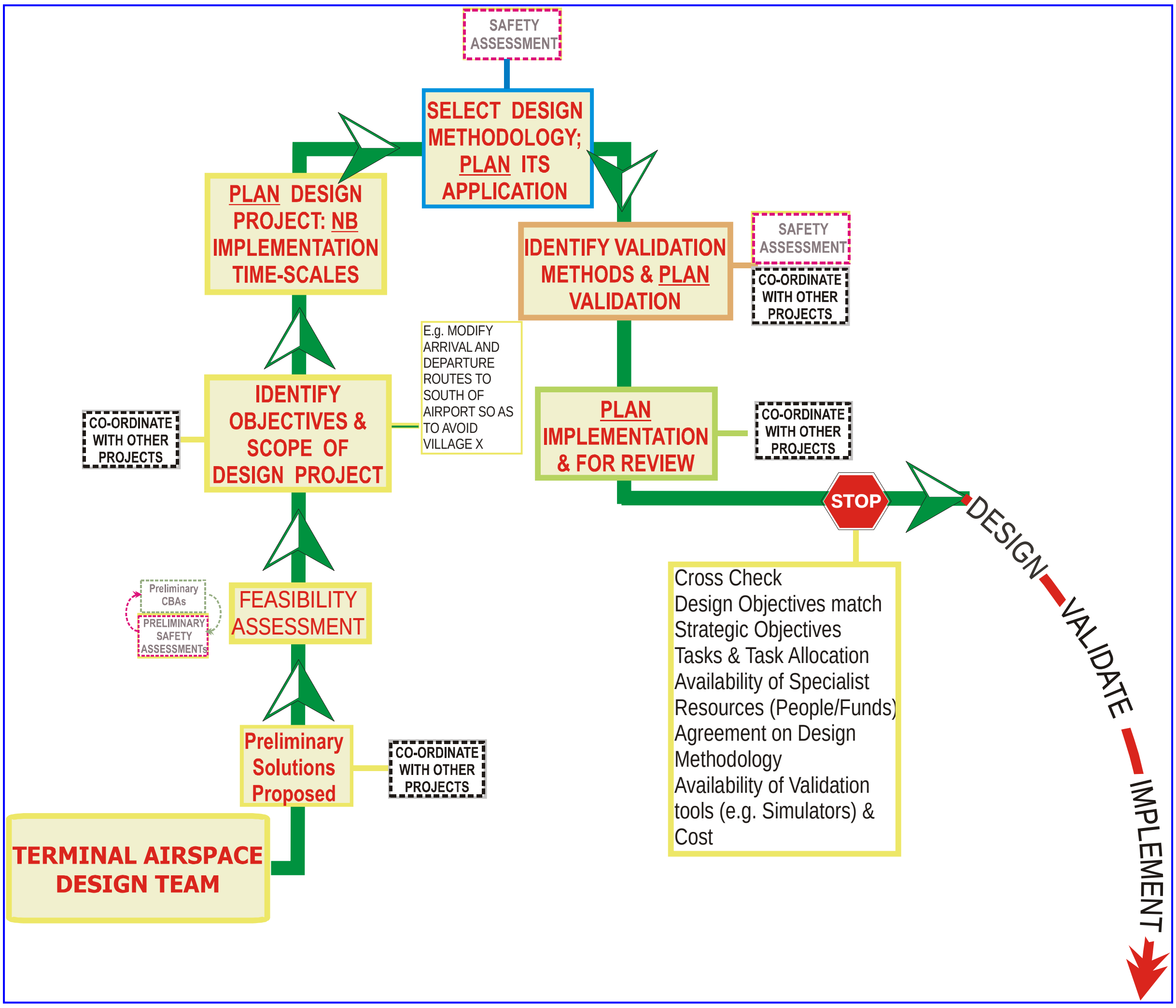


Figure 2 - 6: Sample Project Planning

2.4.1 DESIGN OBJECTIVES

Irrespective of the way in which a project is initiated, one of the first tasks of the Terminal Airspace design team is to determine the project's **design objectives**.

Thus, as a first step, the Terminal Airspace design team identifies ways in which higher goals (be they project and/or strategic objectives) might be fulfilled from a Terminal Airspace design perspective. Not every solution proposed is likely: to be acceptable, solutions must be safe in ATM terms, and a solution's benefit is usually required to outweigh its costs. This ratio between benefit and cost is usually determined by undertaking a **CBA** (Cost Benefit Analysis). Thus **the feasibility** of each solution is **assessed** in terms of safety and cost, and a 'solution' is chosen.

Usually the solution chosen is one -

[i] **which meets the objectives of ATS Safety Management**[1] (this includes determining the likelihood of the safety assessment showing that the acceptable level of safety will be met)**,**

[ii] **which meets the objectives of the Air Traffic Services**[2] (and compliance with air traffic service Standards, Procedures and guidance material provided for by ICAO and national regulation); and

[iii] whose **Benefits** out-weights its **Cost.**

The 'solution' selected by the Terminal Airspace design team may be called the **Design Objective.**

- An example of a **Design Objective** stemming from the Project Objective, could be to design arrival and departure routes to accommodate a new parallel runway 18L/36R, whilst ensuring that risk is not increased, that current safety levels are at least maintained and environmental impact is minimised. (Note the 'echo' of Strategic Objectives contained in these design objectives)

2.4.2 DESIGN PROJECT SCOPE AND TASK IDENTIFICATION

Defining the **Scope** of the Terminal Airspace design project is the next logical step *after* the, **design objectives** have been identified. It 'wraps-up' ***what needs to be done*** in order to achieve the **design objectives**. If, for example, the design objective cited above is used as a basis for defining the scope, the **scope** from a Terminal Airspace Design Project perspective could include - .

- develop a Terminal Airspace Design Concept i.e. design Routes, Holding Areas, Airspace Volume and ATC Sectorisation;
- decide upon criteria on which the design will be assessed and then qualitatively assess the Terminal Airspace Design Concept and;
- decide upon criteria on which the design will be assessed and then quantitatively assess the Terminal Airspace Design Concept;
- Validate the design using fast- and/or Real-time simulation;
- Undertake a Safety Assessment;
- Design the validated routes in accordance with PANS-OPS criteria;
- Determine controller training requirement and establish training programme;
- Publish and Implement the new Terminal Airspace Structure.

<u>Note:</u> The Scope cannot exist in a vacuum. Not only is it frequently affected by the time-scales for implementation (below) but it also presupposes the existence and application of general principles and a design methodology.

What is evident in the above list is that it also constitutes a core list of **tasks** that will need to be broken down into sub-tasks and scheduled.

Perhaps the most important consideration when deciding the scope is to aim for what can realistically be achieved ***in the time available.*** Although it is tempting to widen a project's scope in order to cover *all* aspects (even those which are not crucial to meet the objectives), success is more likely if the aims are modest and the work undertaken of high quality.

[1] These are to ensure that a) the established level of safety applicable to the provision of ATS within an airspace or at an aerodrome is met; and b) safety-related enhancements are implemented whenever necessary. (PANS-ATM, Chapter 2)

[2] these include preventing collisions between aircraft; expediting and maintaining an orderly flow of air traffic; providing advice and information useful for the safe and efficient conduct of flights; (Annex 11, Chapter 2)

As with the design objectives, the value of properly deciding the **scope** of a project cannot be under-estimated. Not only does the **scope** set the limits of what will be done, but it also constitutes the first –level 'checklist' of tasks to be accomplished.

2.4.3 TASK ALLOCATION AND SCHEDULING

In order to effectively produce a successful design, the tasks identified during the **objectives and scope** phase will need to be broken down into more specific tasks, scheduled so that they are undertaken in the correct order and allocated to team members. Notably, not all identified tasks are necessarily the responsibility of the Terminal Airspace design team. In some organisations, for example, there are dedicated Simulation specialists whose job is to prepare and run simulations so as to validate designs or a Safety specialist whose main occupation is the development of safety cases across a variety of disciplines.

2.4.3.1 Task Scheduling as a function of project dependencies

At this specialist level, project dependencies relate to the relationships that exist (of necessity) between a Terminal Airspace design project and other airspace or airport type projects. (These may have no connection with a larger project being managed by a Project Steering Group in the case of a Major Infrastructure project). If, for example, the En Route network planners are developing scenarios for future route-networks, the Terminal Airspace design team needs to 'link' into this En Route project (perhaps within the context of the greater project under the helm of the Project Steering Group) so as to ensure that – in the example used – the SIDs/STARs to be developed for the new runway will be coherent with the en route plans and vice versa.

At specialist level, therefore, the Terminal Airspace design team may have to consider two sets of project dependencies which may or may not affect task scheduling of the Terminal Airspace design team. Those dependencies identified at high-level (between the yellow boxes shown in next diagram, would relate to a Major Infrastructure project) and those shown in the large grey-shaded circle in the same diagram, which would be relevant irrespective of the project type.

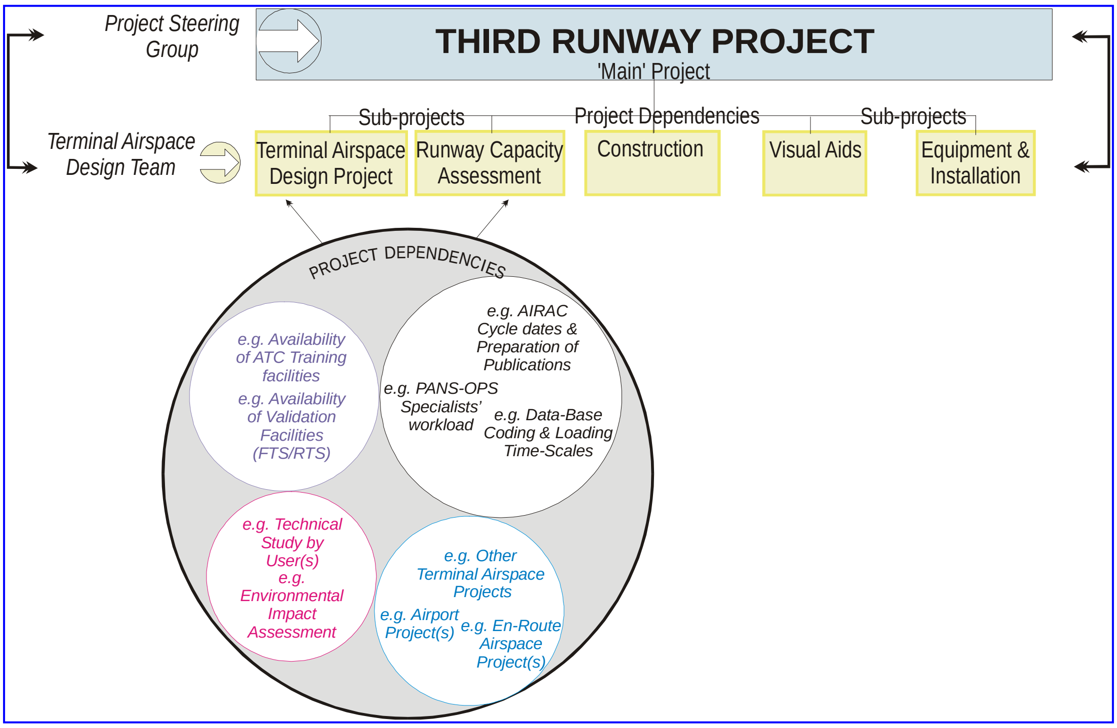


Figure 2 - 7: Examples of dependencies at 'specialist' level – inside circle

Two types of dependencies may be identified:

- **Necessary overlap and interface between other associated projects:** e.g. an En Route airspace project and a Terminal Airspace design team project can only be successful if there is a 'sharing' of team members.
- **Scheduling dependencies:** for example, the PANS-OPS office cannot design the SIDs and STARs in accordance with obstacle clearance criteria until the SIDS/STAR concept has been developed and the SIDs/STARs have been validated in a holistic ATM context.

2.4.3.2 Task Scheduling and Implementation

It is extremely important that the Terminal Airspace design team ensures that **planning allows all identified tasks and activities to be completed before implementation.**

- In those cases where Terminal Airspace design team works within the framework of an ATM Project, the team may be in a position to decide its own implementation time-scales. In this case, care should be taken not to under-estimate the time needed to complete the tasks and to add in extra days (approx. 10%) to allow for error or unforeseen difficulties.
- Where a Terminal Airspace design project is undertaken within the framework of a Major infrastructure project or initiated by External Directive, the Terminal Airspace design team is required to meet a pre-determined time-scale, chosen by someone else. (In the case of an external directive project, time scales could be very short). In this case, the Terminal Airspace design team should ensure that the work is organised so that the tasks can be completed in the time available. Where timescales are extremely short, this would usually result in more human resources being required to accomplish the tasks.

A sample task list is provided as an attachment to this chapter.

2.5 SUMMARY

This Chapter has discussed the planning steps applicable to a Terminal Airspace design project in the context three managerial framework Types. It has shown that *planning* the work and *doing* the work are critical elements to be accounted for when selecting a date for implementation or when working towards an implementation date.

This Chapter contains three Attachments, one shows a Sample Planning schedule, the second a sample task list for a Terminal Airspace Design project, the third a summary of the Planning Process discussed in this and the previous chapter.

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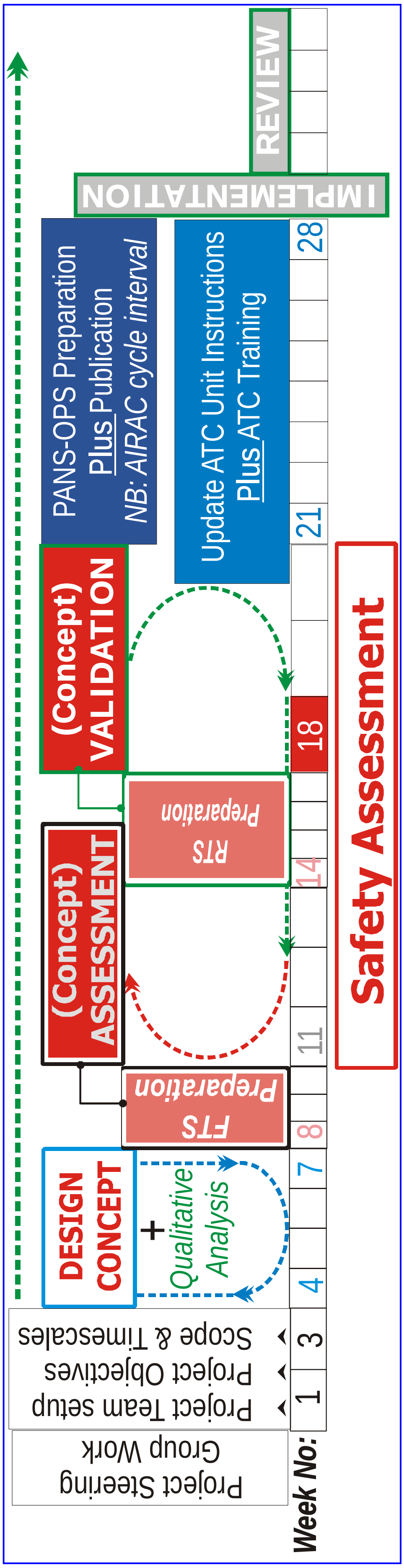
Attachment B.2-1

Sample Project Schedule



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Attachment B.2-2

Sample Project Planning Checklist

TERMINAL AIRSPACE DESIGN PROJECT (ref. Part B)			
PROJECT NAME:		START: [date]	TARGET ↓IMPLEMENTATION↓
ESTIMATED EFFORT (TOTAL)		END: [DATE]	[DATE]
BACKGROUND & CONTEXT:			
INTERNAL DESIGN TEAM MEMBERS:	[NAME]	[NAME]	[NAME]
	[NAME]	[NAME]	[NAME]
EXTERNAL TEAM, MEMBERS:	[NAME]	[NAME]	[NAME]
INTERNAL REPORTS TO:	[NAME]	[NAME]	[NAME]

STRATEGIC CONSIDERATIONS
1. OBJECTIVES:

DESIGN CONSIDERATIONS	
1. OBJECTIVES:	2. SCOPE:
3. DEPENDENCIES:	4. RISKS: performance indicators
5. PERFORMANCE INDICATORS: Safety: Capacity: Environmental:	

A. WORKING ARRANGEMENTS

- Members of Terminal Airspace Design Team
- Leader of Terminal Airspace Design Team, (if applicable)
- Operation Manager, (if applicable)
- Project Steering Group, (if applicable)
- Additional team members (recruit, latest, after Tasks are identified (see below)

Number of days required to set up working arrangements	

B. POLICY AND REGULATORY MATERIAL

- Safety Policy
- Environmental Policy.
- Safety Assessment requirements and guidelines
- Environmental guidelines
- Approved Airspace Design Methodology
- Approved Validation methods (that may be used to validate design)
- Relevant International material e.g. ICAO SARPs, PANS etc.

Number of working days required to identify relevant Policy and Regulatory material	

C. PROJECT DEPENDENDCIES

- Availability of
  - ATC Training Facilities
  - Simulation facilities (once validation method selected)
  - Specialists to undertake specialist/technical studies e.g. Environmental Impact studies.
- Tentatively reserve facilities for ATC Training, Simulation;
- Prepare draft calls for tender w.r.t anticipated technical/specialist studies
- Content and Schedule of other airspace/airport projects
- PANS-OPS specialist (availability)
- Tentatively reserve services of PANS-OPS Specialist.
- AIRAC cycle dates(affects implementation)

Number of working days required to identify project dependencies and complete (tentative) preparatory work	

D. PROJECT TASKS & RELATED /ACITIVITES

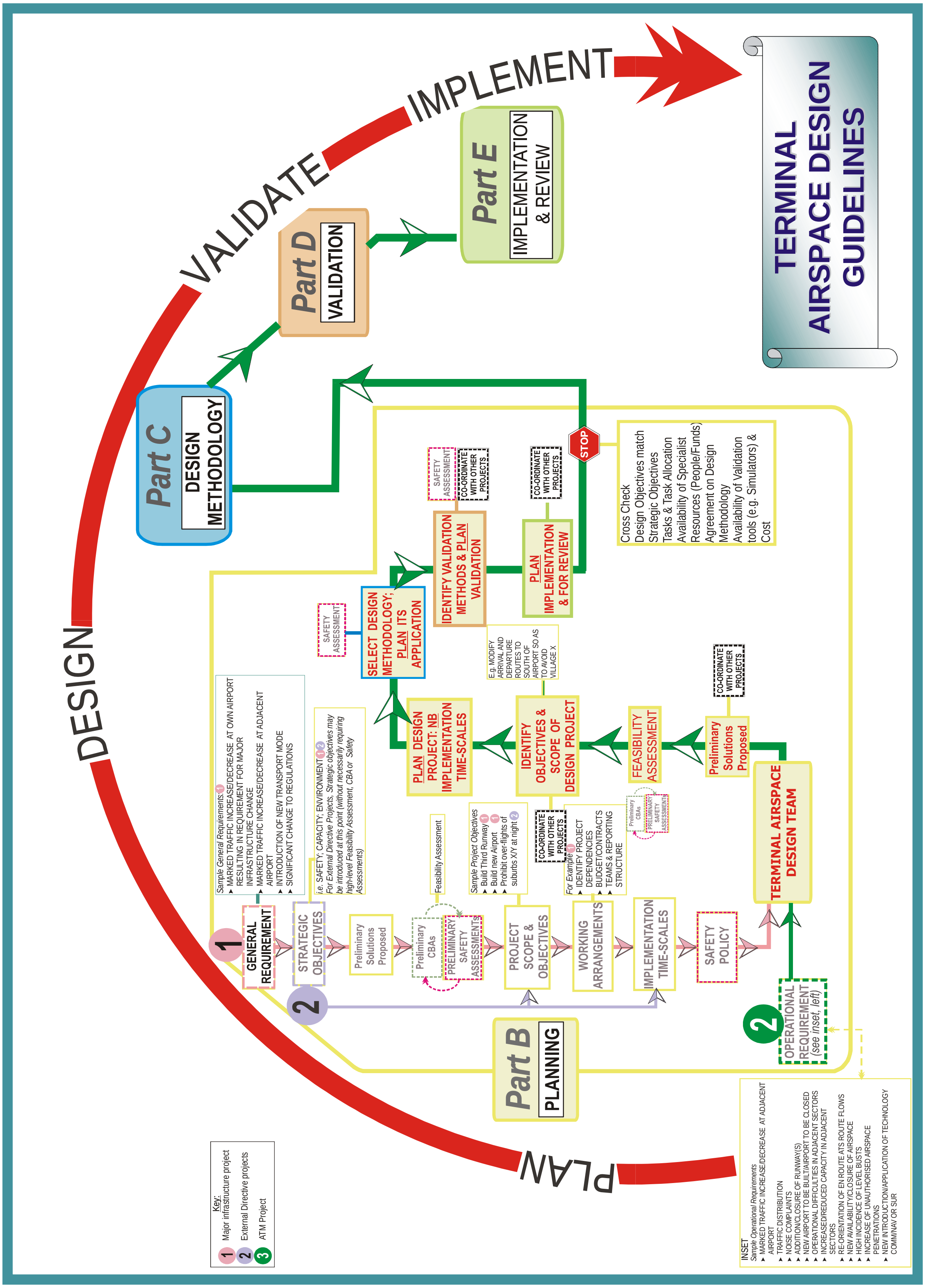
1. Propose design objectives
2. Feasibility Assessment (including Cost Benefit Analysis and Preliminary Safety Assessment)
3. Finalise Design Objectives and Scope
   a) Decide implementation date as a function of Tasks to be completed; or
   b) Tailor Scope/Objective to fit into available time.
4. Firm up Calls for tender w.r.t specialist/technical studies
5. Confirm reservation for ATC training facilities and Simulation
6. Cost Benefit analysis and Preliminary Safety Assessment
7. Statement and Critical Review of Reference Scenario
8. Selection of Performance and Safety Criteria
9. Identification of Assumptions, Constraints and Enablers
10. Development of Terminal Airspace design concept, including
    a) Routes and Holds
    b) Structures and Sectors
    c) Qualitative assessment of concept
    d) Impact assessment of proposed concept (e.g. Environmental impact study)
11. Select Scenario(s) to be Validated
12. Validation of proposed Scenarios and Safety Assessment
    a) Prepare simulation
    b) Run simulation
    c) Data analysis
    d) Write up final report of findings
13. Complete safety assessment documentation as per Safety Policy
14. Finalise outstanding reports
15. Obtain approval for implementation
16. Prepare for implementation
    a) PANS-OPS Specialist to design SIDs/STARs as per PANS-OPS Criteria
    b) AIP and other relevant Publications (NB AIRAC cycle dates)
    c) ATC Training
    d) Amend Letters of Agreement (if required)
    e) Amend local/national ATC Procedures, (if required)
    f) Amend local/national regulations, (if required)

Number of working days required for each identified Task/Activity	

E. TASK ALLOCATION			
Task No:	Responsible Person/s	Due date (Draft Report)	Due Date (Final Report)
1			
2			

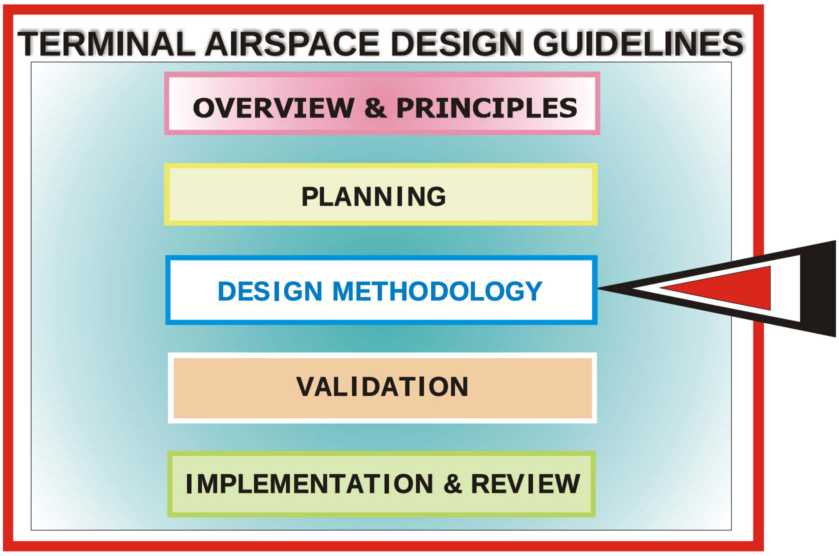
ESTIMATED TOTAL NUMBER OF DAYS (A+B+C+D+E)	

Attachment B.2-3



PART C

DESIGN METHODOLOGY



INTRODUCTION

Part C supplies the level of guidance required by Terminal Airspace Design Planners. Building upon the foundations created in Parts A and B, Part C contains the *Design Methodology.*

As such, Part C assumes that the **objectives** and **scope** of the Design Project (see Part B, para. 1.3.1) have been agreed.

General

Mindful that it is neither possible nor desirable to create a generic blueprint for the design of Terminal Airspace – because each Terminal Airspace is unique and subject to local considerations – Part C should not be construed as a blueprint. Instead, Part C should be viewed as a store of proven methods and guidelines intended to support Terminal Airspace design planners in their quest to meet their strategic and design objectives. As such, expressions such as *should* and *may* are used intentionally throughout Part C. With the increasing availability of new technologies for use by Terminal Airspace designers, Part C will, more than any other part of this document, be updated progressively over time.

Given the level of detail referred to above, the contents of Part C are covered over several chapters as follows:

- **CHAPTER 1: DESIGN METHODOLOGY – AN OVERVIEW**
- **CHAPTER 2: THE REFERENCE SCENARIO**
- **CHAPTER 3: SAFETY & PERFORMANCE CRITERIA**
- **CHAPTER 4: ASSUMPTIONS, ENABLERS & CONSTRAINTS**
- **CHAPTER 5: GUIDELINES - ROUTES AND HOLDS**
- **CHAPTER 6: GUIDELINES – STRUCTURES AND SECTORS**
- **CHAPTER 7: CONCEPT EVOLUTION**
- **CHAPTER 8: DESIGN METHODOLOGY – CHECKLISTS**

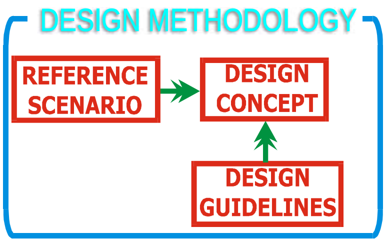
Safety Provisions

The attention of airspace designers is drawn to the following ICAO and EUROCONTROL provisions concerning safety in the context of airspace design and planning. These document references include but are not limited to -

- ATS Safety Management (ICAO Annex 11 Chapter 2);
- Safety Assessments as per (ICAO PANS-ATM Chapter 2);
- Guidance to ATM Safety Regulators (ESARR 3);
- Risk Assessment and Mitigation in ATM (ESARR 4).

Style Notes

1. Because the Design Methodology contained in Part C is detailed, each Chapter begins with its own abridged Table of Contents and a Design Methodology 'Locator Box' (below).

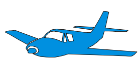


2. When considered helpful, Comment Boxes have been inserted at various places in Part C. These have been given a distinctive in appearance (below), and provide answers to general questions that are frequently asked. For example:

> ***Comment:*** ***What extraneous factors should be considered in selection of a 'futuristic' Traffic sample?***
> *Various factors, not easily visible within a given traffic sample, may influence traffic patterns of the future. Examples of these include …*

3. Exceptionally, more specific comments mainly dealing with RNAV, weather phenomena and the Environment are provided, particularly in Chapters 5 and 6. For convenience, these are preceded by distinctive symbols:

 RNAV

 VFR Operations or VFR Routes

 Weather

 Environment

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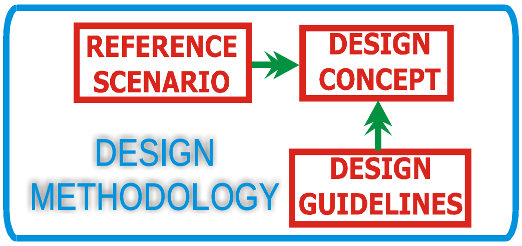
CHAPTER 1

- DESIGN METHODOLOGY: AN OVERVIEW –



Contents

1.1 INTRODUCTION

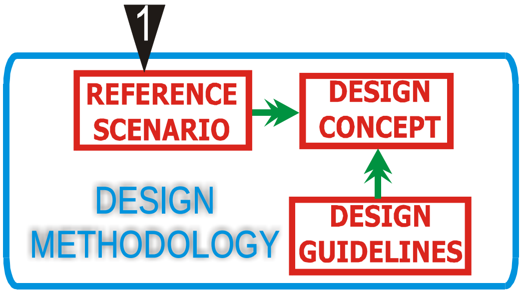
This chapter provides an overview of the *Design Methodology* which consists of the ***Reference Scenario,*** the ***Design Concept*** and ***Design Guidelines.*** It also explains the context of the *Design Methodology* in a Terminal Airspace design project, its potential applications and basic assumptions underlying the design process.

1.1.1 REFERENCE SCENARIO (CHAPTER 2)

The *Reference Scenario* and a *Critical Review* of this reference marks the starting point of the design methodology. Whilst its relevance might not be apparent, its importance is three-fold:

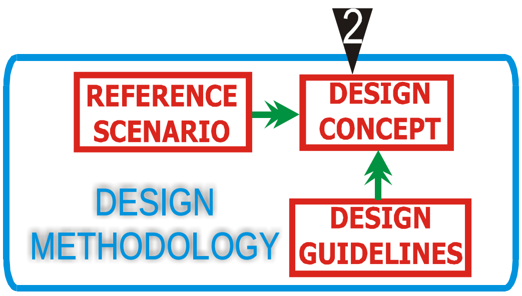
- it is an efficient way of refining the *design objectives* given that a design project is usually undertaken as a means of improving upon the existing design; and
- it provides a benchmark against which the *design concept* can be compared; and
- it prevents design 'weaknesses' identified in the *Reference Scenario* in the *Design Concept*, being repeated.

For the above reasons, the Reference Scenario is where the *Design Methodology* commences.

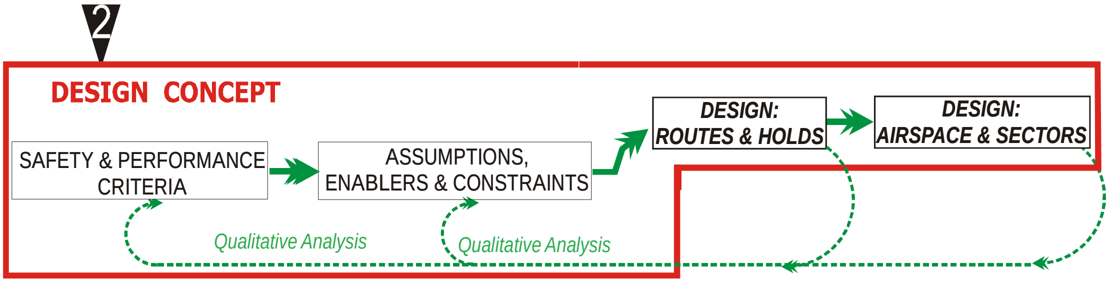


1.1.2 DESIGN CONCEPT (CHAPTERS 3 & 4)

The *Design Concept* marks the second major step of the *Design Methodology* but the **starting point of the design *process***.



The *Design Concept* is not limited to designing routes, holds, the airspace and sectorisation but also includes all the preparatory work involved in the design *process.* For this reason, the *Design Concept* is made up of several components, which are usually undertaken in the (left-to-right) order illustrated below.

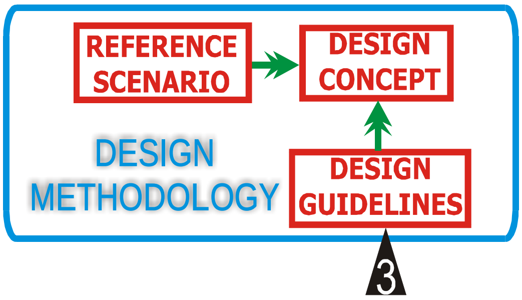


Several remarks may be made about the above illustration:

- The reverse arrows and expression *Qualitative Analysis:.* These serve to show that when the design stage is reached, a continuous cross-checking process is required to ensure that safety and performance criteria are being met and that the assumptions, constraints and enablers are consistent with the design.
- The expression *Qualitative Analysis* is significant in that it implies that expert judgement is required in order to make a meaningful analysis.
- Safety and Performance Criteria as well as Assumptions, Enablers and Constraints are *constants* to the entire Terminal Airspace modification process. They are carried through to the Assessment and Validation phases of the project (see below).

1.1.3 DESIGN GUIDELINES (CHAPTERS 5-7)

Last – but not least – the *Design Guidelines* provide the third component of the *Design Methodology.* They explain ***how*** to design the different parts of a Terminal Airspace i.e. routes, holds, the airspace and ATC sectorisation.



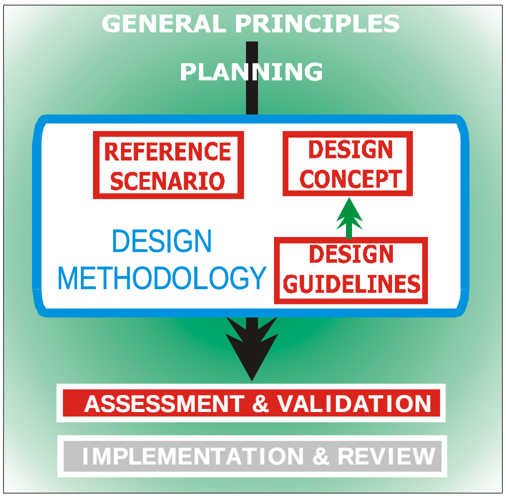
As with the *design concept,* the design guidelines are also made up of several components, undertaken in a specific order. Usually, this order is

- routes and holds are designed **first**;
- the Terminal airspace structure is designed **second;**
- ATC sectors are designed **third.**

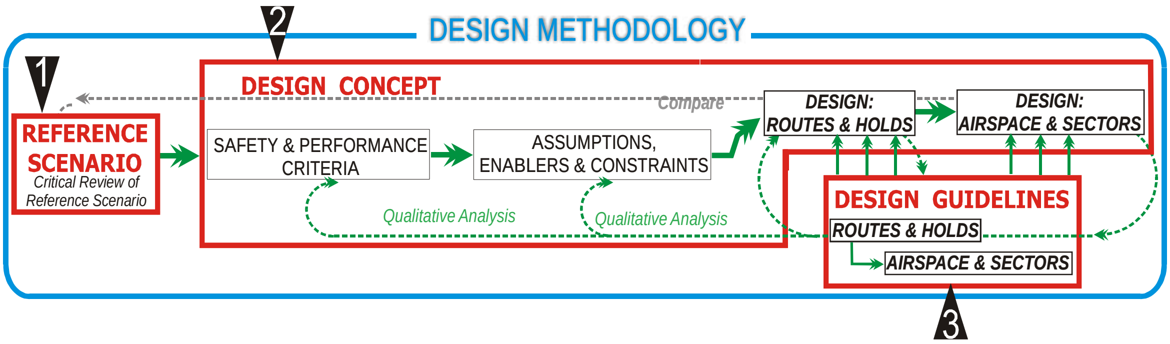
However, throughout the design process, early design of each component may be adapted or altered in light of evolving considerations of the other components i.e. a continuous process of qualitative analysis and adaptation unless a coherent and effective end result is achieved.

1.2 DESIGN METHODOLOGY IN CONTEXT

In the overall Terminal Airspace Design process, the *Design Methodology* underpins the airspace design and is placed after planning (where the operational requirements and objectives are identified) and before assessment and validation takes place.

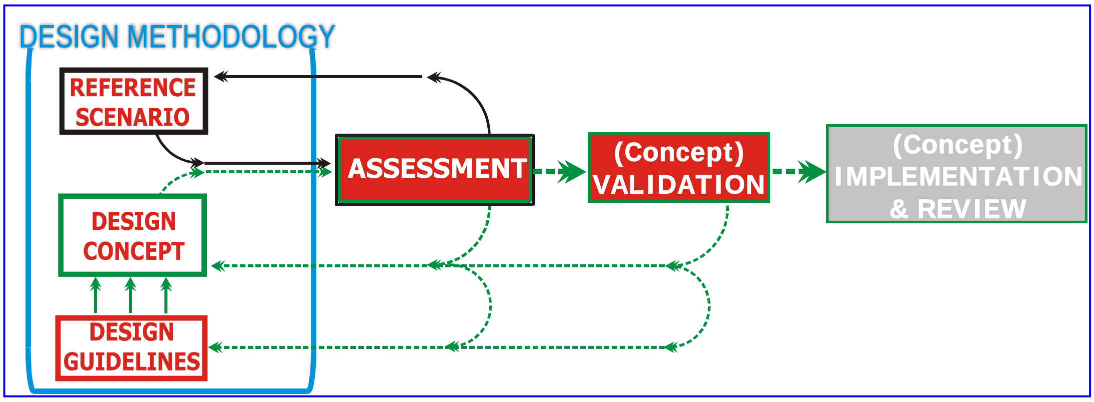


As far as the designer is concerned, the *Design Methodology* starts with the *Reference Scenario* and is followed by the *Design Concept.* This concept would be based on a set of *Design Guidelines* (which may be of a national nature or those contained in this document).



Because this document provides *guidance* as to how a Terminal Airspace should be *designed,* however, the *Design Guidelines* are identified as a separate 'component' of the *Design Methodology.* In reality, however, the *design concept* would be based on the other elements of the design concept and a set of *design guidelines.*

In the context of *actual* Terminal Airspace design, it may be said that the *Reference Scenario* and *Design Concept* are the main products of the Design Methodology. Once established, these two components are then assessed (as discussed in Part D), and once a *Design Concept* is selected – because it has reached a suitable stage of maturity – the Design Concept is validated and implemented (and the Reference Scenario put to one side). Notably, the assessment involves *comparisons* with the Reference Scenario, and consistency checks with the design concept - hence the reverse arrows below.



Although it is not possible to claim that each of the four steps should all be completed in order to ensure successful design, **what can be stated with certainty is that a design *process* starts at a *conceptual* level and that expert judgement is integral to each of the four steps**.

Comment
It is fair comment that the creation of the design concept and its qualitative analysis are relatively inexpensive when compared to later stages identified as Assessment and Validation (usually undertaken by Fast- or real-time simulation). This is one – but certainly not the main– reason why it is advisable to subject the design concept to rigorous qualitative analysis ***before*** *moving to the Assessment and Validation phase. From a practical perspective, some airspace studies have shown that high calibre qualitative analyses make it possible to skip the Assessment and move directly to validation using, for example, a real-time simulation (normally, these are for relatively simple airspace developments). In similar circumstances, high-quality fast-time simulations can serve both the quantitative analysis and validation phase – which may allow for by-passing validation by real-time simulation and proceeding directly to implementation.*
It is commonly believed that results from real-time simulation are better than those provided by fast-time simulation (and that the same is true of fast-time simulation as regards airspace modelling or creation of the design concept). This is not necessarily true: the value of ***any*** *validation steps could be questioned if poor assumptions are made and/or poor formulation occurs.*

1.2.1 POTENTIAL APPLICATION OF THE DESIGN METHODOLOGY

Four situations may be envisaged when seeking to employ the Design Methodology.

(i) Re-design/modification of an existing Terminal Airspace in response to a particular problem or with a view to a future development;

(ii) the creation – for the first time – of a new Terminal Airspace at an existing airport;

(iii) the design of a Terminal Airspace for an airport which has yet to be built, where the runway orientation for the airport is known;

(iv) the design of a Terminal Airspace for an airport which has yet to be built and the runway orientation will be selected from a pre-defined set as a function of the preferred Terminal Airspace design amongst other factors.

Whilst the first option (i) is by far the most common and the incidence of options (iii) and (iv) quite rare, option (ii) is rapidly gaining prominence due to an increasing tendency for low-cost airlines to locate their centre of operations at (previously) 'quiet' regional airports.

Of particular interest, as regards options (ii) to (iv), is the fact that no *Reference* (Terminal Airspace) *Scenario* exists and as such, it is not 'available' for comparison with the Design Concept. In the absence of a *Reference Scenario,* another benchmark is required and the *Design Guidelines* together with designer experience can provide adequate benchmarks.

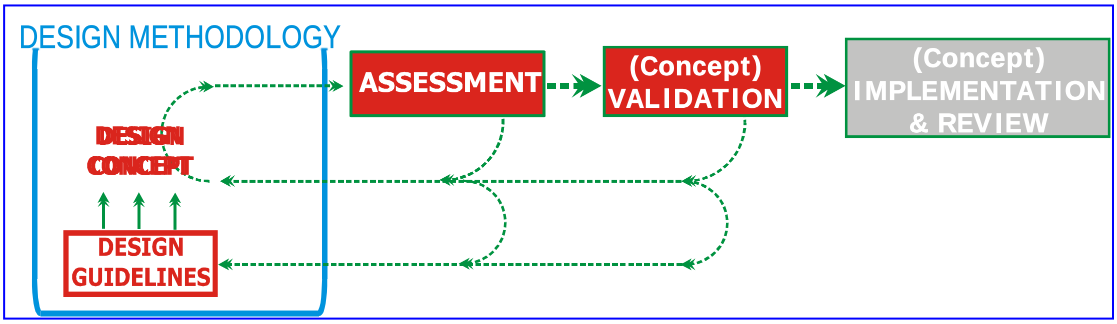


Figure 1- 1: Design Methodology without Reference Scenario

1.3 UNDERLYING ASSUMPTIONS

1.3.1 METHOD

Although this chapter – and indeed, this document – lays considerable emphasis on the importance of following a *method* when designing a Terminal Airspace, it is necessary to state that successful design is not guaranteed if the *methodology* is followed in *form* but not in *substance*. Adherence to a process and working one's way through a checklist is not enough: the planning methodology used in the process needs to be underpinned by a clear **set of objectives** (see Part B para. 1.3.1) as well as a ***realistic*** view of Terminal Airspace operations both present and future. Thus, for example, if the **design objective** of the design project is to find a way to reduce track mileage on a certain STAR, the solution might be to design a STAR for use by aircraft that are P-RNAV certified. This said, the STAR should only be designed ***if*** the aircraft for whose use it is intended are likely to be P-RNAV certified.

As obvious as the above example might seem, an ***unrealistic*** approach to design is one of the frequent criticisms levelled at designers and planners. Flawless though the design of a particular route or procedure may be, if it cannot be used (because, for example, the assumptions on which it is based are unrealistic) the design cannot be successful because it will fail to meet the operational needs. This suggests, therefore, that aside from knowing the **objectives** of the design project, one of the first 'rules' of Terminal Airspace Design concerns a requirement for the project to be based upon a ***realistic*** **assumptions**, ***realistic*** **constraints and *realistic* enablers.** This 'rule' applies equally to the *Reference Scenario* as it does to all phases of the project i.e. design, assessment and validation processes.

1.3.2 COLLABORATION

Whilst all of the Principles described in Chapter 2 of Part A are considered part of the foundation of the Terminal Airspace design process, it is considered opportune to emphasis that user requirements and environmental interests should be accounted for in the design phase. Collaboration is an on-going an extensive process: it applies whether fixing the ***Reference Scenario***, **Assumptions, Enablers and Constraints** or undertaking the design**.** In all cases, input from airspace users, environmental specialists *and* various branches of the air traffic services (i.e. collaborative effort) should be invited.

Importantly, collaboration is not limited to a process within a particular State. In the case of a Terminal Airspace located close to an international border – and especially where *two* Terminal Airspaces are located in close proximity to the common internal border, this collaboration should be extended into the international domain. Input from the adjacent State(s) is also desirable – particularly when designing routes, holds, creating the airspace structure and sectorisation. Indeed, future traffic demands could conceivably require two independent Terminal Airspaces on either side of a border to be transformed into a common cross-border Terminal Airspace.

Comment:
Present day air traffic management is characterised by specialisation in different fields. For this reason, a broad range of specialists should be included in the Terminal Airspace Design team. This means that the design team should include ATC experts as well as Users, PANS-OPS specialists and Environmental representatives. Failure to collaborate effectively with the support of other specialists, adjacent States or to obtain the input of other interested parties could result in the wrong assumptions being fixed or constraints and enablers not being identified correctly. Of necessity, such errors weaken the design and may lead to subsequent rejection.

1.3.3 STRIKING THE BALANCE

General Principles and the principle of collaboration considered, it becomes evident that the designers are frequently required to strike the balance between the diverse and competing interests. Despite this reality, it is opportune to point out that the quest for collaboration should not extend to compromising safety. Whilst safety objectives can be achieved in a variety of ways (which can be viewed as a 'compromise' of sorts), safety itself should not be compromised. Thus in the triangle made up of Safety, Capacity and Environmental interests, Safety is not negotiable.

1.4 SUMMARY

The *Design Methodology* described in this chapter is the anchor point of the Terminal Airspace design project and is aimed at responding to the operational requirements and design objectives described in Part B.

Made up of the ***Reference Scenario,*** the ***Design Concept*** and ***Design Guidelines*****,** the efficiency of the Design Methodology depends upon following a well planned step-by-step process undertaken in collaboration with interested parties with a view to ensuring the safety of operations within the airspace being designed.

To the above ends, qualitative analysis is of particular importance to the entire *Design Methodology* at each part of the process.

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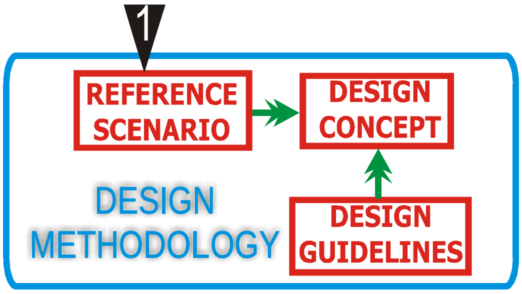
Attachment C.1-1

Document References of Relevance to Terminal Airspace Design

Part C				
Chapter	**Subject**		**Document Reference**	
3	**Safety Assessment**	How to undertake -	Doc. 9689	
		Need For-	Annex 11	Chapter2
		Need For-	Doc. 4444	Chapter 2
		Need for & How to undertake -	ESARR 3 & 4	
4	**Enablers, Constraints**	Environmental Protection	Annex 16	
		RNP - Manual of	Doc. 9613	
		LoA - Common Format	EAPM	Section 6
		Radar Surveillance … Major Terminal Airspace	E-Ref. 1 (below)	Chapter 5
5	**Arrival/Departure Routes**	Design Criteria – Conventional/RNAV	Doc. 8168	Vol. II
		Design Criteria – RNAV	E-Ref. 2 (below)	
		Helicopter Operations	Doc. 9426	Part II, Section 4
		IFR/VFR - Mixed Operations	Doc. 9426	Part II, Section 4
		Instrument Flight Procedures Construction	Doc. 9368	
		Lateral Limits	Annex 4	
		Level Restrictions - (~Vertical Limits)	Annex 4	
		Mixed IFR/VFR Operations	Doc. 9426	Part II, Section 4
		Publication	Annex 4	
		Publication	Annex 15	
		SID/STAR - Establishment of	Doc. 9426	Part I, Section 2
		SID/STAR- Identification of	Annex 11	Appendix 3
		Significant Points - Establishment & Identification	Annex 11	Appendix 2
		Waypoint Naming Convention	E-Ref. 3 (below)	
	Routes - Other	*ATS Routes (RNAV) - Establishment of*	*Annex 11*	*Attachment B*
		En Route ATS Route Design Guidelines	*EAPM*	*Section 4*
	Holding	Design Criteria - Conventional/RNAV	Doc. 8168	Vol II
		Design Criteria - RNAV	E-Ref. 3 (below)	
		Holding - Establishment of	Doc. 9426	Part I, Section 2
		Template	Doc. 9371	
6	**Terminal Airspace**	General Terminal Airspace Information	Doc. 9426	Part I, Section 2
		Publication	Annex 15	Chapter 3
		Vertical/Lateral Limits	Annex 11	Chapter 2
	Airspace - Other	*Airspace Restrictions & Reservations*	*EAPM*	*Section 3*
		General Airspace Guidelines	*EAPM*	*Section 1*
		En Route Design Guidelines	*EAPM*	*Section 4*
	Sectorisation	Capacity Estimation	Doc. 9426	Part II, Section 1
		Capacity Estimation	Doc. 4444	Chapter 3
		Co-ordination	E-Ref.3	
		Co-ordination	Doc. 4444	Chapter 10
		General Information	Doc. 9426	Part II, Section 3
	Sectorisation - Other	*En Route Sectorisation Guidelines*	*EAPM*	*Section 4*
E-Ref.1	EUROCONTROL STANDARD DOCUMENT FOR RADAR SURVEILLANCE IN EN-ROUTE AIRSPACE AND MAJOR TERMINAL AIRSPACE [Edition 1, MARCH 1997]			
E-Ref.2	EUROCONTROL: GUIDANCE MATERIAL FOR DESIGN OF TERMINAL PROCEDURES (DME/DME, BARO-VNAV & RNP-RNAV) [Edition 3, JANUARY 2003]			
E-Ref. 3	Common Format, Cross-Border, Inter-Centre Letter of Agreement Document [ASM.ET1.ST015 DEL01/02]:			

CHAPTER 2

- THE REFERENCE SCENARIO –



CONTENTS

2.1 INTRODUCTION

This chapter presents the *Reference Scenario* which constitutes the first step of the *Design Methodology.*

As stated in the previous chapter, the relevance of the *Reference Scenario* and a *Critical Review* is four-fold:

- it provides a benchmark against which the *design concept* can be compared[1]; and
- it is an efficient way of refining the *design objectives* and ensuring that operational requirements are being addressed (see Part B) given that a design project is usually undertaken as a means of improving upon the existing design; and
- it may help to refine the scope of the existing project; and
- it prevents design 'weaknesses' identified in the *Reference Scenario* being repeated.

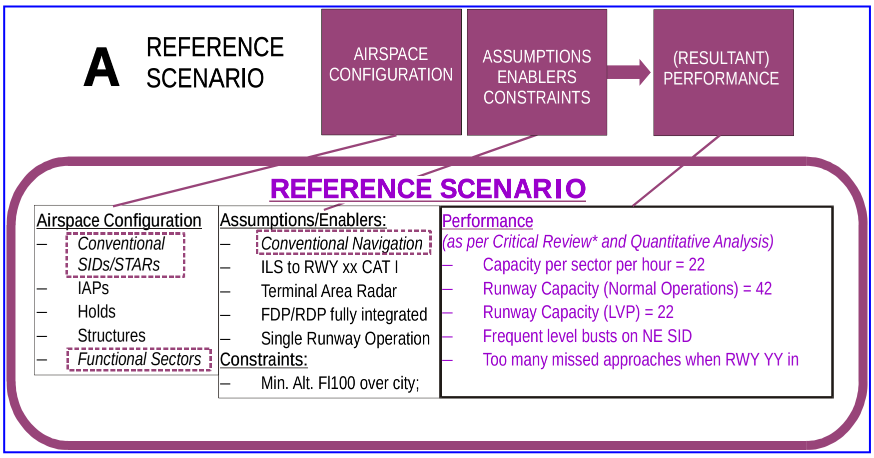
Although the process of describing current Terminal Airspace operations is sometimes considered a tiresome exercise, one of its additional advantages is that it provides the opportunity to discover (and correct inconsistencies) related to the existing design. Examples of these discoveries may include –

- published SIDs/STARs – that are no longer used;
- out-dated instrument approach procedures;
- publication errors in the AIP;
- abandoned navigation aids.

2.2 WHAT IS THE REFERENCE SCENARIO?

In general terms, the *Reference Scenario* is a description of the **current** Terminal Airspace operations. As such, the Reference Scenario describes the **current layout of routes and instrument approach procedures as well as holding patterns, airspace structures, ATC sectorisation and how the traffic is managed within the airspace and in relation to surrounding airspace**.

Given that the (main) purpose of the Reference Scenario is to provide a benchmark against which the new/modified design is compared, the assumptions, enablers and constraints which formed the basis of the Reference Scenario should also be identified.



[1] The relevance of this is that a comparative assessment is the most usual way in which safety is assessed in those instances where 'absolute' measurement is not required. (See Part C, Chapter 3).

Nevertheless, there are cases when the **current** Terminal Airspace is not used as the *Reference Scenario.* This occurs when, for example, previously validated modifications to any aspect of the Terminal Airspace (i.e. routes, or holds or structure or sectorisation) are to be implemented in the short-term i.e. before the implementation of the current project.

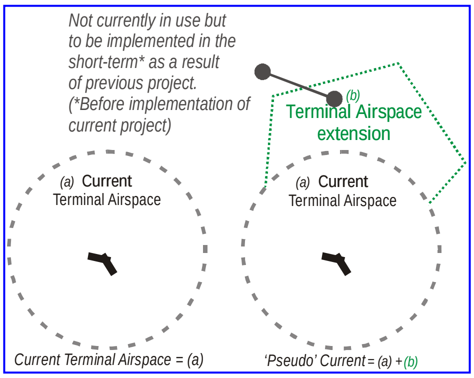


Figure 2- 1: Reference and 'Pseudo' Reference

Figure 2- 1 illustrates the 'Psuedo' current using an example of a change to airspace dimensions. The yet-to-be-implemented change (i.e. (b)) would thus be used as a 'Pseudo' Reference against which new changes are measured. This 'Pseudo' Reference could equally be a based upon a new route or routeing structure, holding patterns or the sectorisation.

2.3 CREATING THE REFERENCE SCENARIO

At this stage of the *Design Methodology,* creation of the Reference Scenario is mainly a paper exercise. Even so, the detail and quality of the information contained in the Reference Scenario should be such that someone unfamiliar with the Terminal Airspace and its operating practices is able to form a comprehensive 'picture' of the airspace.

The Reference Scenario is created from various sources. Ideally, all these sources should be used so as to build the most complete picture as to the current or 'pseudo' current Terminal Airspace operations.

Below, an abridged list is provided showing selected items needed in the statement of the *Reference Scenario.* A comprehensive Checklist and the sample questions is provided in Chapter 8, ***Attachment C-8-1***:

	Information	How obtained
❑	Predominant Runway-in-use at airport(s) within the existing Terminal airspace.	Statistical analysis of existing data over the last few years.
❑	Current Traffic Demand and its geographic and time distribution.	Traffic samples can be obtained from the CFMU and/or local ATC centre(1).
❑	Analysis of the Traffic sample e.g. IFR/VFR mix; Fleet Mix; Aircraft performance mix, etc.	Traffic sample. obtained above.
❑	Routes (IFR & VFR), instrument approach procedures and Holding patterns/areas.	AIP and traffic sample;
❑	Radar Vectoring patterns	Operational controllers
❑	Airspace dimensions	AIP and Operational controllers

❑ Sectorisation (Terminal Airspace, adjacent Terminal Airspace and Lower ACC sectors)	Operational Controllers and ATC System specialists
❑ Traffic Management i.e. Co-ordination agreements between sectors and	Local ATC Instructions and Letters of Agreement.
❑ Existing constraints (e.g. terrain)	PANS-OPS specialists / environmental specialists; policy makers.
❑ Existing ATM/CNS enablers (e.g. 5 DMEs in Terminal Airspace)	Operational controllers/Engineers

<u>Note (1)</u>: *Part C, Chapter 4 explains how to select and analyse Assumptions. One of the most important assumptions is the Traffic Sample.*

2.4 CRITICAL REVIEW OF THE REFERENCE SCENARIO

Once the Reference (or Pseudo Reference) Scenario has been described, it should be critically reviewed. This critical review is a qualitative exercise which involves operational experts closely scrutinising the existing Terminal Airspace operations i.e. each element of the airspace organisation and how effectively and safely it works with a view to identifying operational problem areas. This is the stage at which existing constraints are identified, and the required mitigation and enablers (see Part C, Chapter 4).

Undertaking the critical review is a relatively straight-forward exercise – although it can be difficult for the design team to examine (what may be their previous efforts) in a critical light. As can be seen by the Reference Scenario and Critical Review Checklist in Chapter 8 ***Attachment C.8-1 and C.8-2***, the Critical Review is concerned with establishing *What is wrong*, or *What factors limit* the Reference Scenario. On the positive side, aspects that work well should be identified (so that the benefits are not lost).

If, for example, the SIDs are being critically reviewed, the design team may agree that for most of the year, the existing SIDs meet the operational requirements in that they appear to respond to the actual aircraft performance of the current fleet mix. This said, however, controllers may notice that most heavy aircraft bound for the Far-East are unable to make the level restrictions on one of the SIDs when the temperature are high during the summer months. During the critical review process, this situation is identified – and may indeed be used to refine the design objectives discussed in Part B.

2.5 REFINING DESIGN OBJECTIVE(S)

One of the 'outputs' of the *Critical Review* process is that current design weaknesses or flaws in the current operation may be 'added' to list of design objectives or used to refine the design objectives. In the example used above, the possibility of designing a discrete SID for use during the summer months by heavy aircraft has arisen and as such, it may be appropriate opportune to add this to the design objectives.

2.6 COMPARING SCENARIOS

Although the Reference (or 'Psuedo' Reference) Scenario serves, at a later stage, as the yard-stick against which the success of the new or modified design is measured, it may be considered logically inconsistent to seek comparisons between the Reference Scenario and new Scenarios based upon different assumptions or enablers (or constraints). The diagram below presents this apparent dilemma.

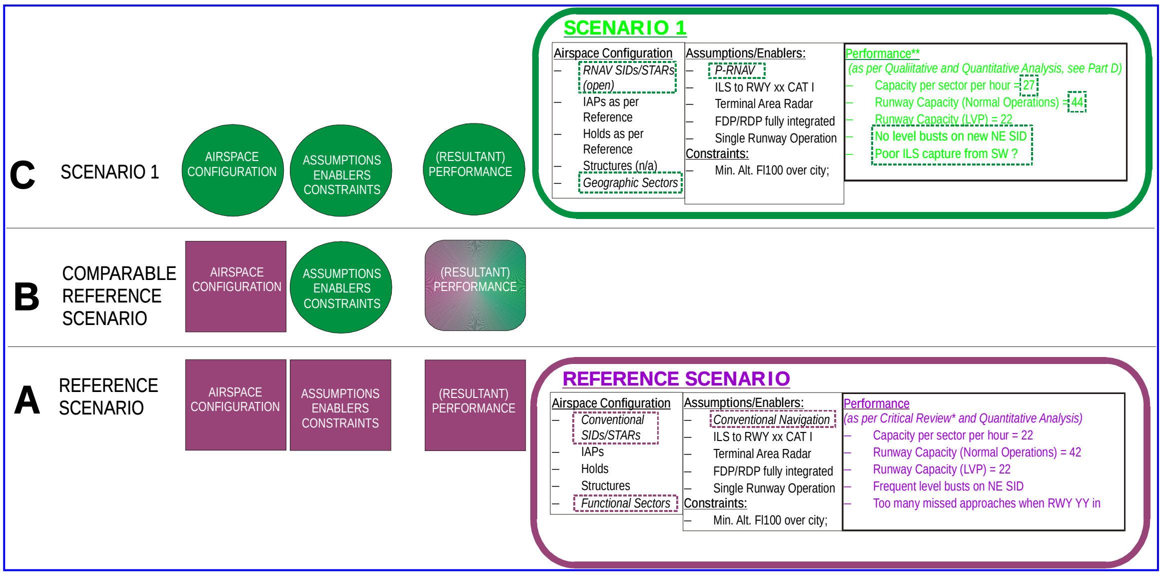


Figure 2- 2: Scenario Comparison

In the above diagram -

A= the Reference Scenario with its particular Assumptions, Enablers and Constraints and its resultant Performance.

C= the new Scenario 1, with, for example, a new set of SIDs/STARs based on a different assumptions (e.g. Navigation means = P-RNAV) and its resultant Performance.

In comparing the Performance of Terminal Airspace C (Scenario 1) with that produced by A (Reference Scenario), it could be argued that A and C are not comparable because the assumptions are different (e.g. navigation) and that the changes made to the SIDs and STARs are therefore substantial. Furthermore, a different sectorisation method has been used. Logically, this argument is correct, and if followed through one would need A to be based on C's assumptions to obtain performance B and that B should then be compared to C so that the comparison is meaningful.

If this approach were followed, it could be argued that the Reference is no longer the Reference once it is based on different assumptions. e.g. assume the 'true' Reference has one runway, and a new assumption is the addition of a parallel runway.

For this – amongst other – reasons, airspace designers seek to compare the performance output of the 'new' scenarios, in order to establish whether the new scenario(s) meets strategic and/or design objectives.

2.7 SUMMARY

The establishment of the *Reference Scenario* is the first step of the *Design Methodology* and is undertaken prior to embarking upon the *Design Concept.* The *Reference Scenario* usually reflects the current Terminal Airspace, though in some instances, use may be made of a 'Pseudo' current Reference Scenario.

As a means of establishing a useful benchmark for comparison with the *Design Concept,* in order to refine the *design objectives* and as a mechanism of identifying existing design weaknesses, the *Reference Scenario* is subjected to qualitative analysis known as a *Critical Review*.

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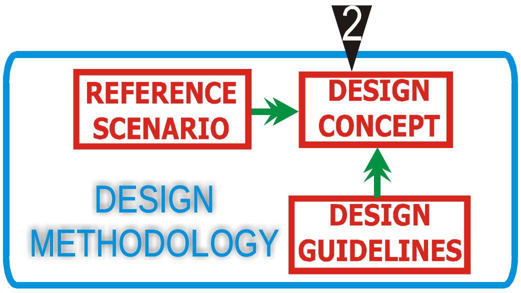
CHAPTER 3

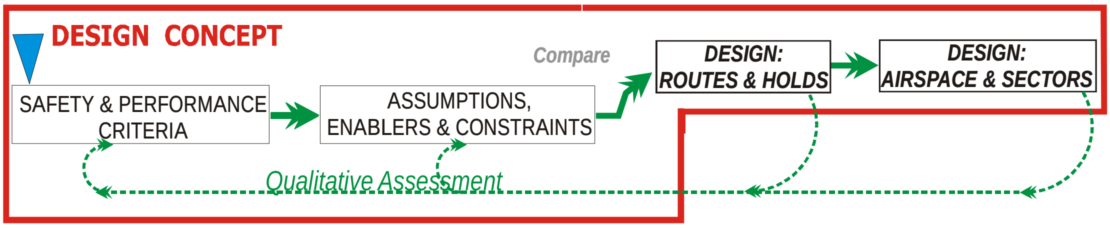
- SAFETY & PERFORMANCE CRITERIA –



CONTENTS

3.1 INTRODUCTION

This chapter discusses *Safety and Performance Criteria* whose formulation constitutes the first phase of the *design concept.*



Safety and performance criteria are important because they provide a yardstick against which the safety and performance of the proposed design can be measured. Identified during initial project planning, these criteria may be translated into project and/or design objectives (see Part B) which accompany the project throughout its life-cycle. These 'benchmarks' remain constant throughout the development of the Terminal Airspace design project though the extent to which they can be successfully 'measured' may be affected by the project phase. For example, it may not be possible during the concept design phase to measure whether a capacity performance target is met, though this can be determined during the validation phase using the appropriate tool. In order for a proposed and implemented design change to be considered successful in safety and performance terms, the selected criteria need to be satisfied.

Although safety and performance criteria have always been important, their significance has increased since the introduction of mandatory ICAO and European requirements for States to undertake a safety assessment when making changes to their airspace design – See Part A, Chapter 2, General Principles.

Since entering into force of ICAO and EUROCONTROL[1] provisions in 2001 and 2003 respectively, expressions such as 'safety case', 'safety argument', 'safety assessment' and 'safety criteria' have become common-place. Sometimes, these terms are not necessarily used in a consistent manner and this has generated some confusion e.g. the expressions 'safety argument' and 'safety case' are sometimes used interchangeably. An awareness of this has influenced the layout of this chapter:

- Attempts have been made to align safety-related terms with their ICAO and ESARR equivalents. However, as this has not been entirely successful (because a one-on-one correlation between ICAO and ESARR terminology is not necessarily provided for), a section of this chapter has been devoted to several 'key' terms/concepts so that they can be recognised and understood irrespective of the nomenclature used.
- 'Safety Criteria' are not discussed in isolation but rather described within the greater context of safety case development. The latter is a generally accepted way of undertaking safety assessments.

Despite the above, attention is drawn to the fact that the aims of this document do not include providing guidance for the undertaking of safety assessments. It is therefore **stressed that the Terminal Airspace design team bears the responsibility for complying with the safety policy prescribed by the National Regulator, and that none of the material contained in this chapter should be construed as relieving the Terminal Airspace design team of such obligations.**

[1] See Part C, Chapter 1, Attachment C.1-1 for reference material related to Safety.

3.2 CONCEPTS

3.2.1 QUALITATIVE AND QUANTITATIVE ASSESSMENT

The need to assess the safety or other performance of a Terminal Airspace design is one reason for establishing safety and performance criteria. **Assessment** is an ongoing process: **qualitative assessment** which begins at conceptualisation and continues through implementation also provides the foundation for **quantitative assessment**.

Two types of assessment have been distinguished: **qualitative** and **quantitative** assessment.

- ***Qualitative assessment*** is achieved by expert judgement being used to assess the design using ICAO standards, recommended practices and procedures as a benchmark. Qualitative assessment relies upon expert (air traffic control/operational) judgement and effectively forms the basis for the design concept (and the Critical Review of the Reference Scenario and the identification of Assumptions, Constraints and Enablers). Qualitative Assessment is an on-going process: as well as providing the basis for the design concept, this expert judgement is also used to qualitatively assess *all* phases of the design methodology, and it is integral to quantitative assessment and to safety measurement – even when the emphasis appears to be on measurement against an absolute threshold. That qualitative assessment forms the backbone of the various validation methodologies will become evident in Part D, and it is used in implementation planning (Part E).
- In contrast, ***Quantitative assessment*** is concerned with 'quantified' results produced in the form of numerical data. e.g. capacity increased by 20%.

It is perhaps because quantitative assessment appears to provide 'tangible' values that these results are perceived as being preferable to those of a qualitative nature. But this perception inaccurate – for at least two reasons:

[i] Qualitative assessment made by expert ATC judgement is the primarily way in which ICAO SARPs and procedures are safe-guarded during the design process; and

[ii] if total reliance is placed upon quantitative results without qualitatively assessing what they mean (i.e. using expert judgement to interpret the results), the value of the quantitative assessment is likely to be less.

[iii] Quantitative assessments are inadequate in effectively depicting and quantifying the complex and highly variable nature of airspace and air traffic operations. This is because quantitative safety assessment models tend to simplify many operational elements in order to be manageable. This results in limiting the number of elements to those having the greatest potential for effect – and this can return incorrect results. For this reason, quantitative assessment needs to be balanced by qualitative assessment i.e. operational judgment and experience for the complex interactions, conditions, dependencies and mitigations for which quantitative assessment cannot provide a meaningful measure.

What will become evident in the next section is that both qualitative and quantitative assessment are essential to the process of safety evaluation.

3.2.2 EVALUATING SAFETY

ICAO Annex 11 and PANS-ATM includes requirements for a Safety Assessment to be undertaken when making certain modifications to the Air Traffic Management System. Significantly, ICAO has detailed those instances in which a Safety Assessment is required and an excerpt from the relevant ICAO material has been included in Part A of this document at Chapter 2. Because airspace designers must ensure and demonstrate that an airspace design is safe[2] (i.e. provide evidence of safety through a safety assessment process), this section provides a broad overview of how safety can be evaluated.

Two methods are commonly used to evaluate safety: one is ***comparative (or relative)***, the other ***absolute***. The use of one method does not exclude the other and most frequently, they are combined.

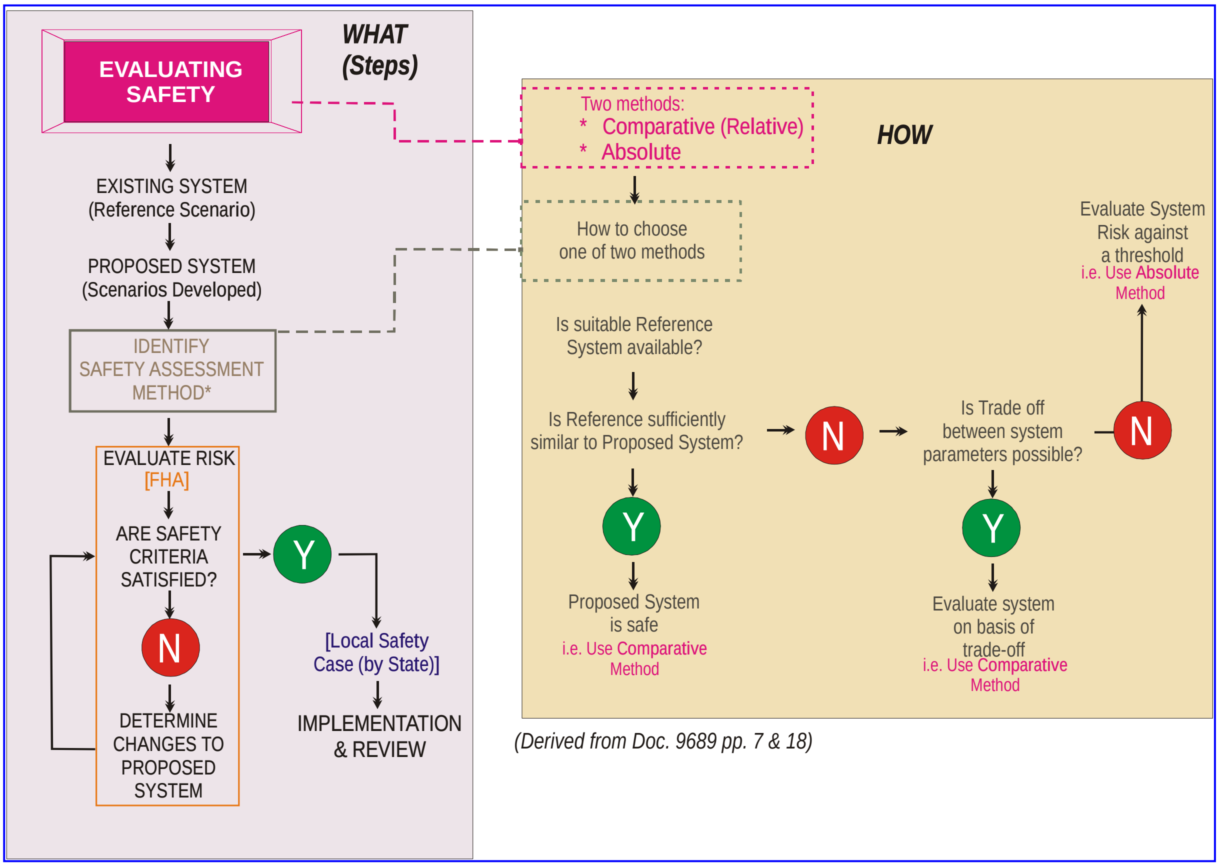


Figure 3 - 1: Evaluating Safety

Most airspace designers are familiar with the ***comparative (or relative) method*** because it is the most and frequently used. When safety is evaluated using this method, the safety of the proposed Terminal Airspace design is compared in relation to an existing design (called a Reference Scenario – see Part C, Chapter 2). Use of this method could therefore show an *increase/decrease or maintenance of safety* of a proposed design which has been compared to a Reference Scenario.

In contrast the ***absolute method*** involves evaluating safety against an ‘absolute’ threshold. An example of such an absolute threshold could be: *that the risk of collision is not to exceed 5 fatal accidents per 1 000 000 000 flight hours.* (This would more commonly be expressed

[2] See Part A Chapter 2, First Principle.

as a requirement to meet a **t**arget **l**evel of **s**afety (TLS) of $5x10^{-9}$). A collision risk analysis using a collision risk model is the usual way in which a determination is made as to whether a TLS is being met – See Part D, Chapter 8.

Notably, **safety criteria** are set whichever method is used. Differently put, a benchmark is created whether the **absolute** or **comparative** method is used. The benchmark, however, is different dependent upon the method used. Whatever the method and/or safety criteria used, a safety evaluation can only be rigorous if **qualitative assessment** forms the backbone of the evaluation process.

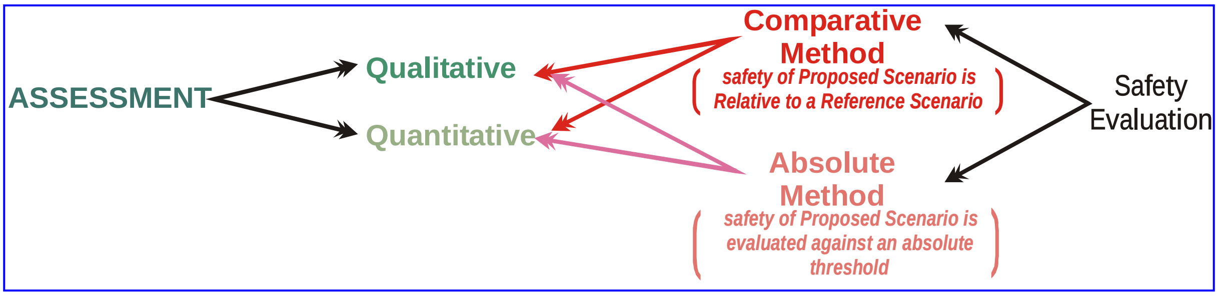


Figure 3 - 2: Assessment & Evaluation

It should be noted that the safety of an airspace design is not *only* dependent upon the correct application of design criteria when designing routes, holding areas, and airspace structures designed in accordance with the design rules and procedures contained, *inter alia*, in ICAO Annex 11 and Doc. 8168 (especially Vol. II). Safety factors are considered before and during this design phase, by, for example –

- developing a feasible airspace design concept (see Part C, Chapter 5 and 6) prior to the application of the PANS-OPS design criteria; and
- ensuring the accuracy of critical aircraft and operational assumptions which are used to form the basis of the PANS-OPS design;

In the 'greater' context, the design is also required to satisfy the safety objectives which are included, but not limited to the generic ATC objectives and whether these are met is most often determined by **qualitative assessment**. Thus whilst Annex 11 and Doc. 8168 provide rules relating to airspace dimensions and obstacle clearance criteria respectively, qualitative assessment criteria are included, but not limited to, PANS-ATM and various ICAO Annexes.

Comment:
How does the designer know when safety should be evaluated using the absolute method? *Typically, the absolute method is to be used when required by ICAO. This usually involves instances when the change envisaged is radical and untried elsewhere (see Ref.1). For example:*
- reduction of the vertical separation minima (RVSM)
- determination of new spacing between parallel ATS routes for which lateral navigation accuracy is specified with a view to applying the separation minima in PANS-ATM Chapter 5, as a basis for route spacing in Terminal Airspace; (see Ref 2)

It is opportune to add that because most Terminal airspace re-designs rely, for the most part, on existing ICAO provisions and do not involve radical changes such as those introduced with the RVSM example, the comparative/relative method is likely to remain the most frequently used (subject to certain conditions). In order to gain a greater appreciation of these two methods, readers are strongly encouraged to refer to the introductory chapters of ICAO Doc. 9689 and requirements of ESARR 4.
Ref.1: Manual on Airspace Planning Methodology for the Determination of Separation Minima, Ch. 6.
Ref. 2: Annex 11, Attachment B, paras. 1.1 & 3.1 in particular.

3.3 THE SAFETY CASE APPROACH

The Member States of ECAC are required to comply with ESARR/4. Whilst ESARR/4 is regulatory in nature, guidance documents have been provided to ECAC States which explain how to undertake a safety assessment. One such document is entitled Air Navigation System **S**afety **A**ssessment **M**ethodology (SAM[3]).

ESARR/4 and SAM are characterised by a **holistic approach**, a **risk based approach** and **system approach** to safety assessment.

Significantly a…" *Safety Assessment should be holistic: it should consider all the implications of new systems within the widest context and at all stages in the life-cycle.*" This includes (investigating) "*The complete chain of events in which the system may be involved in accident and incident causation: the potential consequences of system failures (hazards), their possible consequences on aircraft operations and their possible causes (deficiency of system elements and external events")*. This suggests that such assessments are also made with other elements of the airspace operation e.g. aircraft, systems, procedures etc.

Therefore, the pre-implementation process involves the development of a safety case comprising a reasoned safety argument based on a Functional Hazard Assessment (FHA) and Preliminary System Safety Assessment (PSSA). After implementation, the safety case is revised as well as a System Safety Assessment (SSA). – See diagram below.

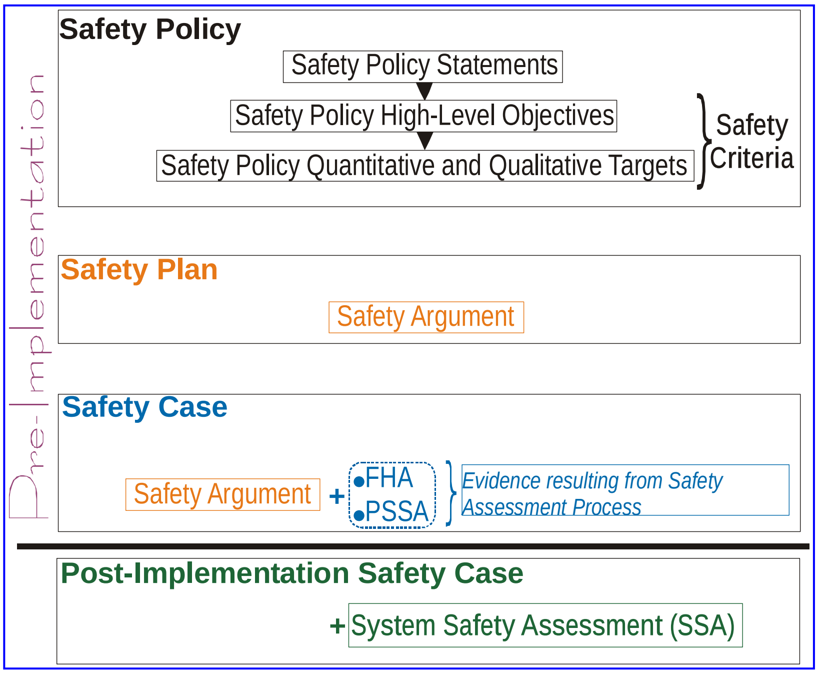


Figure 3 - 3: ESARR Safety Case Approach

3.4 OTHER PERFORMANCE CRITERIA

Performance criteria relate to the way in which the success of a Terminal Airspace design is measured. Whilst 'safe' performance may be viewed as the 'first' measurement of success, it is not enough for a Terminal Airspace to be safe if it does not deliver the performance expected in terms of capacity and environmental mitigation amongst others.

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[3] *Air Navigation System **S**afety **A**ssessment **M**ethodology, EUROCONTROL, 17 April 2000 (SAF.ET1.ST03.1000-MAN-01-00),*

As with the *safety criteria*, ***Performance criteria*** are closely linked to the Design Objectives described in Part B (and, of necessity, the generic set of ATC Objectives described by ICAO in Annex 11). The *Performance criteria* to be selected become evident when answering the question “*What determines the success of the Terminal Airspace design?”* Differently put, *How can one confirm that the objectives have been met?*

The following are examples of performance criteria:

- an airport capacity increase of 20% is demonstrated; and
- no increase in noise pollution is experienced by the residents of Suburb *Y* between 22:00 and 05:00 UTC;
- track mileage flown by arriving aircraft is not extended by more than 5%;

Having decided upon the performance criteria (usually embodied in the strategic and design objectives – see Part B), it is necessary for the Terminal Airspace design team to select the appropriate tool so as to correctly measure these criteria. These are discussed in Part D.

3.4.1 EVALUATING CAPACITY AND ENVIRONMENTAL IMPACT

Although the ***comparative*** and ***absolute methods*** are commonly used in a safety context (above), other performance criteria can also be evaluated using in either a comparative or absolute manner. This can be demonstrated using the examples cited in para. 3.4:

1a. an airport capacity increase of 20% is demonstrated; and	Comparative
2a. no increase in noise pollution is experienced by the residents of Suburb *Y* between 22:00 and 05:00 UTC;	
3a. track mileage flown by arriving aircraft is not extended by more than 5%;	
examples of Absolute measurement being required, are illustrated by changing the wording of the above criteria to new wording below.	
1b.airport capacity = 129 movements p.hour	Absolute
2b. noise emitted by each ACFT does not exceed 65dB at the noise monitoring point.	
3b. track mileage flown by arriving aircraft does not exceed 32 NM from Terminal Airspace Entry point.	

Naturally, normal ATC simulators such as fast- or real-time may not be suitable for measurements relative to noise (e.g. 2a or 2b, above) and noise modelling tools would be required. It should be noted that developments are underway to combine fast time simulation with noise modelling software.

3.5 SAFETY, PERFORMANCE AND PROJECT PLANNING

Because a project’s strategic objectives are closely linked to safety and performance criteria, it is useful to connect the information contained in this chapter with information presented in Part B – Planning. To this end, use is made of a fictitious example:

Strategic Objectives: *Increase existing* ***capacity****; reduce* ***environmental*** *impact over Suburb Y; meet the Target Level of* ***Safety****.*

Design Objectives: *Create new Terminal arrival and departure routes to accommodate a new parallel runway.*

(ICAO ATC Objectives: *Prevention of collision; maintaining a safe and orderly flow of air traffic i.e. creating a design that will be conducive to these objectives)*[4]*.*

[4] inserted for completeness.

Safety Criteria: *the route spacing of 8NM between parallel Terminal Routes is required to meet a target level of safety of* 5×10^{-9}.

Performance criteria: *The Terminal Airspace design will be considered a success if, for example:*

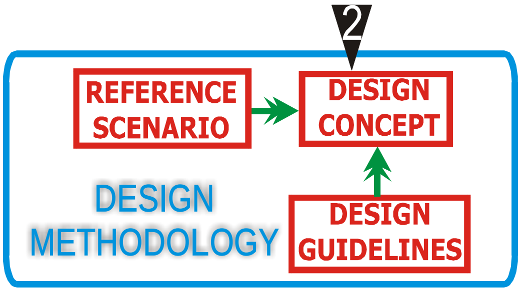
- **(quantitative)** Approach West Sector demonstrates a capacity increase of 20% demonstrated; and
- **(quantitative)** no increase in noise pollution is experienced by the residence of Suburb *Y* between 22:00 and 05:00 UTC;
- **(quantitative)** track mileage flown by arriving aircraft is not extended by more than 5%;
- **(qualitative)** A crossing SID and STAR have been designed in accordance with PANS-OPS criteria complete with profiles. Inadvertently, the profile of both the SID and STAR requires aircraft to be at FL70 at the crossing point. This error would be detected during the qualitative assessment (which is almost an on-going subconscious process for most designers). As such, this error would be identified and the profiles redesigned so that the SID and STAR profiles are separated by at least 1000 feet at the crossing point.

3.6 SUMMARY

This chapter has sought to explain safety criteria in the greater context of the safety case approach to safety assessment. To this end, explanations have been provided on some basic concepts, how safety can be evaluated and an outline of the safety case approach has also been provided.

CHAPTER 4

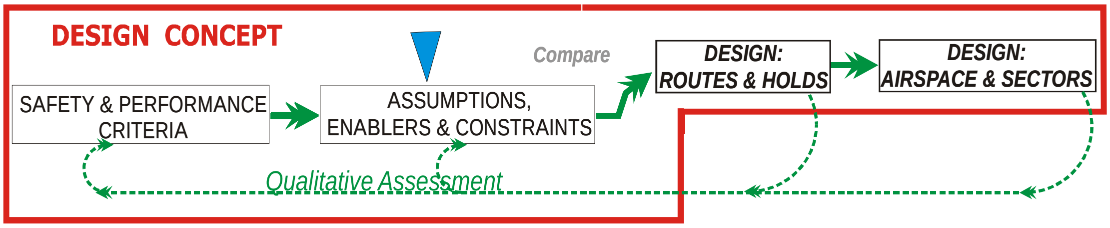
- ASSUMPTIONS, CONSTRAINTS & ENABLERS –



Contents

4.1 INTRODUCTION

This chapter discusses *Assumptions, Enablers and Constraints* which constitute the second phase of the *design concept.*



As stated in Chapter 2, *Assumptions, Enablers and Constraints* are *constants* to the entire Terminal Airspace design process. They are carried through to the Assessment and Validation phases of the project (see Part D)

As suggested in previous chapters, the ***performance criteria, assumptions, enablers and constraints*** are established *before* the Terminal Airspace is designed conceptually or any other design phase is undertaken. Moreover, it is important to note that **assumptions, constraints and enablers underpin <u>all phases</u> of the design process and therefore <u>remain constant</u> throughout the design process** (unless one of the aims of a Scenario (see Part D) is to test an assumption (or enabler, or constraint))**.** This requirement for consistency is illustrated below.

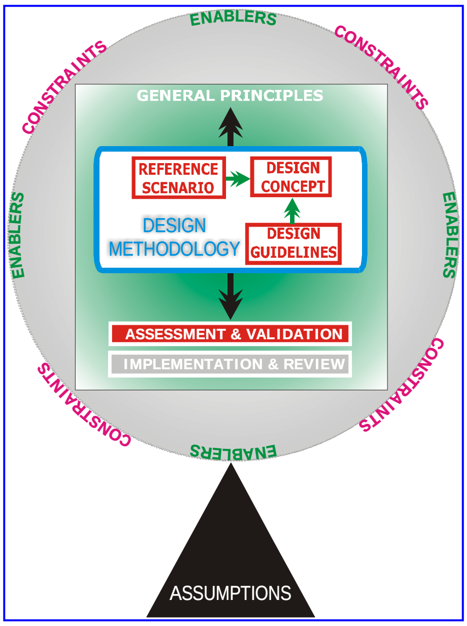


Figure 4 - 1: Consistency

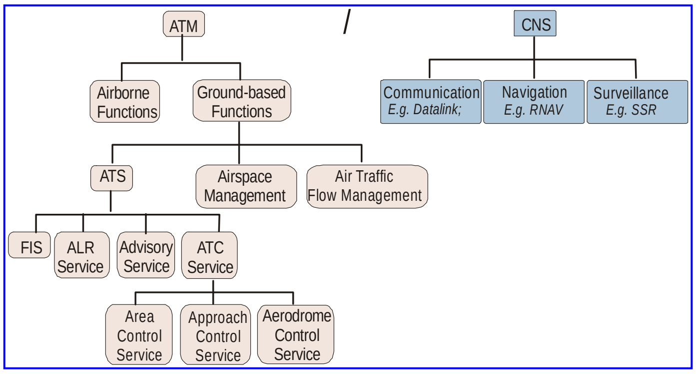


Figure 4 - 2: ATM/CNS[1]

4.2 WHAT ARE ASSUMPTIONS, CONSTRAINTS AND ENABLERS?

4.2.1 ASSUMPTIONS

Assumptions refer to elements of ATM/CNS which are assumed to be 'true' for purposes of the design. ATM/CNS covers a wide variety of fields which often requires most designers to consider factors beyond the limits of their own expertise. Assumptions may also have to be made concerning factors beyond direct ATM/CNS e.g. certain weather phenomena.

Whilst some assumptions are based upon factors/elements which can be relied upon with reasonable certainty within the time-scales of the design project, other assumptions are likely to be no more than an 'educated guess' [because obtaining *firm* knowledge is not possible within the timescales]. It is better to undertake the design process without any uncertainties, but there is sometimes no option but to include them so as not to stop or delay the overall design project.

The incorrect identification of assumptions can be the undoing of a Terminal Airspace design. It is therefore better to err on the side of caution when selecting assumptions. This can be illustrated by way of an example:

Example: Suppose that it is not possible to establish whether a ATS route will be available for traffic from X to Y, and that the absence/presence of the new route is the key to reducing the workload in a particular sector. In this case, it would be better **not** include the new ATS route as an assumption in the traffic sample. This said, however, it may be worthwhile to have a two-phase design plan where the first excludes the new ATS route and the second includes the ATS route, so that the true value of the new route can be quantified.

The identification and selection of assumptions is likely to provide the greatest challenge to the designer in the case of *futuristic* design projects e.g. creating a Terminal Airspace model for the year 2025 for a new airport site with eight parallel runways. As most designers can vouch, the closer the implementation date the easier the assumptions are to select. In the case of futuristic projects, the designer may be left no choice but to use educated guesswork – and ensuring that the final report properly reflects this.

4.2.1.1 Traffic Assumptions

Assumptions made concerning the **traffic demand** in the Terminal Airspace and those made concerning the **predominant and secondary runway(s) in use** are of crucial importance to the design of a Terminal Airspace. **Traffic demand** and **runway(s) in use** are important because the notion of Terminal Airspace includes the 'resultant' airspace created to protect

[1] Derived from International Civil Aviation Vocabulary, ICAO Doc. 9713 (2001), Part 1

IFR flight paths to and from the runway(s) in use. For this reason, it is imperative that the designer:

- properly analyses the **traffic demand**; and
- the **predominant and secondary runway(s) in use**, their mode of operation and any conditions attached thereto are established.

In context, ***traffic demand*** refers to a traffic sample which the design team considers representative of the traffic servicing the airport(s) within the Terminal Airspace. Thus the **representative traffic sample** chosen by the design team is the **'assumption'** and it is this assumption that requires thorough analysis prior to commencing the design process.(How the traffic sample is selected is discussed in para. 4.3.1).

Whilst traffic demand inevitably refers to a traffic sample, a traffic sample may need to be created to cater for *futuristic* Terminal Airspace design projects e.g. a concept design for the year 2025. In such a case future market analyses are undertaken and a traffic sample created for airspace design purposes. (see para. 4.3.1.1).

4.2.1.2 Runway in use

Similarly, identifying the ***predominant and secondary runway(s) in use*** requires assumptions to be made as to which runway orientation is used for the greater part of the day (e.g. RWY20 is used 70% of the time as opposed to RWY02). (How to determine the predominant and secondary runway is discussed in para. 4.3.2)

This important relationship between runway in use and traffic flows explains why the addition of a new runway within a Terminal Airspace invariably results in the need for some modifications being made to the Terminal Airspace design.

4.2.2 CONSTRAINTS

Constraints stand in contrast to assumptions in that they suggest the absence of certain elements of ATM/CNS or limitations created by extraneous factors. Typical constraints include high terrain, adverse weather patterns, the requirement to satisfy environmental needs (which dictate, for example, the noise-preferential runway to be used at night time) or the absence of rapid-exit-taxiways which may limit the landing rate and therefore influence route placement. In general terms, constraints can be said to have a negative impact upon the ATC operational requirements of a Terminal Airspace design. At best, it may be possible to mitigate the constraints using enablers. At worst, constraints have to be accepted because there is no alternative 'solution'.

4.2.3 ENABLERS

Enablers refer to any aspects of ATM/CNS that may be used to mitigate the constraints identified and/or any factors which may be relied upon to 'enable' ATC operations in the airspace designed. Importantly, the identification of enablers may take the form of functional requirements (which are then 'translated' into technical requirements) which require follow up work on the part of the ANSP and may be outside the scope of the design project – see Figure 4 - 3 **and** Table 4 - 1

4.2.4 SIMILARITIES AND DIFFERENCES

Whilst (design) **assumptions** can be viewed as 'uncertainties' which have been elevated to 'facts' to be used as a basis for the design, the role of **enablers** is to <u>mitigate</u> against **constraints** which have been identified. An example can be used to illustrate this difference: Suppose that a designer wishes to design RNAV routes up to the final approach fix in a Terminal Airspace. Because Terminal RNAV Routes with waypoints having a level restriction below MSA or MRVA may only be designed for use by aircraft which are certified for P-

RNAV operations, an assumption can be created that aircraft operating within the Terminal Airspace are appropriately certified. [Note: this sort of assumption should only be made if the design team is sure that aircraft are appropriately certified]. In seeking to design the route based upon this assumption, the designer identifies a **constraint** viz. that the navigation infrastructure is inadequate and therefore does not allow the design of a necessary STAR route. This constraint could be **mitigated** against by the installation of a new DME pair in the Terminal Airspace and the **enabler** would be an enhancement of the navigation infrastructure – see Table 4 - 1. As shown in the diagram below, the means by which the enabler is achieved/provided (functional and technical requirement) usually falls outside the scope of the design team's work. In view of the costs which enablers sometimes incur, a Cost Benefit Analysis (CBA) may be required to determine whether the benefits provided by the enablers outweigh the costs. If this is not the case, it may be necessary to identify alternative mitigation. – See Part B.

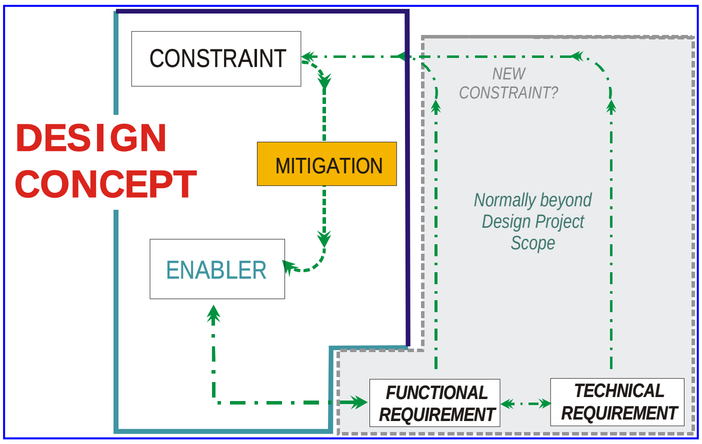


Figure 4 - 3: Constraints – Mitigation - Enablers

CONSTRAINTS	*MITIGATION*	ENABLERS
High Terrain on final approach RWY X	Increase ILS angle by 1°?	Specification change for ILS
Multiple airports within close proximity with poor co-ordination agreement	Letter of Agrrement	EUROCONTROL DOC The Cross-Border Common Format Letter of Agreement
Aircraft Performance Mix limits capacity	Design different SIDs for high and low performance aircraft.	Airspace Design
Aircraft Navigation Performance Mix limits capacity by increasing ATC workload	ATC system modification to allow FDPS/RDPS to show aircraft navigation capability	Software Application Change
Inadequate Navigation infrastructure	New DME at Location A	Enhance NAV infrastructure
High mix of IFR-VFR movements limits capacity	SEGREGATED VFR/IFR ROUTES	Airspace Design
Fixed-wing/Rotor craft mix increases approach workload and complexity	Separated routes based on aircraft category	Airspace design
TSA which adversely affects traffic patterns	Airspace sharing arrangements	Flexible Use of Airspace Concept and EUROCONTROL DOC The Cross-Border Common Format Letter of Agreement
Poor Radar Coverage prevents route placement in part of the Terminal Airspace	Improve Surveillance capability	Enhance Radar infrastructure
Poor Radio Coverage adversely affects route placement in part of the Terminal Airspace	Improve Radio Coverage	Enhance communications infrastructure
Severe weather disrupts traffic, especially at peak times	Create 'contingency' routes for poor weather operations; re-locate holding patterns	Airspace design
No flights permitted over Village X	Diverge departure routes as soon as possible after take-off	Airspace design
Flights over City Y not permitted below 10,000 feet	Continuous Descent Approach	Airspace design and Level constraints in procedures

Table 4 - 1: Constraints, Mitigation and Enablers

4.3 SELECTING ASSUMPTIONS, CONSTRAINTS AND ENABLERS

In order to identify and select assumptions, constraints and enablers, a comprehensive inventory of ATM/CNS elements is needed as well as expert input from, for example, meteorologists and pilots. Although it is possible for a Terminal Airspace design team to formulate the ATM/CNS parts of the inventory based upon their expert knowledge of local conditions, an inventory ATM/CNS completed in this manner is likely to be incomplete. This is because discrepancies frequently exist between what designers *believe* and what *exists (*see Example below*).* For this reason, it is necessary to determine from the outset what elements of ATM/CNS exist and are published in state-originated documents such as the Aeronautical Information Publication (AIP) and what factors can reasonably be assumed.

To these ends, thorough data collection of ATM/CNS elements is needed. If undertaken correctly, this data collection will reveal what can be assumed (assumptions), what is not available or inhibiting the design (constraints) and what is required to make the design workable (enabler). Importantly, assumptions, constraints and enablers should be linked to a certain date (i.e. 'date stamped') so that the design team may quickly identify the (time) period ascribed to a assumptions (or constraints/enablers) should it become necessary at later stage.

In order to illustrate the differences which can exist between perception (on which assumptions are frequently based) and reality of local conditions referred to above, the following examples are provided.

Example: A Terminal Airspace contains four DME stations. A fifth, located in an adjoining State, is assumed to be within the range of most aircraft departing from RWY23 at the only airport within the Terminal Airspace. Based on this belief the designers include the availability of this 'cross-border' DME in their assumptions when designing a SID (intended to be flown by P-RNAV equipped aircraft) from RWY 23. What the designers have not realised, however, is that the co-ordinates of this fifth DME are not WGS84 compliant (which is pre-requisite for SIDs designed for use by P-RNAV equipped aircraft). (Data collection obtained from an official source such as the AIP of the neighbouring State would reveal this shortfall.) Thus the 'assumptions' has turned out to be a constraint requiring mitigation.

Example: Having tested various sectorisation options, designers decided upon a combined functional/geographic sectorisation option because (a) it was the most efficient and (b) it did not require extra working positions and allowed them to make use of the existing three. When seeking to implement these new sectors, however, they were informed by ATC system specialists that the current ATC system was incapable of functional sectorisation and that it was no longer possible to modify the system software. (In this instance, the input of an ATC systems expert during the design phase would have prevented this option being chosen).

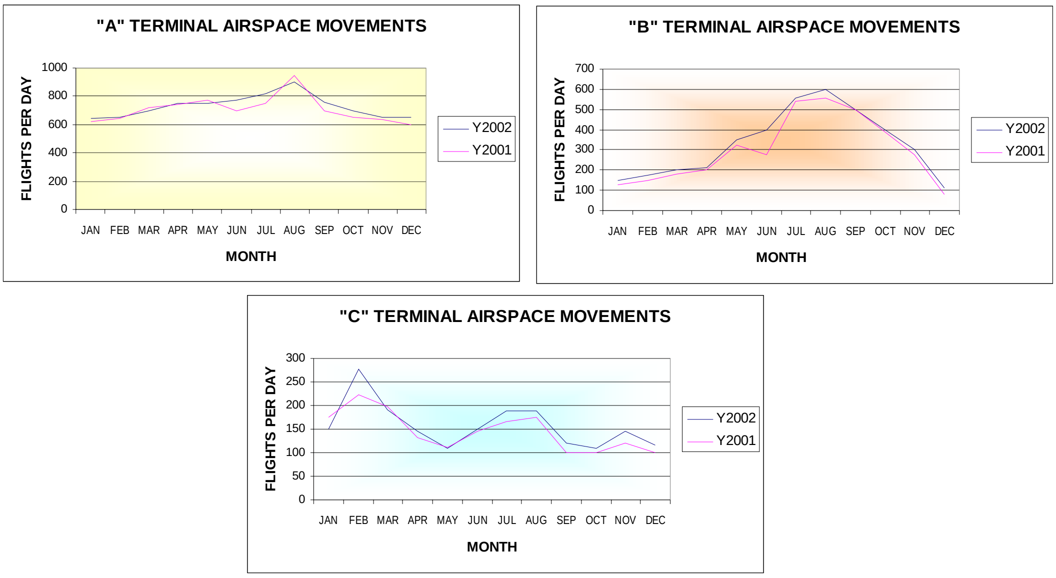
4.3.1 CHOOSING A TRAFFIC SAMPLE

As stated previously, ***traffic demand*** refers to a traffic sample which is considered representative of the traffic servicing the airport(s) within the Terminal Airspace. This **representative traffic sample** is an **'assumption'** which needs to be selected with care. Selection of a traffic sample that is most representative of the traffic within a Terminal Airspace is best achieved by combining statistical analysis with ATC experience and by looking beyond the information available. Two elements of the traffic sample are to be distinguished, which for convenience, will be described as *Traffic Distribution over Time* and *Geographic Distribution of traffic*. An appreciation of both elements is crucial to choosing a *representative* traffic sample.

4.3.1.1 Traffic distribution over Time

As regards *Time,* a feasible starting point is a snapshot analysis of the number of movements through the Terminal Airspace *by month* so as to determine the regularity of the resultant graph[2].

Using the sample graphs below (of three fictitious Terminal Airspaces) the following information can be drawn: Where Terminal "A" has a graph that is characteristic of large Terminal Airspaces in the core area, Terminal "B" is typically representative of summer holiday resorts and Terminal "C" typical of winter holiday (ski) resorts.



Graph 4 - 1: Distribution of Traffic over Time

Whilst in the case of Terminal "A" it is obvious that *one day's traffic* (the traffic sample) should be selected from one of the busier months, airspace design planners for Terminals "B" and "C" may wonder whether selecting one day during the busiest month truly constitutes a *representative* traffic sample. Because two busy months of the year may not be 'representative', airspace designers from these two Terminal Airspaces would do well to select *two* traffic samples i.e. one day from the busy months and one day from the quieter period.

The advantages reasons for this are two fold:

- to enhance the potential to apply the Flexible Use of Airspace concept (see Part A, Chapter 2 and Sections 1 and 3 of the EUROCONTROL Manual for Airspace Planning).
- if the geographic spread of the traffic is significantly different during the 'quiet' and 'busy' months, it may be necessary to create two sets of Terminal Routes;

[2] It is also useful to ascertain the 'busiest day' of the year determined annually by EUROCONTROL.

Comment: Is it viable to create two (or more) sets of Terminal Routes to accommodate significant changes in traffic density and/or distribution? *Opinions diverge as to how significant changes in the operating environment should be accommodated. Whilst one view holds that an 'unstable' or 'changeable' airspace structure is to be avoided, the opposing view contends that it is not only possible but desirable to use airspace in a flexible manner. Whatever the philosophy followed, designers should ensure that the design fully supports safe and orderly air traffic management.*

4.3.1.2 Geographic distribution of traffic

Having selected a one-day traffic sample from a *Time* perspective (i.e. one that is representative of periods of high and low activity), it is necessary to determine the geographic distribution of this traffic with a view to identifying the predominant and secondary traffic flow(s). To this end, the traffic sample needs to be analysed using, for example, a spreadsheet. Because traffic data files contain information on each flight, flights can be sorted in several ways, e.g. –

- **Terminal Area entry "point"** (in the case of arrivals) and **Terminal area exit point** (for departures).
- **origin (**in the case of arrivals) and **destination** in the case of departures;

Comment: *Once sorted, a graphic representation of the geographic distribution of traffic by* ***entry/exit point*** *can be depicted as per Figure 4-4.*

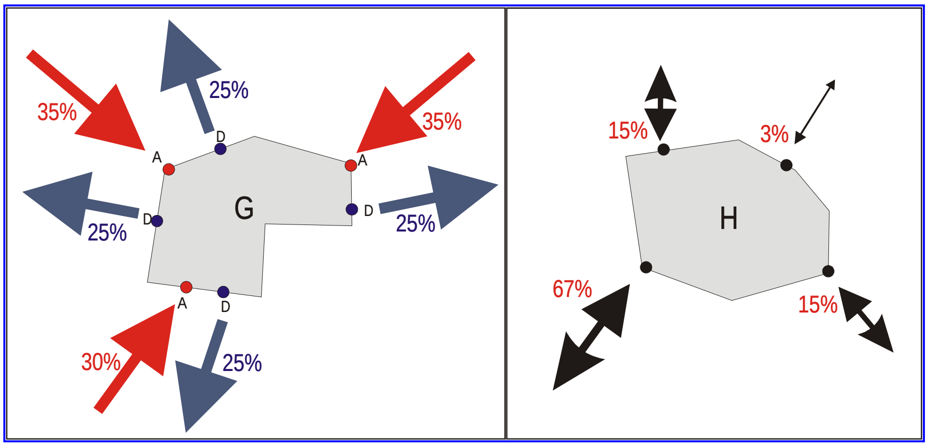


Figure 4 - 4: Geographic Traffic Distribution

(Of the two samples, Terminal Airspaces, "G" is typical of the core area of Europe and "H" of the geographic periphery of Europe. Because of the marked predominance of traffic distribution to the south/south-west of Terminal Airspace 'H', this model could fit the northern geographic periphery of Europe. Inversely, were the major traffic flow to/from the North, the model would probably fit that of the southern geographic periphery of Europe. The same can be said of dominant east or west flows).

Sorting the geographic traffic distribution by **origin and destination** so as to identify the raw demand[3] is only necessary when (i) doubt exists that the current En-Route ATS route network is not sufficiently refined thus making it lightly that some aircraft are not on the most direct route or, (ii) in the case of futuristic design projects for new airports where part of the exercise is trying to develop an entire airspace organisation on a clean sheet. The diagrammatic representation of raw demand is not nearly as clean as that of entry/exit point.

[3] this is usually the same as market demand.

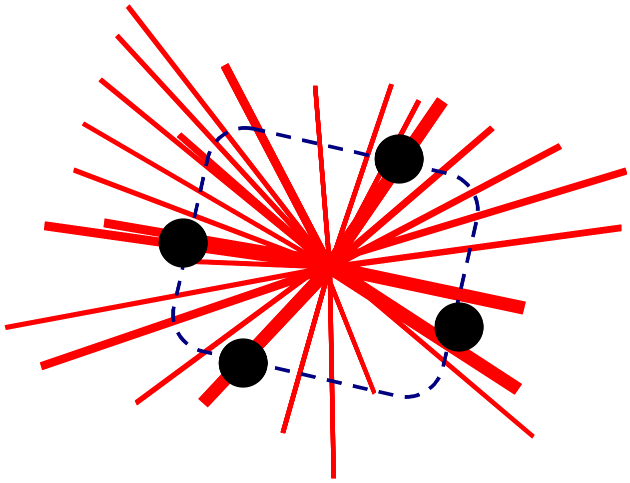


Figure 4 - 5: Geographic Distribution – Raw Demand

Given that the thicker lines in the above diagram represent routes of heavier (raw) demand, it is possible to ascertain – by comparing the location of existing Terminal entry/exit point [black circles above] in relation to these lines –whether these points have been placed effectively.

In those instances where En Route airspace designers alter their route network within the greater EUR ARN so as to minimise the differences between the raw demand 'tracks' and actual traffic routeings, it is not necessary for Terminal Airspace design planners to undertake the 'raw demand' exercise – providing that En-Route or Terminal Airspace design is undertaken collaboratively[4] as a matter of course.

The significance of the proper identification of the predominant traffic flow(s) becomes evident when undertaking the route design process described in Part C Chapter 5. This is because the designer should strive to meet all the Guidelines of route design as regards the major traffic flows. Thus where a 'conflict' arises between the interests of a major flow and minor flow, the interests of the major flow should prevail.

Comment:

Why should the traffic sample be analysed when ATC knows the traffic distribution? *Many designers are surprised to discover errors in the way they perceive their major/minor traffic flows. This is particularly true when dealing with traffic samples based on forecast traffic where it may be incorrectly assumed that traffic increases will be proportionate to each entry/exit point.*

4.3.1.3 Using Forecast Traffic Samples

Forecasting air traffic provides its own challenges: the more futuristic the forecast, the greater the likelihood of error creeping into some of the assumptions. Complex by definition, traffic forecasts attempts to determine whether and to what extent the traffic will change (increase or decrease) by examining the triggers that may bring about these changes. Whilst some triggering events can be forecast with reasonable accuracy, others cannot be easily foreseen.

Examples of 'triggering events' which can be determined with relative certainty include –

[4] Terminal airspace and En Route experts work together on airspace design projects be these projects 'En Route' or Terminal Airspace, by definition.

- GDP trends and their effect on the individual's propensity to fly;
- Timescales for the introduction of another transport mode between two city pairs (e.g. the high speed train between Brussels and Paris) which could significantly reduce the number of flights between the two points;

  Note: Whilst determining the timescales for the introduction of a new transport mode may be relatively simple, the same cannot necessarily be said when it comes to determining the effect of the alternative transport mode. In the case of high-speed trains, the total travel time gained/lost by the HST when compared to air travel is a significant factor.

Examples of 'triggering events' which are more difficult to predict include –

- political developments across Europe in 1989/1990 (which, for example, started a new tourist trend between Russia and northern Greece);
- the 1991 Gulf war (which affected traffic density)
- the wars in South-East Europe in the early 1990s (which affected the geographic distribution of traffic as a consequence of closing large tracts of airspace in the area.)

In closing, it is opportune to add that undertaking a 'raw demand' analysis such as depicted in Figure 4 – 5, is also useful for such futuristic projects.

4.3.2 DETERMINING THE PREDOMINANT & SECONDARY RUNWAY(S) IN USE

By and large, the **predominant and secondary runway(s) in use** are usually easier to identify (e.g. either because environmental requirements or weather phenomena dictate runway use). The importance of identifying which runway(s) is used more than another will be seen in the following Chapter, the predominant Terminal Routes invariably take precedence over minor routes.

Whilst **'predominant runway in use**' is a relative term (as is 'major traffic flow'), a predominant runway is one that is used most of the time. Usually stated as a percentage e.g. 80% (which equals 292 days a year), it may be said that RWY20 is used 80% of the time, and RWY02 20% of the time. At multiple-runway airports, this 'predominance' may be distributed among several runways e.g. e.g. RWY20 is used 80% of the time by arriving aircraft, and RWY 18 is used 90% of the time by departing aircraft.

4.3.3 CONSTRAINTS, MITIGATION AND ENABLERS

As stated in Part C, Chapter 3, the Critical Review provides an occasion to identify constraints in the Reference Scenario, and possible mitigation measures and associated enablers. This said, however, constraints are also identified once the conceptual design phase starts (see next Chapter, Chapter 5).

Whilst Table 4-1 depicts *enablers* as being the means whereby constraints can be overcome, enablers are also what make it possible to realise design objectives. In either case, the viability and correct identification of enablers is to be most effectively found in a partnership between technical/engineering expertise (e.g. PANS-OPS specialist), air traffic controllers and pilots.

Because of the increasing use of RNAV in ECAC terminal airspace (and therefore the increasing 'visibility' of navigation), ***Attachment C.4-1*** provides an overview of Navigation as an enabler in the context of RNAV.

Similarly, because of the importance of the ATC system to the design, **Attachment C.4-2** is provided, entitled *Understanding the ATC System: Constraint or Enabler.*

Guidelines on *how* to plan the design of routes, holds and airspace sectors are discussed in Chapters 5 & 6.

Chapter 8 at ***Attachment C.8-4*** provides a checklist which designers may find useful for the identification of assumptions, constraints and enablers. Although some of the items on the sheet do not always appear to be directly related to issues of Terminal Airspace design issues, many of them capture the factors which may influence the design plan.

4.4 WHEN TO IDENTIFY ASSUMPTIONS, CONSTRAINTS & ENABLERS

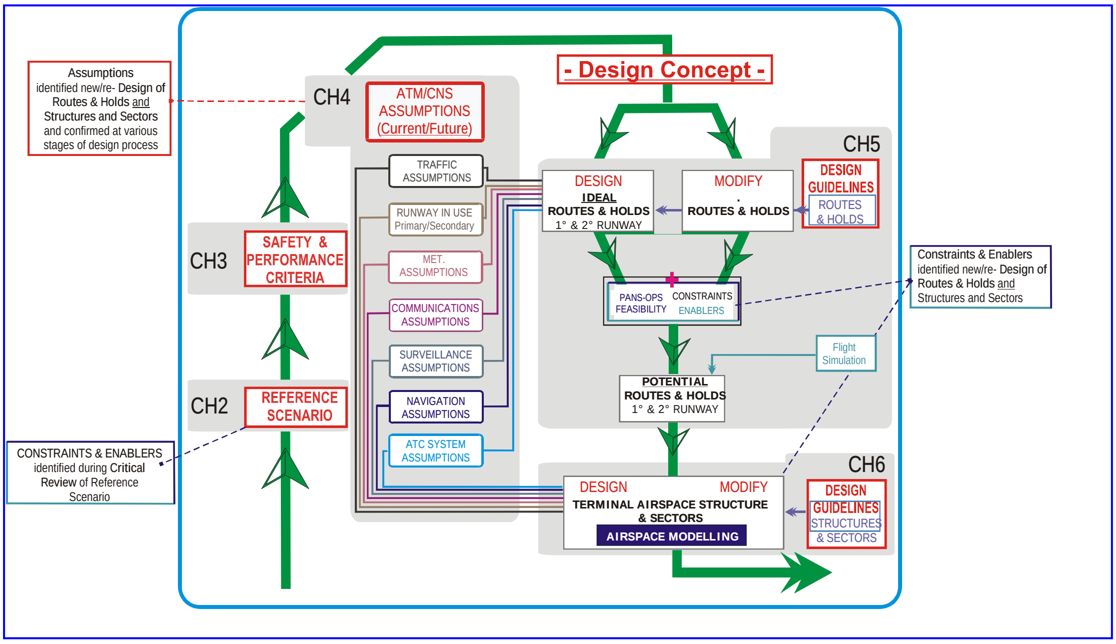


Figure 4 - 6: Phases for Identifying Assumptions, Constraints & Enablers

As shown in the above diagram, Assumptions, Enablers and Constraints are identified at different stages of the design process. Constraints and Enablers enter the design process during the critical review of the Reference Scenario where the constraints and enablers refer to the Reference Scenario. The Assumptions are identified prior to commencing the conceptual design -–and these are verified at different stages of the process. During the design process i.e. the conceptual design of Routes, Holds, Structures and Sectors, constraints, mitigation and enablers are identified. In some cases, a Cost-Benefit analysis may be required (see para. 4.2.4).

4.5 SUMMARY

The importance of correctly identifying *assumptions, constraints* and *enablers* cannot be over-stated for it is on these elements that the design concept of the Terminal Airspace rests. Most importantly, these assumptions, constraints and enablers should be *realistic.*

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Attachments C.4-1

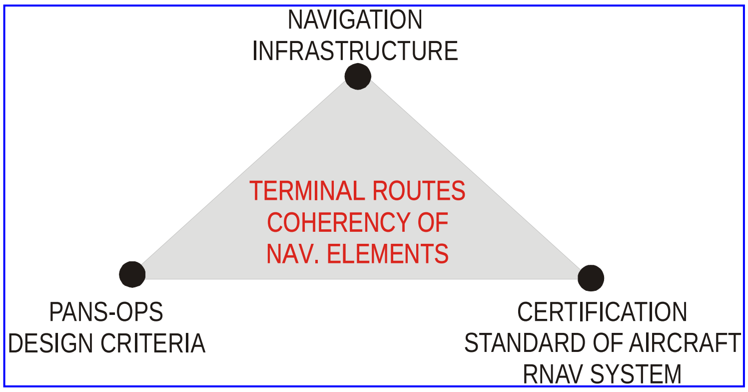
Area Navigation as an Enabler.

Whilst communication, surveillance and navigation are all vital elements to be considered in the design of a Terminal Airspace, the importance of navigation into the design equation has increased through the application of area navigation (RNAV) in Terminal Airspace.

In its *Definitions,* PANS-ATM describes Area Navigation ***(RNAV)*** as *A method of navigation which permits aircraft operation on any desired flight path within the coverage of station-referenced navigation aids or within the limits of the capability of self-contained aids, or a combination of these.* (Attention is drawn to the fact that this definition describes a **navigation method** and not RNAV system capabilities or certification)**.**

In order to design RNAV Terminal Routes (e.g. SIDs/STARs for use by RNAV-equipped aircraft in Terminal Airspace), coherency is required between

- the availability of a navigation infrastructure that supports the standard of RNAV to be employed. (Navaids can be ground- or space-based or self-contained on-board the aircraft); <u>and</u>
- Design of the procedure in accordance with PANS-OPS design criteria stipulations of the PANS-OPS Design Criteria used; <u>and</u>
- the aircraft's onboard **RNAV system** being certified (or the navigation function included in a flight management **system** (FMS)) being certified to the RNAV standard required by the Terminal area procedure and/or SID/STAR (and the flight crew having the appropriate operational approval);



In ECAC, two RNAV standards exist:

- Basic RNAV (B-RNAV) which was introduced into the upper airspace of ECAC in 1998; and
- Precision RNAV (P-RNAV) for use in Terminal Airspace.

<u>*Note:*</u> *With effect from ± 2010, RNP RNAV is likely to be the applied in Terminal Airspace.*

For both B-RNAV and P-RNAV, this coherency referred to previously between the navigation infrastructure, PANS-OPS design criteria and the certification standard of the aircraft's RNAV system is required. Thus different obstacle clearance criteria (PANS-OPS) apply for B-RNAV compared to P-RNAV, different certification standards exist for B-RNAV and P-RNAV, and the navigation sensors (which relate to the navigation infrastructure) that can be used for B-RNAV and P-RNAV are not necessarily the same (though similar.

The main differences between any RNAV type and another concerns:

- RNAV Systems Description

  (E.g. a database needed; positioning sensors to be used etc)

  - Airworthiness Certification Objectives:

    Described in terms of accuracy, Integrity & Continuity of service

  - Functional Criteria:

    (Required; Recommended)

  - (Area of application: where it can be used…and how)

The differences for RNAV System Descriptions are identified in the following table:

	B-RNAV	P-RNAV	RNP $_{(x)}$ RNAV*
Accuracy	5 NM Lateral	1 NM Lateral	(x) NM Lateral and Longitudinal
Integrity	Low	Medium	High
Continuity of Function	-	Loss = Remote	Loss = Extremely Remote

* According to MASPS DO236-B

The increasing level of sophistication of the RNAV System (B-RNAV < P-RNAV < RNP(x) RNAV) results in a proportional increase on the Requirements for respectively the RNAV Systems, Accuracy/Integrity/Continuity and Required Functionalities.

The main differences in what is required and what is recommended for Functional Criteria between any RNAV type and another are identified in the following table:

	B-RNAV	P-RNAV	RNP (x) RNAV*
Required	4 Way point storage (manual data entry; Display of distance/bearing to Way-point)	NAV Data Base; Data Integrity; leg types (e.g. TF; CF; FA)	NAV Data Base; Integrity (RNP alerting); leg types (e.g. RF; FRT)// Off-set
Recommended		// Off-set	

* According to MASPS DO236-B

Where and how different RNAV types can be used i.e. the Area of Application is described in the following tables:

	B-RNAV	P-RNAV	RNP* (x) RNAV
Area of Application	• ENR • Above MSA/MRVA	• ENR • TERMINAL AIRSPACE up to Final App WPT • Below MSA/MRVA	• ENR • TERMINAL AIRSPACE depends on Functional Requirements

* According to MASPS DO236-A

Depending on the RNP accuracy the following distinction can be made:

RNP_1 RNAV	RNP_3 RNAV	Functionalities specified by JAA (EASE) determine area of application
ENR TA up to FA WPT Below MSA/MRVA	ENR TA inside FA WPT Below MSA/MRVA	

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Attachment C.4-2

Understanding the ATC System: Constraint or Enabler

This Attachment provides a high-level description of the basic principles of an ATC system. It is presented with a view to increasing awareness of the role played by the ATC system in the Terminal Airspace Design concept. With this objective in mind, a general description of the ATC system is provided first, and then a selection made of certain components because of their relevance to Terminal Airspace design.

Designers' attention is drawn to the fact that the need to understand the technical capabilities and limitations of the ATC system should not be under-estimated. The same can be said of the requirement to ensure that a proposed Terminal Airspace design can be supported by the ATC system. As a basic rule, it may be stated that the more complex the design of a Terminal Airspace, the greater the demands made on the technical capabilities of the ATC system.

❑ GENERAL TECHNICAL DESCRIPTION OF THE ATC SYSTEM

In simple terms, it may be stated that the basic aim of the technical ATC system is to get the data related to a flight to relevant controllers in a timely and complete manner.

In a technical ATC system, the main data carrier is called a flight plan. It is often referred to as a System Flight Plan or a Current Flight Plan and FPL, SFPL or CPL are commonly used abbreviations.

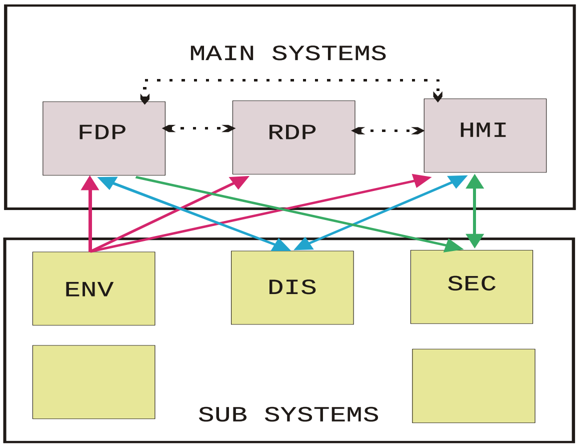
In general terms, it can be stated that the technical ATC system generally consists of three main components:

- Flight Data Processing (FDP)
- Radar Data Processing (RDP)
- Display System or Human Machine Interface (HMI)

From a Terminal Airspace Design perspective, the following sub-components of the system are also relevant:

- Environment Data Processing (ENV)
- Flight Plan Distribution (DIS)
- (Flexible) Sectorisation (SEC)

The following diagram provides an overview of the relations between main components and sub-components of the technical ATC system.



DESCRIPTION OF SPECIFIC COMPONENTS OF THE ATC SYSTEM

Environment Data Processing (ENV)

Environment Data Processing refers to the management of Route-points, Routes and Sector shapes etc. This is called static Environment data. In order to determine the feasibility of implementing a design, the designer should ensure that the design can be incorporated in the Environment data. (This is especially important with complex Terminal Airspace designs). In order to whether the design concept can be incorporated into the Environment data, the following questions could be asked::

1. Does the system support independent layering of sectors?
2. Is it possible to create new route-points or points in the system?
3. Is it possible to group/un-group sectors in the operational environment?

The relevance of question 1 is that if a system can not do this it is probably not possible to implement complex sector structures.

The relevance of question 2 is more related to the implementation process of a particular design. In some systems considerable effort is required in creating new structures (e.g. changes need to be made in the code). Considerations well beyond the design project scope may result in constraints on the design process (e.g. system availability, system safety considerations, ownership issues with the system provider etc.).

The relevance of question 3 is that if the answer is negative it may become necessary to simplify the design as much as possible because all operations need to be performed in the same operational configuration.

It is important to note that all three 'main' ATC system components FDP, RDP and HMI are 'clients' of an ENV function. The consistency of the ENV data for the main components is a safety issue. Verification of this consistency is required to ensure the safety of the design before implementation. A design should **not** be the solution to an insufficient technical ATC system.

Flight Plan Distribution (DIS)

Flight Plan Distribution refers to the most basic aim of the technical ATC system i.e. to get the data related to a flight to relevant controllers in a timely and complete manner. It is obvious that a more complex design results in a more stringent requirement to ensure that the controllers get flight plan information when it is required.

The Distribution Function may not have a direct effect on the design as such but it is prudent to ensure that the technical system provides this service. If it does not, the designer may work with wrong assumptions on the level of technical support that is provided to the controller that operates in the TMA. In addition it is advisable to establish the quality of the distribution function. For example, it is possible that the function is available but does not adapt after a sectorisation change or a runway change. Again, this could result in a flawed assumption being made regarding the level of technical support to the controller.

In general the FDP and HMI are clients of the DIS function. In systems where the Code Callsign Correlation function is part of the RDP system, the RDP may be a client as well, but these are all considerations for the technical infrastructure and not for the design as such.

➢ **(Flexible) Sectorisation (SEC)**

(Flexible) Sectorisation refers to a system's capability to adjust the sector configuration in the operational environment (i.e. in the OPS room) by combining or de-combining sectors in accordance with capacity demands in real-time.

If a technical ATC system does not have this capability there is a direct impact on the design. The designer will be restricted to one final design and will not be able to propose different sectorisation approaches that provide solutions for different capacity demands.

❑ SUMMARY

The rationale from a designer's point of view is that management of airspace starts with the design of airspace based on operational requirements which may stem from safety, capacity and Environment objectives. From this perspective, the technical ATC system is an enabler which supports the optimum design and airspace use.

If the technical ATC system cannot support the design, two courses of action are available to the designer:

1. Limit the possibilities for the design and limit airspace use (i.e. Constraint); or
2. Add requirements on the technical ATC system (i.e. identify Enabler(s))

In general, the second option requires additional investment. It is usually subject to processes outside the scope of any design project.

In closing, the readers attention is drawn to the fact that not all ATC Systems necessarily 'fit' into the pro forma described in this attachment and that many ATC systems include additional elements such as STCA (Short Term Conflict Alert), MSAW (Minimum Safe Altitude Warning) and Trajectory Prediction Tools.

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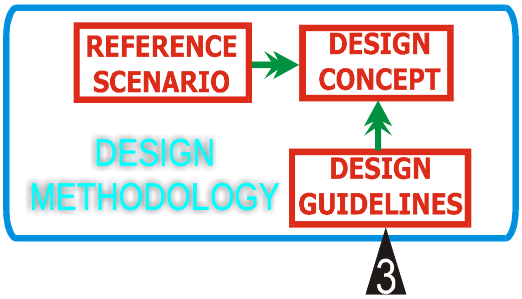
CHAPTER 5

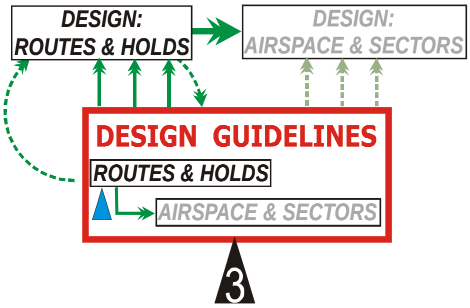
- DESIGN GUIDELINES: ROUTES & HOLDS -



Contents

5.1 INTRODUCTION

This chapter presents Design Guidelines for *Routes and Holding Patterns.* They are intended to support creation of the *design concept* for Routes and Holds for a specific Terminal Airspace*.* This concept would be based on certain assumptions. Given the phased approach described in Chapter 4, constraints and enablers would be identified in a phased manner as per para. 5.4.1. Furthermore, the design would be qualitatively assessed against the selected safety and performance criteria as well as the Reference Scenario, if appropriate*.*



5.2 ROUTES AND HOLDING AREAS

Whilst the generic ICAO definition of ATS Route is broad, (see grey shaded area in Figure 5-1, below), ATS routes within Terminal Airspace are usually arrival and departure routes. These arrival and departure routes may be -

- **designated**, as is the case with IFR departure and arrival routes which are usually published as SIDs/STARs (based upon RNAV or conventional navigation means), designated VFR routes (promulgated, for example, by visual reporting points) or VFR corridors; and/or
- those which are **not designated,** as is the case with tactical routeing 'created' by ATC in the form of Radar Vectors or instructions to proceed "direct to" an RNAV way-point.

Since B-RNAV became mandatory in the upper airspace of the member states of ECAC, RNAV has been increasingly used as a basis for the design of **RNAV-based instrument approach or departure procedures**. Usually, the RNAV-based instrument approach procedure does not include the final approach and/or missed approach segment. In many cases, the tracks depicting these procedures are designed to replicate radar vectoring patterns because these procedures are used as a substitute for radar vectoring by ATC. These are depicted in Figure 5-1 in the blue-red box beneath the SIDs/STARs and discussed in para. 5.2.1.

Note: Whilst instrument approach procedures based upon conventional navigation are sometimes used as a substitute for Radar Vectoring, this is less common.

Note: For more general information on RNAV Routes, see Attachment C.5-1.

Although Radar Vectoring has been used by ATC for traffic separation and sequencing for several decades, the increased use RNAV in Terminal Airspace has resulted in ATC being able to provide tactical instructions to a way-point. Unlike Radar Vectors, instructions to a way point result in aircraft flying a particular track (as opposed to heading). Whilst Radar Vectors and instructions to proceed direct to a way-point are not considered to be ATS Routes (in the traditional sense), they have been included in Figure 5-1 because Terminal Airspace designers are required to consider *all* routes when designing an airspace, whether these are 'created' in a strategic or tactical manner.

In light of this variety, the generic expression ***Terminal (Arrival/Departure) Routes*** is used to describe the sub-set of ATS Routes comprised of arrival and departure routes, SIDs/STARs and RNAV-based instrument approach or departure procedures i.e. those contained inside the red-line in Figure 5- 1. Naturally, the designer is also required to consider tactical routes shown in the green box in this figure.

Note: When used specifically, expressions such as ATS Routes, Arrival or Departure routes, SIDs/STARs and Instrument Approach Procedure (or parts thereof) are to be ascribed their ICAO meaning.

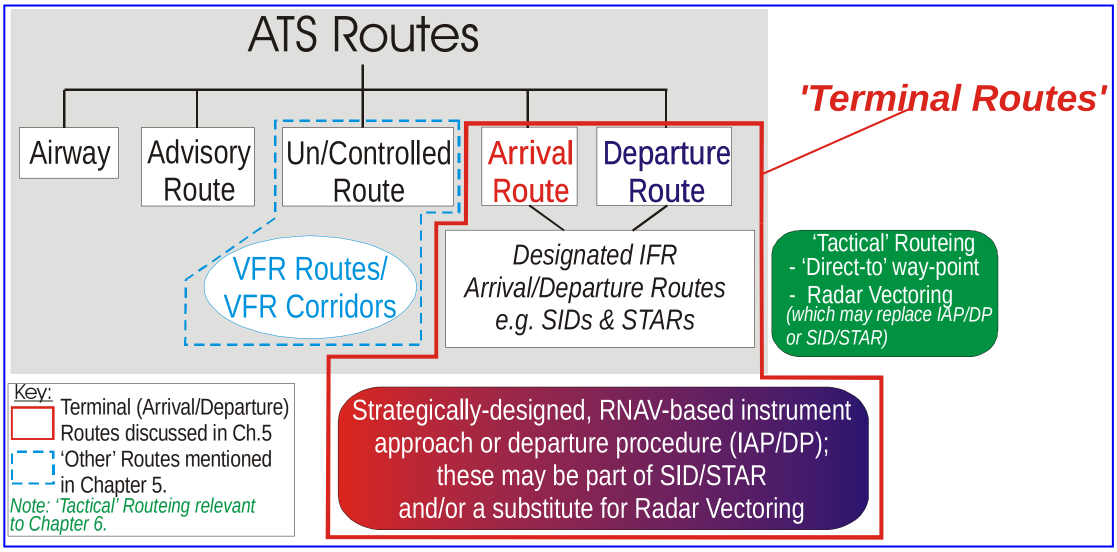


Figure 5- 1: ATS Routes & Terminal Routes

5.2.1 STARs & INSTRUMENT APPROACH PROCEDURES IN AN RNAV ENVIRONMENT

STARs and instrument approach procedures are defined in ICAO Doc. 8168 and explanatory material is provided by ICAO in the *ATS Planning Manual*, Doc. 9426. The identification of STARs (and SIDs) is provided for in Annex 11, Appendix 3.

Over the years, States interpretation of this material has resulted in two quite distinct 'models' of STARs in ECAC Terminal Airspaces. Whilst in the first the STARs provides the connection between the En Route ATS Route system and the Terminal Airspace, in the second, STARs commence closer to the landing runway. Thus in the first case, the STAR begins in the En Route system and ends (usually) inside the Terminal Airspace, often at a holding fix, whilst in the second, the STARs tends to begin at – approximately – the Terminal Airspace boundary (or the Approach Control Unit area of responsibility).

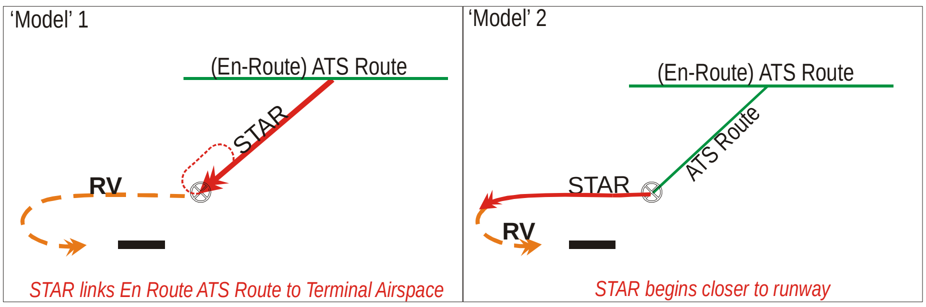


Figure 5- 2: STARs

The introduction of B-RNAV the ECAC en route airspace in 1998 made it inevitable that RNAV application would be extended into Terminal Airspace. Indeed, RNAV is being used in Terminal airspace, not only as the basis for the design of STARs but also to design RNAV-based instrument approach procedures.

As far as 'Model' 1 is concerned, the introduction of RNAV as the basis for Terminal Route design envisages replacing or replicating Radar Vectoring patterns with RNAV-based instrument approach procedures (or RNAV STARs, in some cases).

- ***Open and Closed STARs***

Although neither 'Open' STARs and "Closed' Stars are ICAO expressions, they are commonly used in the design of RNAV-based STAR or RNAV-Based instrument approach procedures used increasingly in Europe and North America. Whilst the *Open Star* provides and publishes track guidance (usually) to the down wind position from which the aircraft is tactically guided by ATC to intercept the final approach track, *Closed STARs* provide track guidance to the final approach track whereupon the aircraft usually intercepts the ILS. In theory, the *Closed STAR* suggests that the aircraft can navigate itself along the published route onto the final approach track, without being dependent on ATC for navigational guidance.

Significantly, however, Closed STARs can be designed and published in a manner that anticipates alternative routeing to be given by ATC on a tactical basis. Whilst tactical routeing instructions to 'close' an Open STAR are necessary to align the aircraft with the final approach track, 'tactical' way points may be included in a Closed STAR so as to permit ATC to alter the routeing of an aircraft e.g. to provide a short cut. (These tactical instructions may be given in the form of instructions 'direct to a way-point' or Radar Vectors).

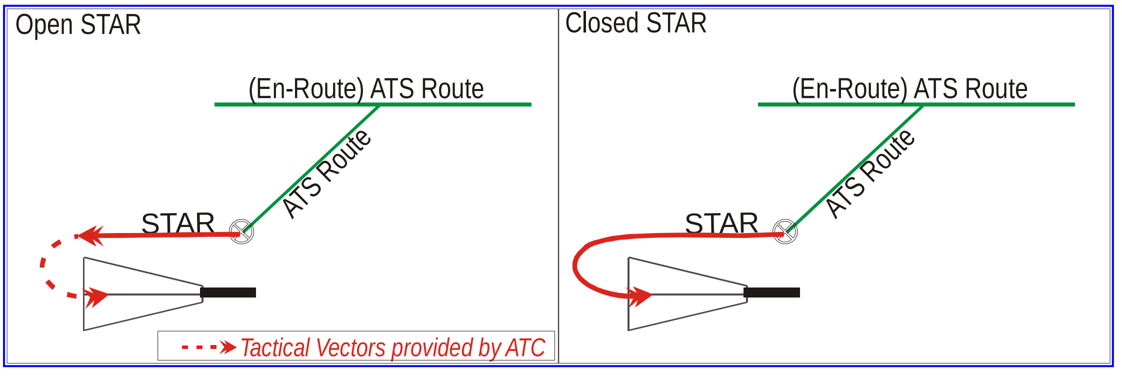


Figure 5- 3: Open & Closed STARs

<u>*Note:*</u> Neither of these diagrams should be construed as a preference for either *Closed or Open* STARs. The implications of radio communication failure (RCF) are different depending on whether STARs are open or closed. As such, RCF would have to be considered.

5.3 STRIKING THE BALANCE

Figure 5- 4, whilst oriented towards *Routes and Holding Areas* repeats the theme of a similar diagram in Part A of this document. It has been inserted to draw designers' attention to the fact that the design of terminal routes and Holds is rapidly becoming a major challenge in Terminal Airspace increasingly constrained by national boundaries, environmental needs and competing user requirements.

Seldom are these competing interests as evident as when seeking to relocate or design new terminal routes and holds at the most suitable place for Air Traffic Management purposes. Frequently, the most appropriate placement of a route for ATC does not necessarily meet the requirements of an adjacent Terminal Airspace and/or environmental or user needs. Thus a trade off is required.

Mindful that sustaining capacity is already a challenge in some ECAC Terminal Airspaces, it is impossible to over-state the need for a collaborative approach between adjacent Terminal Airspaces and between users, ATC and Airport Operators and/or other environmental interest groups when designing terminal routes. (See Part A, Chapter 2, General Principles). Thus before embarking upon the design of terminal routes and Holding Areas, Terminal Airspace designers require clear directions as to whether, and to what extent, Environmental and User requirements are to be taken into account and when this consultation should occur.

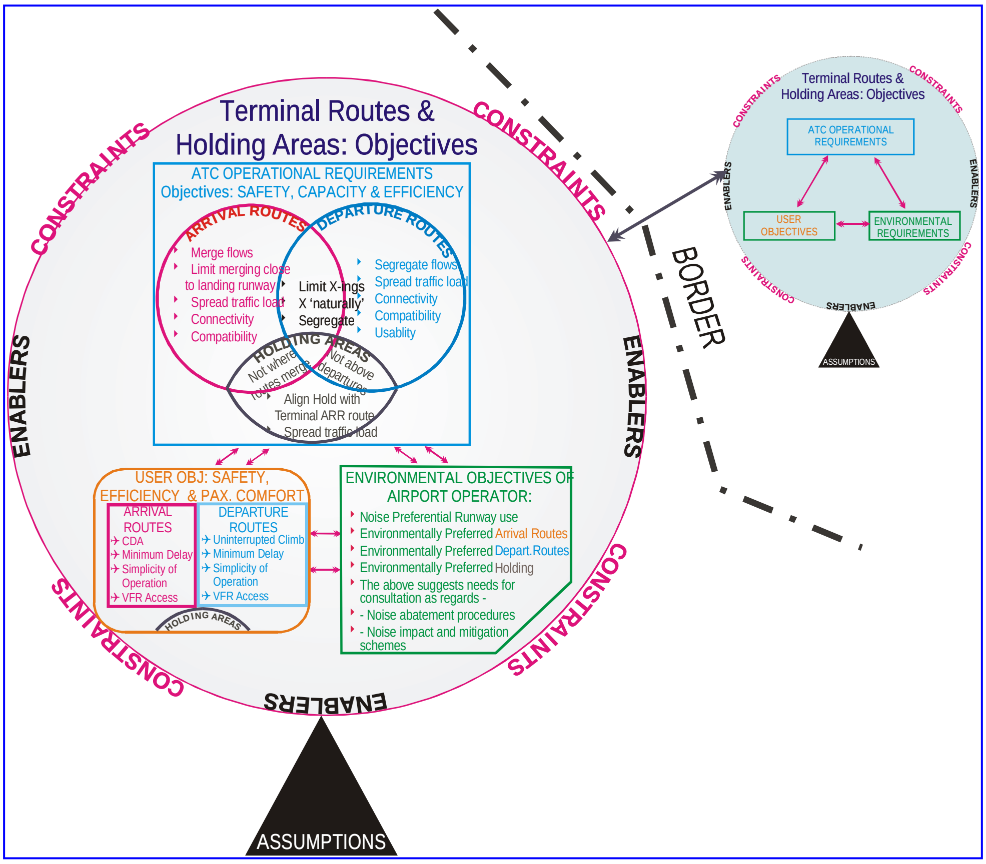


Figure 5- 4: Competing Interests – Striking the Balance

As will become evident in the Guidelines which follow, it is often necessary to affect a trade-off when there is a 'competing interest' between the Routes themselves, and/or between the best placement for the holding patterns. The more complex the airspace design, the greater the likelihood of more 'purely operational' trade-offs. This is discussed in Chapter 7.

In view of the above, it is stressed again that a collaborative approach to design is required. Once the routes and holds have been created and are available for use – as agreed collaboratively between all parties – they should be used in accordance with the conditions agreed by all parties.

> ***Mandatory Consultation Process:*** *In some countries where a mandatory consultation process exists, Terminal Airspace development can be discontinued because of a failure to comply with this consultation process.*

5.4 GUIDELINES

In this section, Design Guidelines for terminal routes and Holding Areas are described with a view to creating a conceptual design based on certain *assumptions, enablers and constraints.*

Guidelines related to terminal routes are preceded by an "**R**" and those to concerning Holding Areas, by an "**H**". They are not prioritised.

Whilst, for the most part, the Guidelines for the Design of terminal routes and Holding Areas concentrate upon IFR flights, many of the notions contained in these design guidelines apply equally to terminal routes promulgated for use by VFR flights. This said however, special mention is made of route planning for VFR use where appropriate.

These Design Guidelines are based on three assumptions:

Assumption 1: An air traffic control service is provided and Radar Surveillance is available within the Terminal Airspace;

Assumption 2: Within the context of needing to strike a balance between competing interests referred to in para. 5.3 (above), these Design Guidelines aim primarily for efficient design of Routes and Holds with a view to enhancing safety and maximising ATM capacity.

Assumption 3: Strategic and Design Objectives as well as assumptions have been identified by the design team.

> *Within the context of Striking the Balance (para. 5.3) and Assumption 2 (above), policy may dictate that the optimisation of Terminal Route design is weighted in favour of environmental mitigation. In such instances, designers may be required to design 'longer' routes and/or, minimise the likelihood of tactical routeing by radar vectors over noise-sensitive areas.*

5.4.1 PHASED DESIGN APPROACH

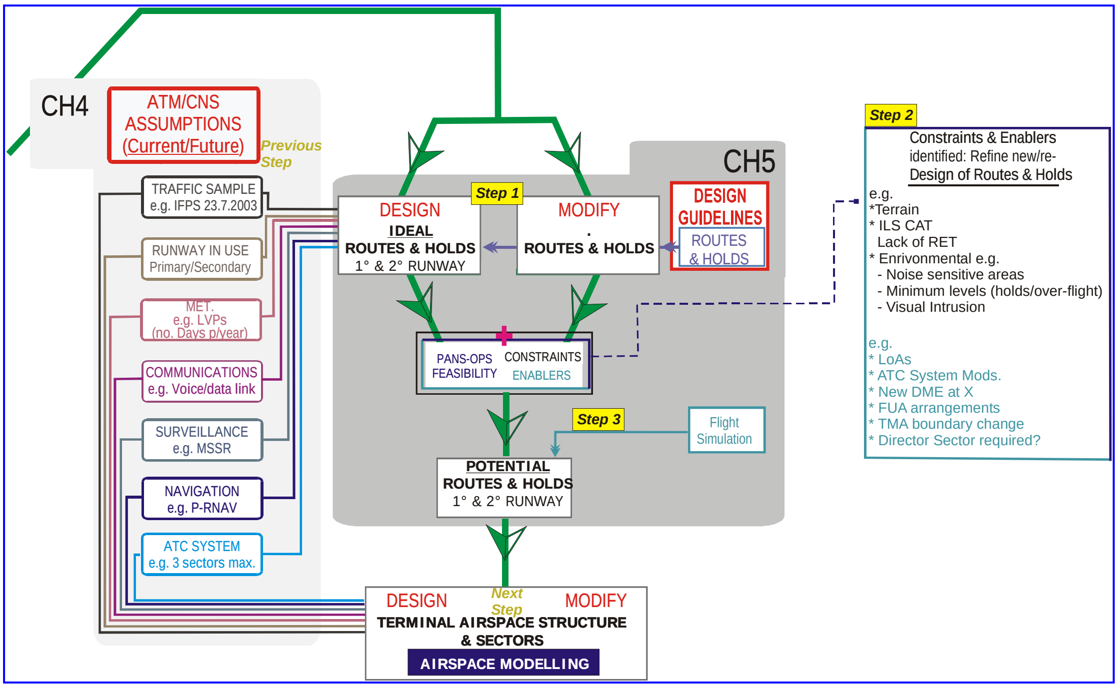


Figure 5- 5: Phased Approach

Figure 5- 5, above, suggests **a phased approach** to the design of routes and identification of constraints and enablers.

– *Step 1:* using assumptions only, create a conceptual design either of ('ideal') routes and holds or modify existing routes/holds; then

– *Step 2:* refine the output of Step 1 by 'adding-in' PANS-OPS feasibility. Constraints and enablers are identified at this stage and the routes modified accordingly.

- *Step 3:* may be used if it is necessary to establish the flyability of the terminal routes.

Note 1: Usually, holding patterns are designed along routes and the routes are therefore designed first. Where required, however, it may become necessary to identify the airspace available for holding and design the relevant terminal routes as a function the placement of the holding areas.

Note 2: Throughout the design process, a qualitative analysis should be undertaken – see Part C, Chapter 3 and iterations of the Routes after the design of the Holds are required to stream-line the conceptual design of Routes and Holds.

Note 3: Designers' attention is drawn to the importance of the ATC System as an enabler (or constraint) in the context of designing Routes and Holds. See Chapter 4, ***Attachment C.4-2***

Comment: When should designers design an ideal system of routes and holds as opposed to modifying the existing system? *In most instances, a major change to the operating conditions of the Terminal Airspace would be a good time to attempt a clean start by designing an ideal route/hold system. Such major changes may include (i) the addition/closure of a runway at a major airport; (ii) the creation/closure of an airport within a Terminal Airspace; (iii) addition/removal of Terminal Area Radar; (iv) addition/removal of critical navigation or landing aids; (v) significant change to traffic distribution (e.g. as brought about by political events). Above and beyond this, some designers find it a useful exercise to periodically design an ideal system and use it as a benchmark against which to measure the actual design.*

5.4.2 TERMINAL ROUTES

R1. TERMINAL ROUTES SHOULD BE SEGREGATED AS MUCH AS POSSIBLE

R1 FULL DESCRIPTION: TO THE EXTENT POSSIBLE FROM AN ATM OPERATIONAL PERSPECTIVE, TERMINAL ROUTES SHOULD BE SEGREGATED FROM EACH OTHER BOTH LATERALLY AND VERTICALLY SO AS TO ENHANCE SAFETY AND TO MINIMISE THE CONSTRAINING EFFECT OF THESE ROUTES UPON EACH OTHER.

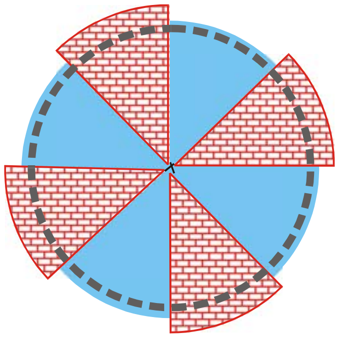


Figure 5- 6: Segregate Arrivals from Departures

This Guideline contains three elements, all of which aim to ensure that Terminal (arrival and departure) routes are kept apart as much as possible. Whilst Guideline R1.1 and R1.2 are alternative ways of resolving the SID/STAR interaction (though R1.1 is preferred, see below) Guideline R1.3 is an add-on which may be viewed as complementary to R1.1 and R1.2. These three Guidelines are described in shaded text below with illustrations.

- R1.1: TO THE EXTENT POSSIBLE, TERMINAL ARRIVAL AND DEPARTURE ROUTES SHOULD BE LATERALLY SEGREGATED FROM EACH OTHER;

This Guideline means that the entry and exit points of a Terminal Airspace should be different. The illustration provided at Figure 5-7 demonstrates this Guideline; A denotes the entry point (arrivals) and D the exit point (departures).

Can the type of route shown in Figure 5-7 be designed for B-RNAV certified aircraft? *Given that B-RNAV certification has no requirement for a database (the RNAV system is only required to accept manual entry of four way points) and that the turn anticipation is in the region of 22NM, B-RNAV. terminal routes requiring precise turns such as shown in Figure 2-3 cannot be designed for aircraft having only B-RNAV certification. (see Attachment C.4-1 of Chapter 4)*

Can the type of route shown in Figure 5-7 be designed using P-RNAV? *Yes. The requirement for a database is one of the fundamental differences between B-RNAV and P-RNAV. This said, whilst P-RNAV certified aircraft are capable of more precise turns, consistent track keeping is not guaranteed. For this, RNP RNAV with its Radius to Fix capability is required. (see Attachment C.5-1, this Chapter).*

Does RNAV change how close the down-wind can be designed to the landing runway? *It does not… The minimum distance between the downwind and the landing runway is a function of aircraft performance e.g. the slower the aircraft the closer the downwind can be placed. This said, inertia of (particularly) large aircraft on the turn makes it impracticable to place the downwind closer than 5NM. (Placing the down-wind closer than this increases the risk of aircraft over-shooting the final approach track when turning to final.*

Space Permitting, it is recommended that terminal routes are not designed through areas of known and/or frequent turbulent weather phenomena.

To the extent possible, designated VFR routes should be segregated from IFR arrival and departure routes. To this end, visual reporting points (see para. 2.2) should be carefully selected.

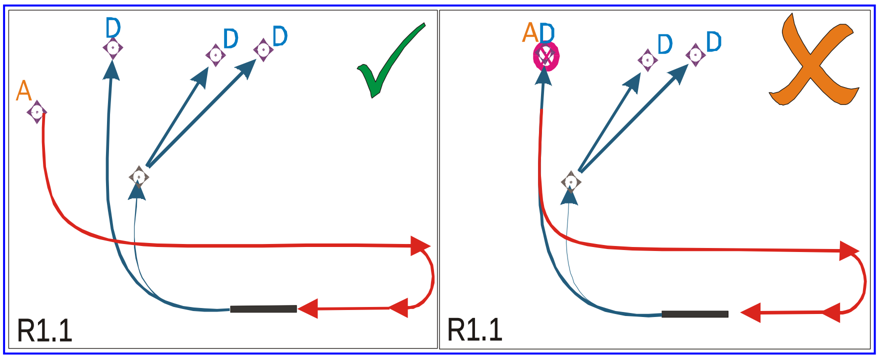


Figure 5- 7: Application R1.1

- R1.2: TO THE EXTENT POSSIBLE, TERMINAL ARRIVAL AND DEPARTURE ROUTES SHOULD BE VERTICALLY SEGREGATED FROM EACH OTHER AS A FUNCTION OF AIRCRAFT PERFORMANCE: WHERE ARRIVAL AND DEPARTURE ROUTES ARE REQUIRED TO CROSS EACH OTHER, THE CROSSING POINT SHOULD BE CHOSEN SO THAT THE 'OPTIMUM' VERTICAL PROFILES OF CLIMBING AND DESCENDING HAVE A MINIMUM CONSTRAINING EFFECT ON EACH OTHER.

Fulfilment of this Guideline requires an understanding and appreciation of aircraft performance. Given that the General Principles elaborated in Part A, Chapter 2 encourage a collaborative approach to Terminal Airspace design, aircraft performance information could be obtained from pilots on the design team. (Of special interest would be optimum aircraft performance i.e. not constrained by ATC or environmental requirements).

The aircraft performance in question concerns primarily the aircraft's speed and rate of climb and descent in a temperature band common to the operating environment. Given that a Terminal Airspace usually caters to a wide range of different aircraft (this can be determined from the traffic sample – see Part C, Chapter 4), account will need to be taken of this performance range. Designers should be aware that the same aircraft type may operate quite differently with different payloads or during different seasons. Seeing as some Terminal Airspaces are subjected to seasonal traffic peaks (See Part C, Chapter 4), the overall design plan should strive, as far as practicable, design routes in a manner that satisfies those (seasonal) peaks . However, the final result is likely to be a compromise.

Used together, Figure 5- 7, Figure 5- 8, and Graph 5- 1 can serve to illustrate the application of this Guideline. The left hand sketch of Figure 5- 8 shows that the departing aircraft has flown ±7NM from take-off when the arrival is ±30NM from touchdown. By referring to Graph 5- 1, this crossing can be considered feasible because a departure at ± 7NM after take-off is likely to be at approximately 3500 feet AMSL (and accelerating to 250kts, for example) when arriving aircraft at ±30NM from touchdown are likely to be between 7500 and 10,000 feet (dependent on the Rate of Descent). Thus the minimal vertical distance likely to exist between arriving aircraft and departing aircraft on 'optimum profiles' at this crossing point is 4000 feet.

Using the right hand sketch in Figure 5-8 together with Graph 5- 1, a different situation emerges, between the two arrival slopes and two departure gradients at 7% and 10% respectively. At the point marked CP, the right hand sketch of Figure 5- 8 shows that the departing aircraft has flown ±22NM from take-off when it crosses the arrival which is ±32NM from touchdown. This is an unsuitable crossing because departures at ±22 NM after takeoff on a 7% or 10% gradient are likely to be between 7600 feet and 11,000 feet respectively when the arriving aircraft at ±32 NM from touch down are likely to be 7930 feet and 10,225 feet respectively. Given that it is desirable to ensure that the optimum profiles facilitate 'naturally' the minimum vertical separation minima of 1000 feet, this crossing point is unsatisfactory.

The above does not suggest that aircraft climb performance is the only factor to be considered in determining the vertical distance between the aircraft at the crossing point. Neither should it suggest that 1000 feet is the *minimum* vertical separation to be applied at all crossing points. On the contrary, designers and planners should take various other factors into account in the determination of the vertical distance between the aircraft at the crossing point. These include :

- History of level busts: where applicable. (Mitigation might include publishing level restrictions which ensure 2000 feet between the climbing and departing aircraft at the crossing point);
- Nuisance ACAS alerts: an appreciation of how ACAS Traffic and Resolution Advisories may be triggered by route geometry. (For information on ACAS 'hotspots' and ACAS safety information, see ACAS *Safety Bulletin 1*[1] of July 2002;
- Low Transition Altitude: Experience has shown that requiring climbing aircraft to stop their climb at or in the vicinity of a low Transition Altitude may increase the likelihood of level busts. The same may be true of arriving aircraft as regards the Transition level.

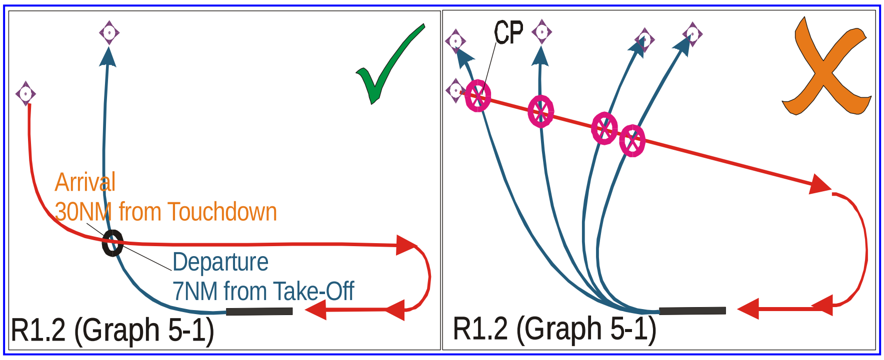


Figure 5- 8: ApplicationR1.2 (&R1.1)

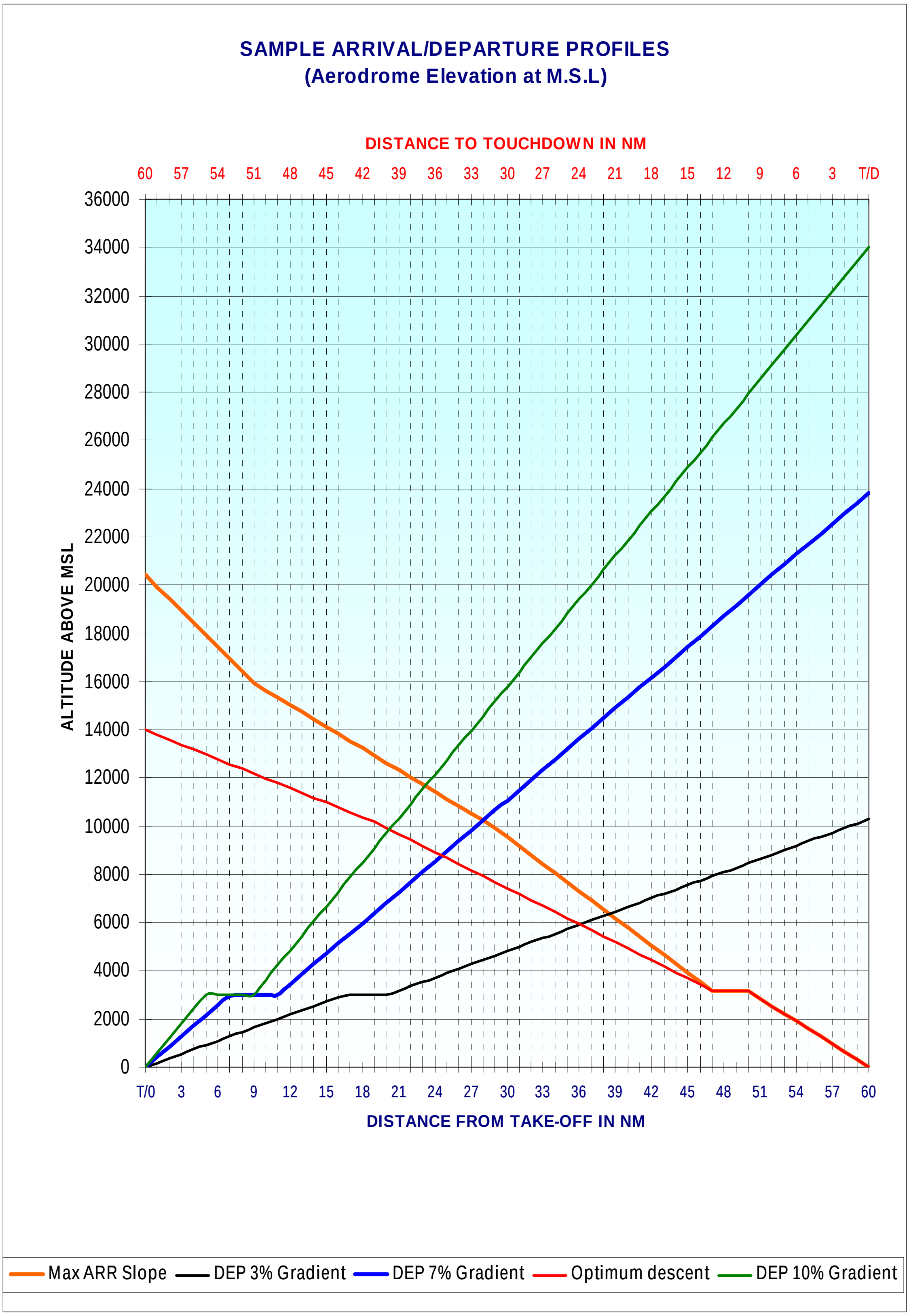
RNAV is all about point-to-point navigation; why is it necessary to design the downwind leg of RNAV STARs close to the runway (as per R1.2/*Figure 5- 8****)?*** *R1.2 concerns finding the most suitable crossing point between an arrival and departure route so as to restrict, to the minimum, the vertical profile of the crossing aircraft. The application of RNAV does not change the desirability of applying R1.2. Although users sometimes react adversely to the realisation that RNAV has not served to reduce track mileage in this instance, they usually react positively to the freer aircraft profiles.*

What are the alternatives to designing a downwind as per R1.2/*Figure 5- 8****?*** *This question arises where the downwind as shown not be designed either because of noise sensitive areas close to the airport* ***or*** *where the richness of terrain makes such design impossible.*

Fortunately, alternatives do exist especially if a robust &detailed equivalent of Graph 5- 1is custom made for a Terminal Airspace. If this graph is developed with the assistance of pilots, it should provide a greater spread of descent/climb profiles which may provide alternative which include –

- *RE-locating the SID/STAR crossing points whilst respecting R1.2, if possible (e.g the SID could continue on runway heading for a greater distance);*
- *raising the climb/descent level restrictions at the crossing point shown in Figure 5- 8;*
- *permitting only 'quieter' aircraft to fly on the SID/STAR shown in Figure 5- 8(these aircraft would be identified as a combined function of Graph 5- 1 and data collected from noise monitoring points in the vicinity of the airport)*

[1] http://www.eurocontrol.int/acas/LatestNews.html



Graph 5- 1:SAMPLE CLIMB/DESCENT PROFILES

- R1.3: TO THE EXTENT POSSIBLE, TERMINAL [DEPARTURE] ROUTES SHOULD BE LATERALLY SEGREGATED AS SOON AS POSSIBLE AFTER DEPARTURE, SUBJECT TO GUIDELINES R1.1 AND R.1.2

This Guideline may be considered the converse of Guideline R3 (which requires arrival routes to be merged progressively as they approach the entry point of a Terminal Airspace).

Whilst this Guideline seeks to laterally segregate Terminal Departure Routes as soon as possible after departure, it should only be used within the limits of Guideline R1.2 (see commentary which follows Figure 5- 8, above).

The differences between the designs shown in the two right-hand diagrams in Figure 5- 9 (overleaf) concerns the arrangement of the departure routes. Whereas the departure routes fan-out in the top-right sketch, the departure tracks in the bottom right hand sketch are parallel after the first turn and likely to be spaced by a distance exceeding the Radar Separation minima. This configuration would probably make it easier to manage a relatively complex crossing of the downwind.

If 3NM is the Radar separation used in a Terminal Airspace, will the aircraft operating on parallel RNAV terminal routes spaced at 5NM be 'procedurally' separated? *No. In order for aircraft to be procedurally separated in such instances, the parallel RNAV terminal routes should be spaced at a distance detailed in ICAO Annex 11 Attachment B.*
If 3NM is the Radar separation used in a Terminal Airspace, is it possible to design parallel RNAV terminal routes at 5NM? *Yes – but the aircraft operating on the centrelines of these routes are* ***not 'automatically' separated and it is incumbent upon the Radar Controller to ensure that the 3NM Radar Separation is not infringed.*** *This technique of route design is sometimes used in high-density Terminal Airspace; the publication of such parallel RNAV terminal routes reduces the amount of Radar Vectoring that the controller has to do, though the Radar monitoring workload may be high.*

Aircraft performance and RNAV permitting, would be possible to build an altitude restriction into the right-turn departure tracks so that they can be 'hopped over' the arrival downwind track? *Extreme caution should be exercised if an operational requirement is identified for a SID to climb above a STAR, as opposed to the failsafe option of the departure being constrained below an arrival route. This is because the existing PANS-ATM criteria related to the Area of Conflict (see PANS-ATM Chapter 5), are not generally considered useful in ECAC Terminal Airspace. (This is because the PANS-ATM provisions do not provide distances from the crossing point which are considered practicable for ECAC Terminal Airspace operations, most of which are conducted in a Radar environment. Furthermore, PANS-OPS obstacle clearance criteria cannot be used to determine track separation.*

When the traffic mix is populated by a high-number of low performance aircraft, it may be useful to design separate Terminal Departure or Arrival Routes to accommodate these aircraft. This can be particularly advantageous as regards noise. Examples include the design of SIDs with 'early turnouts' for less noisy aircraft, or the design of Terminal (Arrival) Routes for 'lower' performance aircraft (which may also simplify sequencing for ATC_.

Whenever possible, VFR (departure) routes should be designed so as to clear the initial departure area used by IFR routes, as soon as possible

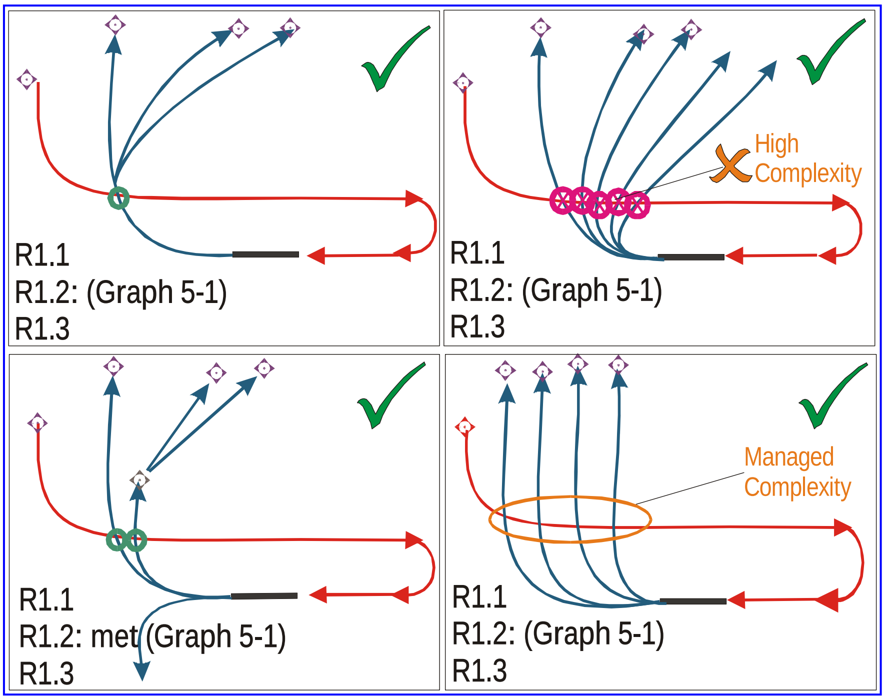


Figure 5- 9: Guidelines R1.1 – R1.3 combined

- R1.4 TO THE EXTENT POSSIBLE, MISSED APPROACH TRACKS SHOULD BE SEGREGATED FROM EACH OTHER AND FROM THE INITIAL DEPARTURE TRACK OF TERMINAL DEPARTURE ROUTES SO AS TO EXTRACT THE MAXIMUM BENEFITS OF OPERATING INDEPENDENT RUNWAYS AND/OR CONVERGING RUNWAYS.

Requirements for the design of departure and missed approach procedures from parallel (or near parallel) runways are detailed in PANS-ATM (Doc. 4444) and PANS-OPS (Doc. 8168), together with guidance on operations in dependent, independent and segregated mode. See also the ICAO SOIR Manual, Doc. 9643, 1st Edition 2004.

✈ R2. TERMINAL ROUTES TO BE CONNECTED AND COMPATIBLE

R2 FULL DESCRIPTION: TO THE EXTENT POSSIBLE, TERMINAL ROUTES SHOULD BE CONSISTENTLY CONNECTED WITH THE EN ROUTE ATS ROUTE NETWORK AND BE COMPATIBLE WITH TERMINAL ROUTES IN ADJACENT (TERMINAL) AIRSPACES., IRRESPECTIVE OF THE RUNWAY IN USE.

Closely related to Guidelines R1.1, this guideline establishes that Terminal Routes be integrated into the greater Route Network of ATS routes. Furthermore, it requires that these points of connection remain constant irrespective of the runway in use. This Guideline contains three elements: viz. **consistent connection** with the En route ATS route network irrespective of the runway(s) in use, **compatibility** with other terminal routes in other Terminal Airspaces irrespective of the runway in use, and a requirement to minimise the complexity of the terminal route structure when **changing the runway(s) in use**.

- R2.1: TO THE EXTENT POSSIBLE, TERMINAL ROUTES SHOULD CONSISTENTLY BE CONNECTED WITH THE EN ROUTE ATS ROUTE NETWORK IRRESPECTIVE OF RUNWAY IN USE.

The points at which the en route ATS routes and terminal routes connect should – for both arriving and departing flights - remain constant.

Significantly, this Guideline does not imply that precedence should be given to the En Route ATS Route Network i.e. there is no 'automatic' requirement for terminal routes to 'fit in' with the existing ATS route network (see Part C, Chapter 7, especially Stage 4 and 5 Terminal Airspaces.

Consistent with the General Principle of collaboration (Part A, Chapter 2), adjustments to both the En route ATS route network and terminal routes should be accommodated so as to obtain the best overall result as regards the design and strategic objectives.

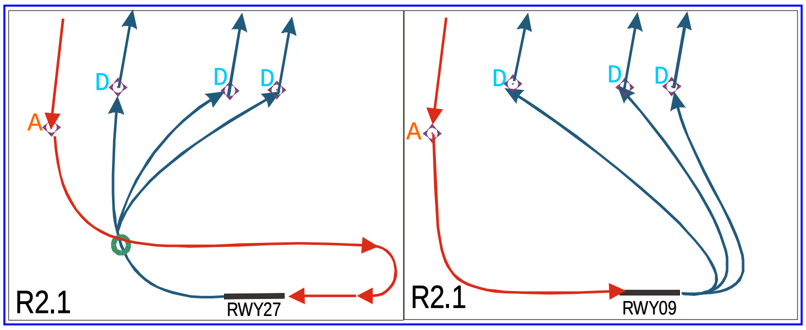


Figure 5- 10: Consistent Connectivity, R2.1

Indeed, the entry and exit points of large Terminal Airspaces (e.g. London and Paris) often influence significantly the placement of ATS Routes in the En Route ATS Route Network. The converse is true of smaller Terminal Airspaces, where the placement of terminal routes is driven by the requirements of the EUR ARN.

- R2.2: TO THE EXTENT POSSIBLE, IRRESPECTIVE OF RUNWAY IN USE, TERMINAL ROUTES SHOULD BE COMPATIBLE WITH ROUTES IN ADJACENT TERMINAL AIRSPACES (WHETHER THE TERMINAL AIRSPACE IS REMOTE OR IMMEDIATELY ADJACENT).

This Guideline seeks to ensure the same consistency between terminal routes of adjacent Terminal Airspaces as is required in R2.1. Significantly, this Guideline draws attention to the fact that this compatibility be sought even with terminal routes in more 'remote' Terminal Airspace – even those located in a different sovereign airspace

- R2.3: TO THE EXTENT POSSIBLE, CHANGE TO THE RUNWAY IN USE SHOULD CREATE MINIMUM OPERATIONAL COMPLEXITY TO THE TERMINAL ROUTES STRUCTURE.

Whilst this Guideline effectively repeats the ideas embodied in R2.1 and R2.2, it is stated specifically with a view to drawing attention to the terminal routes *inside* the Terminal Airspace. As such, this Guideline suggests that the terminal route structure for one runway configuration should **seek to mirror** that of the inverse runway configuration so as to minimise operational complexity. Naturally, neither R2.1 nor R2.2 should be compromised, as far as practicable.

The difficulty inherent in this guideline occurs particularly in those instances when the geographic distribution of traffic is unequal – as is often the case with Terminal Airspaces located on the geographic periphery of Europe (see Part C, Chapter 4, para. 4.3.1.2).

In Figure 2-8 below, the crossing point marked with an X may appear to be contradict R1.2 above. This said, a calculation using the Graph 5-1 is likely to reveal that the crossing is workable.

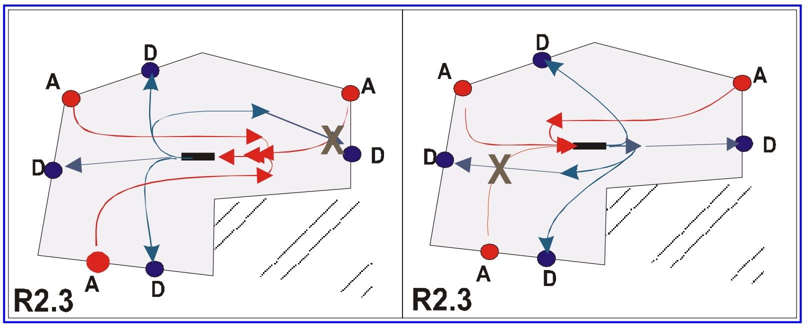


Figure 5- 11: Application R2.3

Whenever possible, this guideline should be applied in particular to VFR routes so as to minimise the likelihood of adding to complex operations when a change is made to the runway in use.

✈ R3. TERMINAL ROUTES SHOULD BE MERGED PROGRESSIVELY AS THEY APPROACH THE TERMINAL AIRSPACE

R3 FULL DESCRIPTION: TO THE EXTENT POSSIBLE, PUBLISHED TERMINAL ROUTES SHOULD BE PROGRESSIVELY MERGED AS THEY APPROACH THE TERMINAL AIRSPACE SO AS TO LIMIT THE NUMBER OF ARRIVAL GATES INTO THE TERMINAL AIRSPACE TO A MAXIMUM OF FOUR.

This guideline aims to simplify the route structure within Terminal Airspaces by ensuring that the complex task of traffic merging is done *outside* the Terminal Airspace (which is usually constrained in size).

Whilst the merging of arrival traffic flows should (ideally) be accomplished outside the Terminal Airspace, this does not suggest that the Terminal Airspace should only have four entry points. Indeed, there are two well known instances where it is desirable *not* to merge the arrival flows towards a common point. These are –

- where the aircraft performance mix is such that there is a marked speed difference in a large percentage of the traffic; or (/and)
- where the Terminal Airspace contains several major airports.

In either of the above cases, it is usually better to merge the arrival flows towards what might be called entry *gates,* each of which may contain arrival flows which are segregated either for different performance or for different airport destinations. In exceptional circumstances, it may even be necessary to split a common arrival flow into segregated routes inside the Terminal Airspace, especially to segregate different aircraft (speed) performance.

To appreciate the difference between merging arrival flows merged towards one entry point and one entry gate, where arrival routes remain segregate to accommodate different aircraft performance, (a) and (b) of Figure 5- 12 can be compared. Similarly, Figure 5- 12 *can be* compared *to* diagrams in Chapter 7.

Note: This Guideline does not suggest that Terminal Airspace **exit** points should be limited in number. See illustration at para. Figure 5- 6.

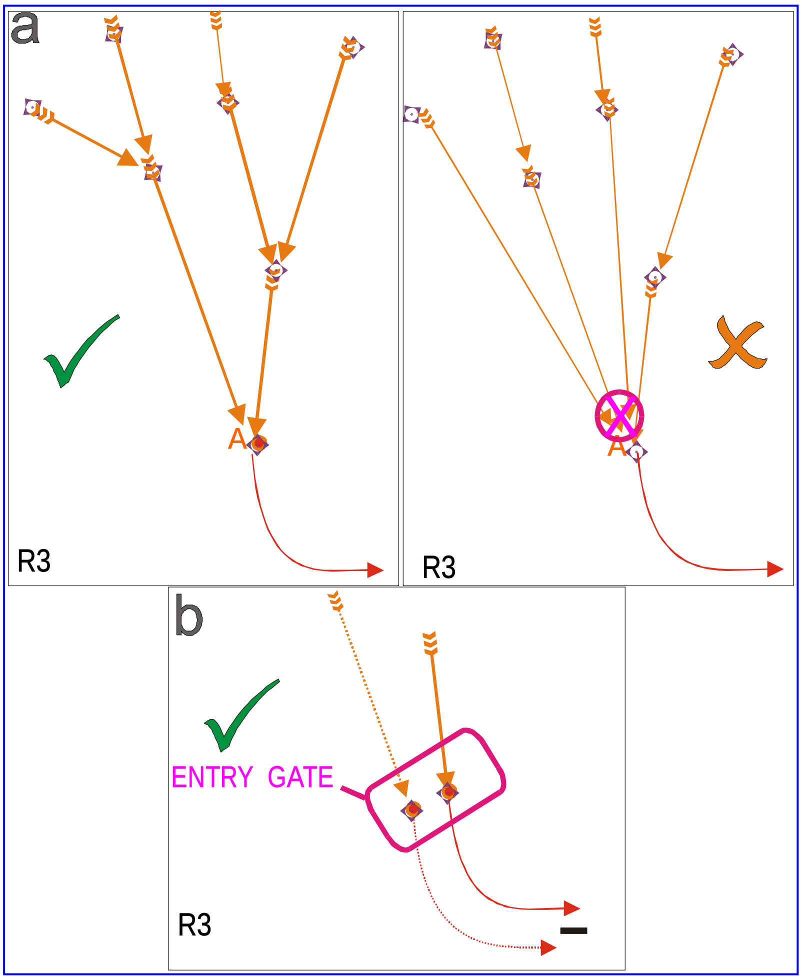


Figure 5- 12: Application of R3

5.4.3 HOLDING AREAS

✈ H1 HOLDING AREAS SHOULD BE LOCATED WHERE THEY WILL CREATE MINIMUM OPERATIONAL COMPLEXITY.

H1 FULL DESCRIPTION: TO THE EXTENT POSSIBLE, PUBLISHED HOLDING AREAS SHOULD BE LOCATED SO AS TO ENSURE MINIMUM OPERATIONAL COMPLEXITY BETWEEN EN ROUTE AND TERMINAL AIRSPACE (AND ADJACENT TERMINAL AIRSPACE).

Two methods are commonly employed to meter aircraft bound for congested Terminal Airspaces: one uses departure delay mechanisms (to avoid aircraft holding on entering the Terminal Airspace), and the other uses holding patterns to stack aircraft for sequencing into the Terminal Airspace.

Comment:
Whilst the choice of either method can be argued convincingly and applied efficiently, it is opportune to mention the reason commonly cited by proponents of the "holding pattern" method for this choice of option. The placement of holding patterns at strategic points prior to Terminal Airspace entry is based upon the idea that by keeping constant 'pressure' on the Terminal Airspace, less airspace is likely to be 'wasted' because the 'metering' of traffic is done closer to landing. Thus where "holding patterns" are used, the metering and sequencing is likely to be tactical and respond in real time to the actual traffic situation (as opposed to the longer range/strategic mechanism that the departure delay method involves).

Because VFR flights usually hold over a visual reference point and the airspace required for VFR holding is generally much smaller than that required for IFR flights.

This Guideline H1 has two elements, both of which are integral parts of the whole – and related to Guideline R3.

- H1.1: TO THE EXTENT POSSIBLE, HOLDING PATTERNS SERVING A TERMINAL AIRSPACE SHOULD IDEALLY BE LOCATED EITHER AT AN ENTRY POINT OR GATE OR OUTSIDE THE TERMINAL AREA.

The reason for this is the same as that given for R3. This Guideline implies that holding patterns should not be located at Terminal Airspace *exit* points/gates or at the crossing point of Terminal Departure and Arrival Routes. (See Guidelines for Routes).

In contrast what this guideline suggests for IFR holding patterns, many designers find it useful to locate the VFR holding areas relatively close to the airport so as to facilitate the sequencing of VFR flights with IFR arrivals.

- H1.2: TO THE EXTENT POSSIBLE, THE LOCATION OF HOLDING PATTERNS SHOULD BE SUCH AS TO CREATE MINIMUM OPERATIONAL COMPLEXITY FOR BOTH EN ROUTE AND TERMINAL AIRSPACE AND FOR ADJACENT TERMINAL AIRSPACES.

Ideally, the location of holding patterns should strive to create minimum overall complexity for the entire air traffic system. This implies the need for a collaborative approach (between En Route and Terminal and between Terminal Airspaces) and making the necessary trade-offs when seeking to locate holding patterns.

- H1.3: TO THE EXTENT POSSIBLE, THE LOCATION OF HOLDING PATTERNS SHOULD REMAIN CONSTANT, IRRESPECTIVE OF THE RUNWAY IN USE.

This guideline supplements R3. The location of the holding patterns should not be affected by change to the runway in use.

This guideline is of particular importance as regards VFR holding areas, and should be applied to the extent possible.

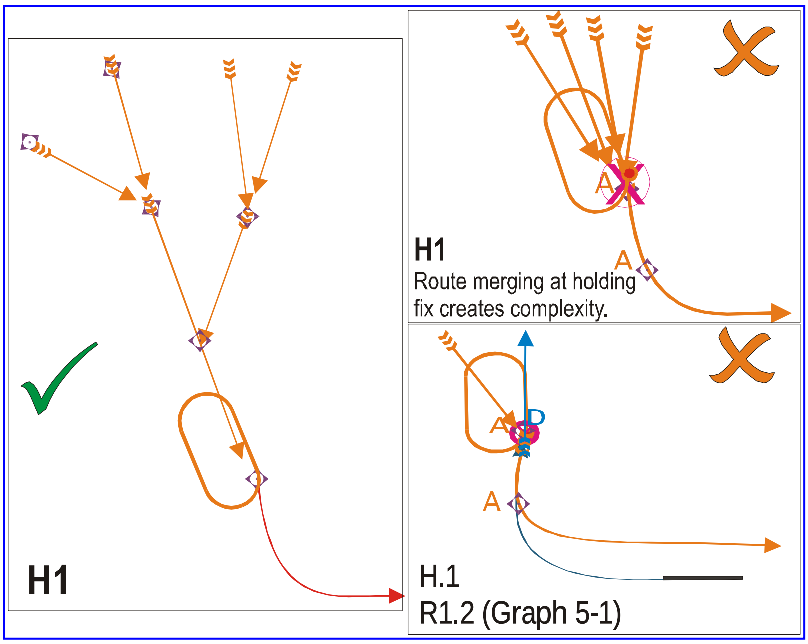


Figure 5- 13: Application of H.1

As far as practicable, Terminal Holding Areas should not be located in areas of known and/or frequent turbulent weather phenomena, so that they can be used when airport operations have been suspended due to adverse weather..
When the traffic mix is populated by a high-number of low performance aircraft, it may be useful to design separate Terminal Holding Areas to accommodate these aircraft. This can be advantageous as regards noise and simplify sequencing for ATC.

✈ H2 THE INBOUND TRACK OF A HOLDING PATTERN SHOULD BE CLOSELY ALIGNED WITH THE SUBSEQUENT TERMINAL ARRIVAL ROUTE.

H2 FULL DESCRIPTION: TO THE EXTENT POSSIBLE, THE INBOUND TRACK OF PUBLISHED HOLDING PATTERN SHOULD BE ALIGNED WITHIN 30° OF THE SUBSEQUENT TERMINAL ARRIVAL ROUTE.

This guideline aims to enhance the efficiency of the holding pattern by assuring that aircraft are not required to make excessive turn manoeuvres when leaving the holding pattern and thus risk over-shooting the turn. If such excessive turn manoeuvres are inevitable, a speed restriction could be included into the procedure to reduce the risk of overshooting the turn.

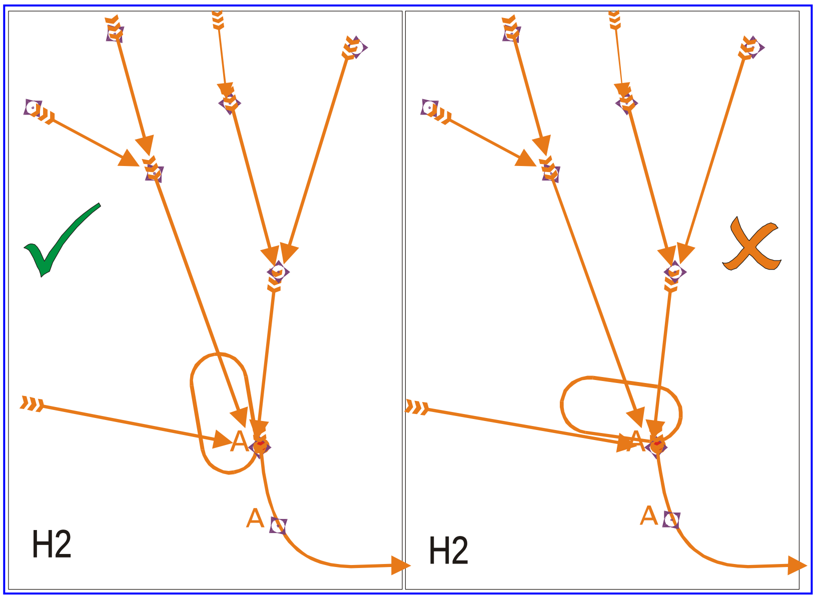


Figure 5- 14: Track Alignment, H.2

5.5 SUMMARY

Design Guidelines for the design of Routes and Holding areas have been presented in this chapter. To the extent possible, designers are encouraged to apply the above guidelines when designing arrival and departure routes. In most instances, these guidelines are applied in combined form. Where specification situations render it impossible to successfully apply combinations of guidelines, trade-offs are required. (See Chapter 7).

The attention of designers is drawn to the fact that these guidelines **do not** constitute design criteria. It is incumbent upon designers to use the design criteria for Routes and Holds contained, inter alia, in ICAO Doc. 8168 and Annex 11 when designing these routes and holds. A full set of document references pertaining to Terminal Airspace design are located at Part C, Chapter 1 ***Attachment C.1-1.***

A checklist for undertaking the Conceptual design of Routes and Holds can be found at Chapter 8, ***Attachment C.8-5.***

Attachment C.5-1

RNAV Routes & Holds

Although the guidelines contained in this chapter make several references to RNAV-based terminal routes, some additional information concerning RNAV Routes and Holds is provided in this Attachment in recognition of the increased use of RNAV in European Terminal Airspaces. A comparison between Conventional and RNAV routes is provided and particular information is provided on route information and the design of turns in RNAV routes.

This attachment is of relevance to paras. 5.2.1 & 5.4 of this chapter, as well as Attachment C.3-1 of Part C, Chapter 3.

Differences and Similarities between Conventional and RNAV Routes

- *Route Placement*

The most obvious difference between RNAV and conventional routes concerns the freedom the designer has as regards route **placement.** In contrast to conventional terminal routes, RNAV routes need not be designed so as to pass directly over or be aligned directly with a ground-based navigation aid. This means that although RNAV-based routes rely on the navigation infrastructure (including GNSS which is not used to design conventional Routes), greater flexibility is provided as regards where the routes can be placed.

- *Way-points*

Another significant difference between RNAV and conventional routes is that RNAV routes are defined by **way-points** as opposed to conventional fixes. (Note, however, that a conventional fix may also be defined as an RNAV way-point). Unlike conventional routes which are usually defined by tracks between fixes, an RNAV route is defined by tracks between way-points.

- *Route Information*

A third noteworthy difference between RNAV and Conventional terminal routes is the way in which **route information** is provided to the operator. Whilst route information for both conventional and RNAV routes is provided to operators in 'original' AIP format consisting of charts and explanatory text, RNAV route information needs to 'translated' into a format which can be stored in a navigation database before it can be *used* by the aircraft navigation system.

This transformation of aeronautical data from 'State' published format into usable data for the operator occurs in a series of steps. Using State-originated aeronautical information, data base suppliers collect and code this information in a standard data format known as ARINC424 (Navigation System Database Specification). This data format, which is usable by navigation system databases, is then 'packed' by the original equipment manufacturer (OEM[2]) for use in the database of a particular operator (the 'end' user).

This transformation of route information into ARINC 424 format is made possible by the use of 'Path and Terminators' developed by ARINC. Simplistically, 'Path Terminators' can be described as industry standard for describing a route information. These Path Terminators are two-letter codes: the first describes the type of flight path (e.g. a track between two way-points) and the second the route termination point (e.g. a fix). Thus, for example, track to a fix (TF) path terminator would be used to "code" a route between two way-points.

[2] Original Equipment Manufacturer of the RNAV system.

✈ *Turns*

From an airspace designer's perspective, it is useful to understand that the design of turns on RNAV routes by PANS-OPS designers is different to conventional routes. As with straight segments of routes, turns also have to be coded into the route information using the Path and Terminator system. Turns can be coded in one of four ways:

Fly-By Transitions	Fly-Over Transitions	Fixed-Radius Transitions	Conditional Transitions
The navigation system anticipates the turn onto the next leg. In en route mode (see below) turn anticipation can start as much as 20NM before the (turning) way-point.	The aircraft over-flies the way-point before starting the turn onto the next leg. This type of turn is exclusive to Terminal Airspace, and then only when it is not possible to use a fly-by or fixed-radius transition e.g. to define an extended centre line.	In this instance, the aircraft flies a specific turn with a defined radius. This type of turn provides the most accurate, predictable and repeatable turn performance by all aircraft and is, generally, the preferred method for transitions with large track angle changes. Most current RNAV systems cannot accommodate this coding at present.	where the RNAV system initiates a transition once a specific altitude has been reached. Conditional transitions that involve a turn are defined by the preceding leg, the subsequent leg and an altitude restriction.

Note: From the designer's perspective - particularly that of the PANS-OPS specialist – it is useful to be aware that the way in which the RNAV system executes the turn is determined by whether the RNAV system (or FMS) is operating in 'en route' or 'Terminal' mode. Generally, it may be said that when in 'en route' mode, the turn anticipation for fly-by transitions will be considerably greater in Terminal mode. Significantly, the designer should be aware that the all RNAV systems (and FMS) do not necessarily define 'en route' and Terminal' mode the same way. Being aware of these aspects, the PANS-OPS procedure designer strive to design routes so that its coding ensures the greatest track predictability for air traffic control.

RNAV Holds

With the existing RNAV standards currently used in Europe – particularly P-RNAV in Terminal Airspace – it is possible to design RNAV holding patterns. Given the absence of fixed radius turn capability in such standards, however, the holding areas of current RNAV holding patterns is of similar shape and dimension to those whose designs are based on conventional navigation. Should the design of holding patterns become based upon RNP RNAV in the future, it should become possible to make significant reductions to size of the holding area (MASPS DO236()). This will provide interesting possibilities for Terminal Airspace designers. On some occasions, it may allow for holding patterns to be placed where it is currently not possible so to do, or for three holding patterns to be placed in an space currently limited to two holding patterns.

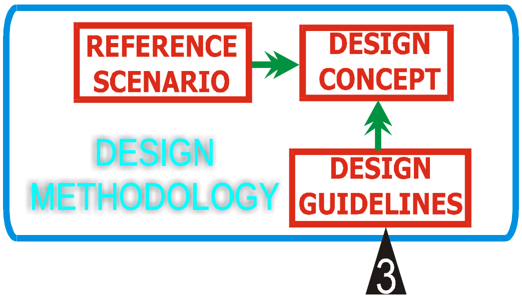
RNAV – future prospects

Increasingly, airspace designers and developers of ATM/CNS standards are becoming interested in the potential benefits that may accrue to ATM thanks to the potential availability of containment integrity inherent in the RNP RNAV MASPs[3]. Should this, it is hoped that it will become possible to reduce the spacing between parallel RNAV routes and enhance or develop or extend the use of RNAV-based separation standards

[3] In the MASPS (DO-236()), ***containment integrity*** is defined as .." A measure of confidence in the estimated position, expressed as the probability that the system will detect and annunciate the condition where TSE is greater than the cross track containment limit. Containment integrity is specified by the maximum allowable probability for the event that TSE is greater than the containment limit and the condition has not been detected. That **is,** P(E2) = Pr(TSE>containment limit and no warning is given)

CHAPTER 6

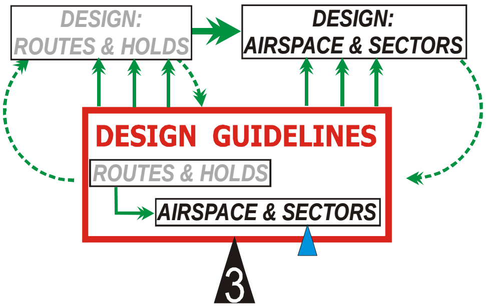
- DESIGN GUIDELINES: STRUCTURES & SECTORS -



Contents

6.1 INTRODUCTION

This chapter presents Design Guidelines for *Structures and Sectors.* They are intended to support creation of the *design concept* for for a specific Terminal Airspace*.* This design concept would be based on certain assumptions. The design of Structures and Sectors follows the design of Routes and Holds (previous chapter). Given the phased approach described in Chapters 4 and 5, constraints and enablers for Structure and Sectors are identified in a phased manner as described in 6.4.1, below. As with Routes and Holds, the structures and sectors need to be subjected to a qualitative assessment against the selected safety and performance criteria as well as the Reference Scenario, if appropriate*.*



6.2 STRUCTURES AND SECTORS

Given the generic meaning to be attributed to Terminal Airspace (Part A, Chapter 1) and that the controlled airspace surrounding an airport can be designated in various ways in accordance to ICAO, the Guidelines for Terminal Airspace structures are slightly less specific than those pertaining to Routes, Holding patterns – and sectors.

Comment: *In practice, many designers give little attention to the shape of the Terminal Airspace structure. Indeed, many designers are disposed to the idea that the shape and size of the Terminal Airspace structure is fixed and cannot be changed. This point of view is difficult to defend, particularly when one consider the purpose of the (controlled) airspace structure i.e. the protection of IFR flight paths.*

As an entity, the Terminal Airspace structure plays an important role in the overall 'equation' of the type of air traffic service provided within the airspace. Because the ICAO airspace classification system determines the extent of the ATS provided within a particular airspace, the airspace classification to attributed to an airspace is important when designing the shape of the structure. Whilst some airspace classifications prohibit VFR flights, others cater for a mix of IFR and VFR and provide for different levels of service to be provided to them. Thus designer should, when designing the airspace, be mindful of the type of service that will be provided in the airspace. (See EUROCONTROL Manual for Airspace Planning, Section 2)

6.3 STRIKING THE BALANCE

A diagram oriented towards airspace structures and Sectors based upon a variation of the diagram from Part A, of this document is inserted below. Intentionally, its depiction is such as to draw designers' attention to the fact that diverging user requirements – and national interests most frequently challenge the design of the airspace structure and ATC sectorisation.

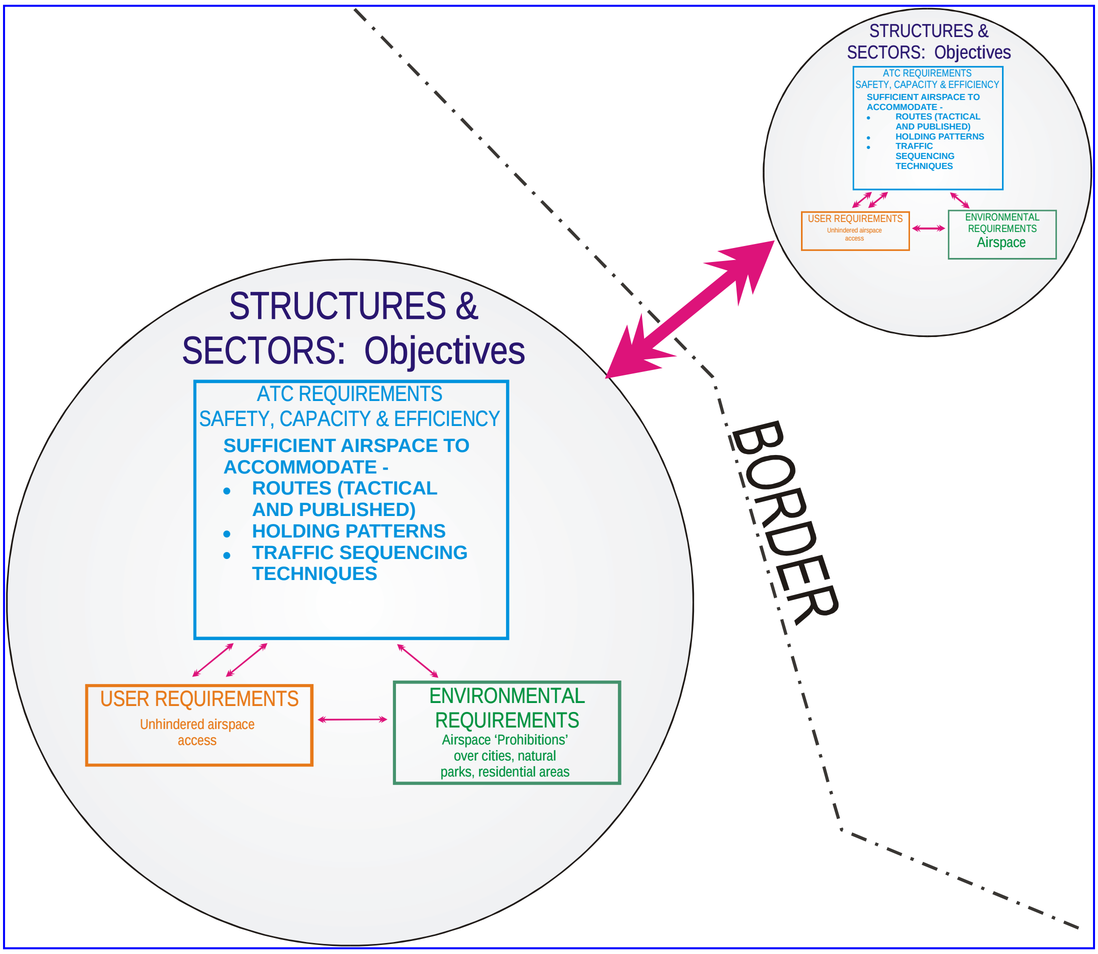


Figure 6- 1: Striking the balance

Whereas the triangular tensions between ATC-environment- users dominate the design of routes and holds, different tensions emerge when it comes to designing an airspace structure or an ATC sector. This is because 'airspace' (or airspace structures) have traditionally been linked to (national) sovereignty. Steeped in history and inherited from different political eras, varying perceptions of 'exclusive' airspace 'ownership' is visible between States in ECAC today. In a similar vein, it is not uncommon within one State, to find 'civilian' or 'military' making claims for exclusive airspace use – or for recreational aviation to insist upon their slice of the airspace.

Fortunately, these problems are being actively tackled in various fora – see EUROCONTROL Manual for Airspace Planning (Section 3) and the *Airspace Management Handbook*.

6.4 GUIDELINES

In this section, design Guidelines related to Terminal Airspace Structures and ATC Sectorisation are described. Those related to Terminal Airspace Structures are preceded by a "**St**" and those to Sectorisation, by an "**Se**". They are not prioritised.

Both sets of Design Guidelines are based on the four assumptions:

Assumption 1: An air traffic control service is provided and Radar Surveillance is available within the Terminal Airspace; and

Assumption 2: Within the context of needing to strike a balance between competing interest referred to in para. 6.3, (above), these Design Guidelines aim primarily for ATM efficiency and capacity.

Assumption 3: Strategic and Design Objectives, Assumptions, enablers and constraints have been identified by the design team. A concept design for Routes and Holds has also been developed.

Assumption 4: the expression terminal routes is used in the same context as in Chapter 5.

6.4.1 PHASED DESIGN APPROACH

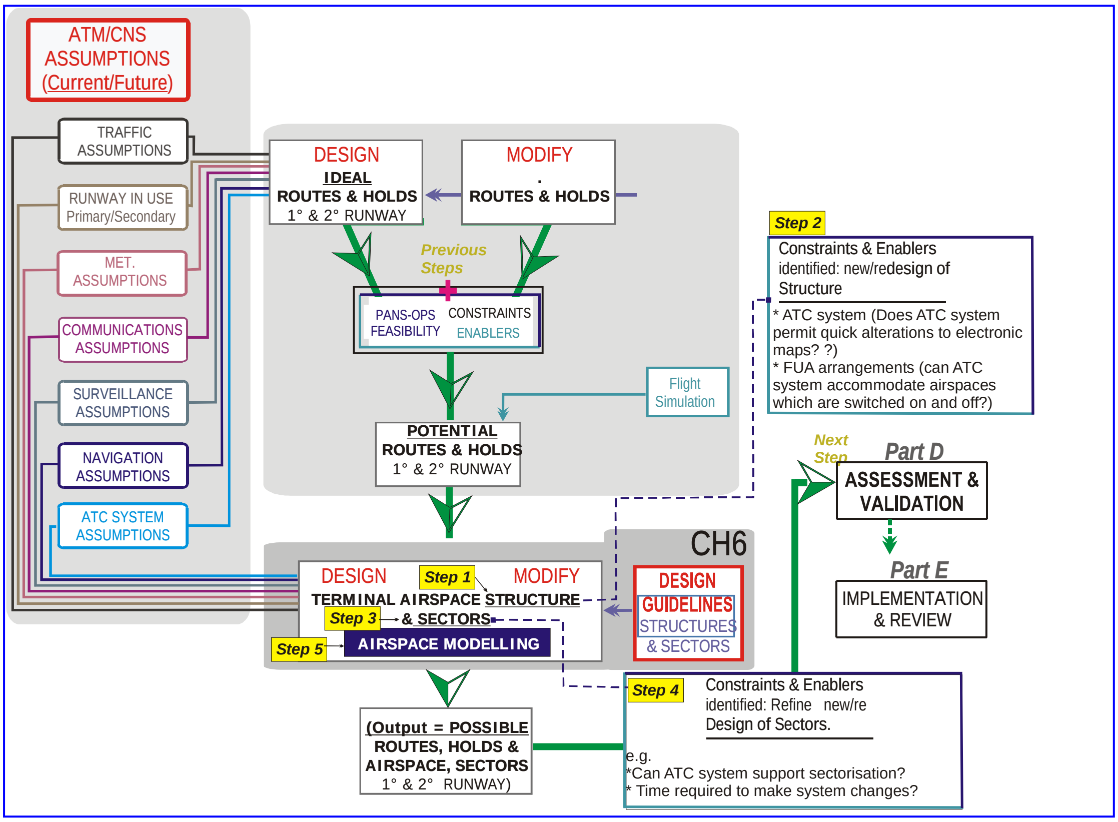


Figure 6- 2: Phased Approach

Whilst consideration of all assumptions, enablers and constraints is crucial to creating the design concept for the Structure and Sectorisation (*after the routes and holds)* those most relevant at this stage of the design are shown on the left.

As with routes and holds, **a phased approach** is suggested for the design of structures and sectors and identification of constraints and enablers.

- *Step 1:* Using assumptions already identified, create a conceptual design of the Terminal Airspace structure to protect the Routes and Holds already designed.
- *Step 2:* Refine the output of Step 1, by adding in constraints and identifying enablers.
- *Step 3:* Building on Step 2 and based upon certain assumptions explore sectorisation options, if required (see below).
- *Step 4:* Refine output of Step 3, add in constraints and identify enablers.
- *Step 5:* Qualitatively assess the viability of Routes & Holds with new Structures and Sectors, using an Airspace Modeller, for example. (See Part D, Chapter 2)

The output from this phase together with the Routes and Holds designed previously constitutes the product of the design concept. This is then subjected to assessment and validation in the next phase

Note 1: Because the 'structure' is sectorised, the structure is built first.

Note 2: Throughout the design process, a qualitatively analysis should be undertaken – see Part C, Chapter 3.

Note 3: Designers' attention is drawn to the importance of the ATC System as an enabler (or constraint) in the context of defining the ATC sectors. See Chapter 4, ***Attachment C.4-2***

6.4.2 TERMINAL AIRSPACE STRUCTURES

✈ ST1: TERMINAL ROUTES, HOLDING PATTERNS AND THEIR ASSOCIATED PROTECTED AIRSPACES ARE TO BE CONTAINED WITHIN CONTROLLED AIRSPACE (SEE ANNEX 11)

ST1 FULL DESCRIPTION: TO THE EXTENT POSSIBLE, WHERE THE TERMINAL AIRSPACE IS SURROUNDED BY UNCONTROLLED AIRSPACE, THE PROTECTED AIRSPACE OF DESIGNATED TERMINAL ROUTES AND HOLDING AREAS ARE TO BE CONTAINED WITHIN THE TERMINAL AIRSPACE IN BOTH THE LATERAL AND VERTICAL PLANE.

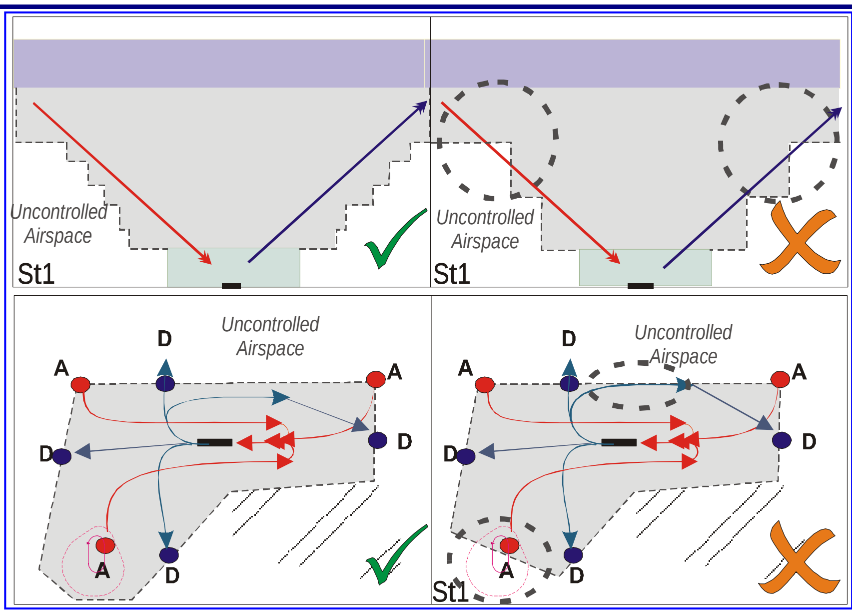


Figure 6- 3: Protection of IFR flight paths

Two sub-guidelines complement St1.

- ST1.1: TO THE EXTENT POSSIBLE AND WHEN NECESSITATED BY OPERATIONAL REQUIREMENTS, THE UPPER LIMIT OF TERMINAL AIRSPACE SHOULD COINCIDE WITH THE LOWER LIMIT OF SUPERIMPOSED CONTROLLED AIRSPACE IN ORDER TO PROVIDE CONTINUOUS PROTECTION TO IFR FLIGHT PATHS.

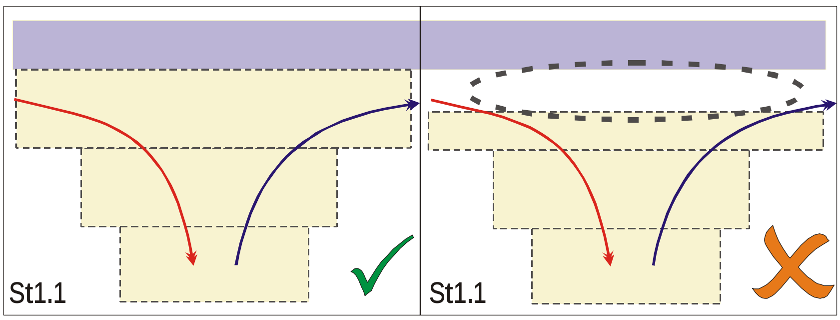


Figure 6- 4: Continuous Protection for IFR Flights

The circle in the right hand diagram shows the area in which no protection is given to IFR flights on leaving the upper limit of the Terminal Airspace. Where Terminal Airspaces are located in remote areas, this design may be intentional.

✈ ST2: TO THE EXTENT POSSIBLE,. A TERMINAL AIRSPACE SHOULD BE COMPATIBLE WITH THE ROUTES AND HOLDS TO BE CONTAINED WITHIN IT.

Because the shape and design of a Terminal Airspace depends upon the Terminal routes and holds to be contained within it, and that Terminal routes/holds are based on certain assumptions, it follows that the shape of each Terminal Airspace will be unique

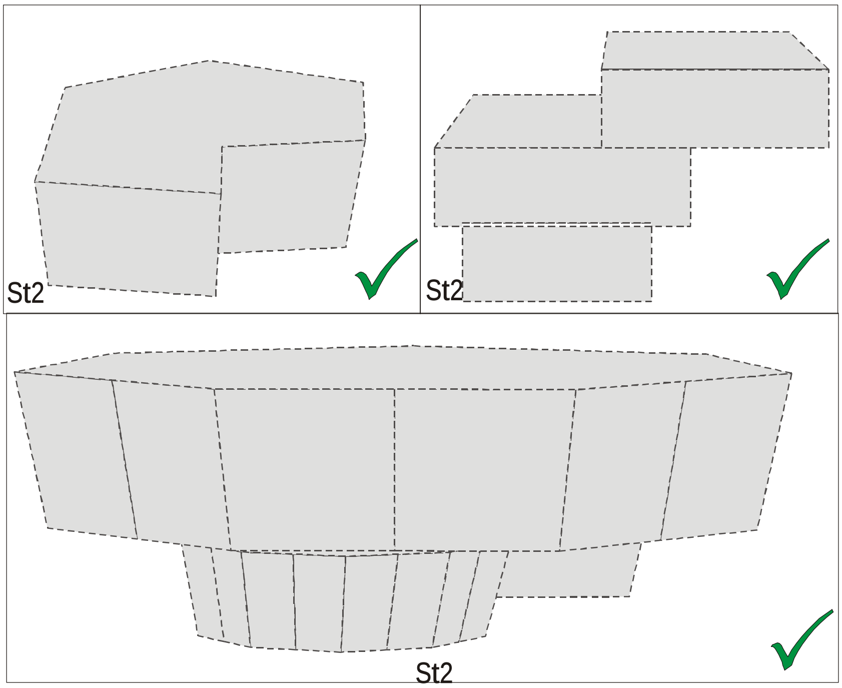


Figure 6- 5: No 'fixed' shape for Terminal Airspace

Being three dimensional, Terminal Airspace structures have width, length and height/depth with defined lateral and vertical limits. That these limits need not be uniform is a natural result of this Guideline. Indeed, the structure's lower limits are frequently stepped as may be the case with the upper limit.

Note 1: If tactical vectoring is to be used by ATC, the Terminal Airspace dimensions should ensure that sufficient space if provided for sequencing and separation of traffic.

- ST2.1: TO THE EXTENT POSSIBLE, BOTH VERTICAL AND LATERAL DIMENSIONS OF A TERMINAL AIRPACE STRUCTURE SHOULD BE COMPATIBLE WITH AIRCRAFT FLIGHT PROFILES, HAVING TAKEN OBSTACLE CLEARANCE CRITERIA INTO ACCOUNT .

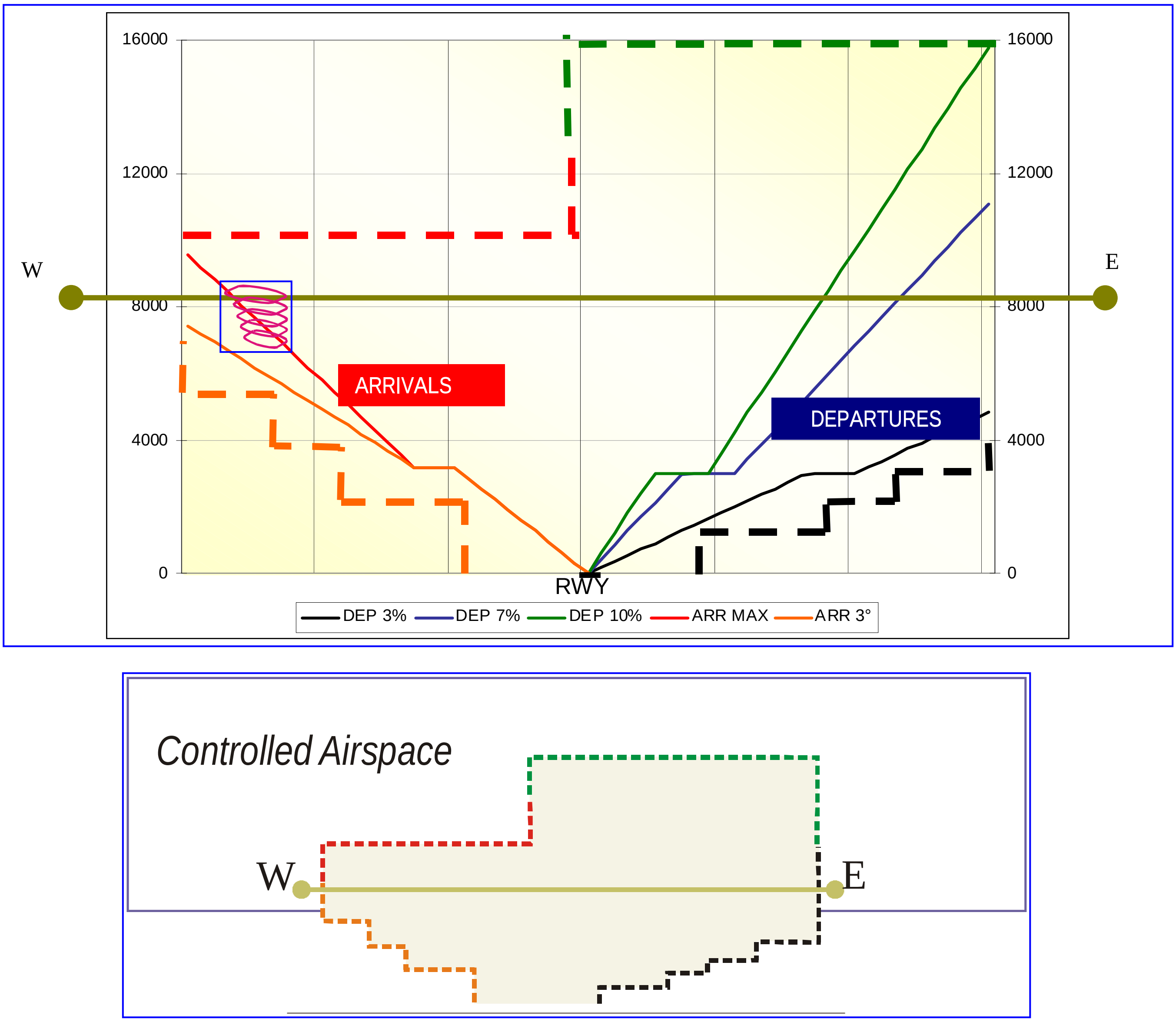


Figure 6- 6: 'Compatibility' between Routes & Structure (Simplified)

Whilst the above diagrams suggest that the Terminal Airspace structure is a function only of the aircraft performance, obstacle clearance must be accounted for as well. As such, they illustrate (simplistically) how to arrive at compatibility between the Structure and the routes and holds protected by the structure. The diagrams show how the vertical limits <u>and</u> horizontal limits of the Terminal Airspace may be arrived at with sample climb and descent profiles based on Graph 5-1 from Chapter 5. Significantly, tactical vectoring routes should also be accounted for when deciding the structure's dimensions. The conclusion that may be drawn from these diagrams is that there is a relationship between the width/height of a Terminal Airspace and aircraft profiles.

In effect, designers creating the Terminal structure would have available several graphs showing an extensive spread of performances. Importantly. the lower limit of the airspace must not be lower than a minimum height described by ICAO – excluding the part of the structure that is to serve as a CTR (which by definition, starts at the surface).

For complex airspace structures, see Chapter 7.

Compatibility needs also to be assured as regards non-designated Terminal routes e.g. Radar Vectoring. The Terminal Airspace should allow for sufficient space for Radar Vectoring to occur.

✈ ST3: TO THE EXTENT POSSIBLE, ONLY THE AIRSPACE NECESSARY TO CONTAIN THE TERMINAL ROUTES SHOULD BE DESIGNATED AS TERMINAL AIRSPACE SO AS NOT TO CONSTRAIN THE OPERATION OF NON-PARTICIPATING (USUALLY VFR) FLIGHTS.

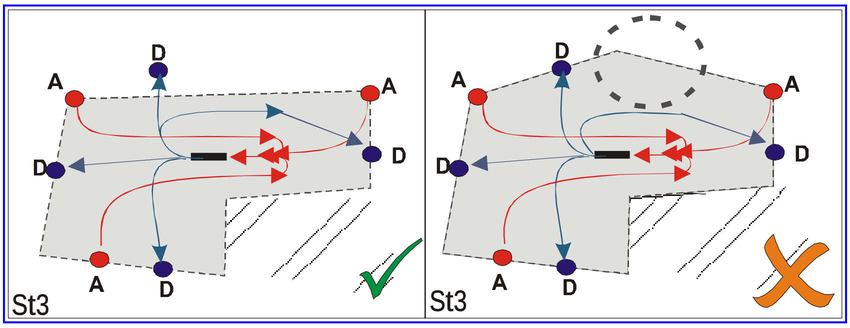


Figure 6- 7: Application St3

Despite the non-desirability of 'taking' more airspace than is required, designers should keep in mind that VFR pilots usually navigate by visual reference points and as such, the boundary of the Terminal Airspace should be 'easy' for VFR pilots to detect.

To this end, two sub-guidelines are provided.

- ST3.1: TO THE EXTENT POSSIBLE, IN ORDER TO AVOID UNAUTHORISED PENETRATIONS OF THE TERMINAL AIRSPACE, THE DETERMINATION OF ITS LATERAL LIMITS SHOULD TAKE INTO CONSIDERATION THE ABLIITY OF NON-PARTICIPATING VFR FLIGHTS TO IDENTIFY VISUAL REFERENCE POINTS DENOTING THE CONTROLLED AIRSPACE BOUNDARY

Although it is tempting to design a complex structure to avoid airspace wastage, if the limits of the structure are difficult for VFR pilots to detect, the structure could be instrumental in reducing the safety of operations by increasing the likelihood of unauthorised airspace penetrations. :

- ST3.2 TO THE EXTENT POSSIBLE, IN ORDER TO AVOID UNAUTHORISED PENETRATIONS OF THE TERMINAL AIRSPACE, THE DETERMINATION OF ITS LOWER LIMITS SHOULD TAKE INTO CONSIDERATION THE NEEDS OF NON-PARTICIPATING (USUALLY) VFR TRAFFIC TO OPERATE FREELY BENEATH THE TERMINAL AIRSPACE (1).

Examples of Terminal Airspace whose lower limit is not the surface of the earth include TMAs and CTAs.

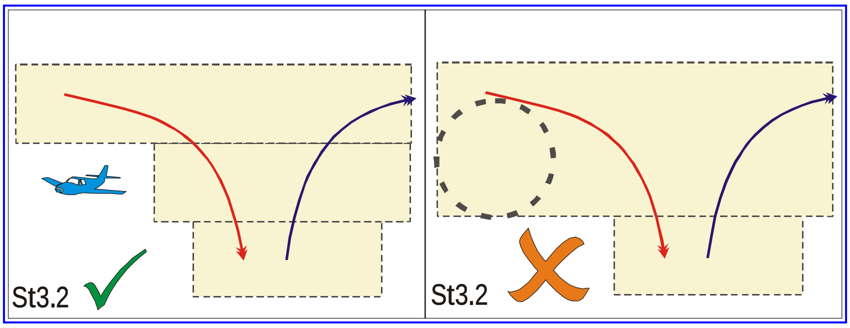


Figure 6- 8: Application St3.2

While the circle in the right hand diagram suggests airspace 'waste' (due to a fixed single lower limit of the Terminal Airspace, Chapter 7 will discuss how this trend is common in complex airspace structures.

✈ ST4: WHEN NECESSITATED BY OPERATIONAL REQUIREMENTS DESIRABLE, ADJACENT TERMINAL AIRSPACES SHOULD BE FUSED INTO ONE TERMINAL BLOCK SO AS TO REDUCE OPERATIONAL COMPLEXITY.

<u>ST4 FULL DESCRIPTION:</u> WHERE ADJACENT TERMINAL AIRSPACES WHICH ARE IN CLOSE PROXIMITY TO ONE ANOTHER AND HAVE INTER-DEPENDENT TERMINAL ROUTEING SCHEMES, CONSIDERATION SHOULD BE GIVEN TO NEGOTIATING WITH THE APPROPRIATE AIRSPACE AUTHORITY TO FUSE THE TERMINAL AIRSPACES INTO ONE TERMINAL AIRSPACE BLOCK WITH A VIEW TO INCREASING THE ATM EFFICIENCY IN THE TOTALITY OF THE SINGLE BLOCK.

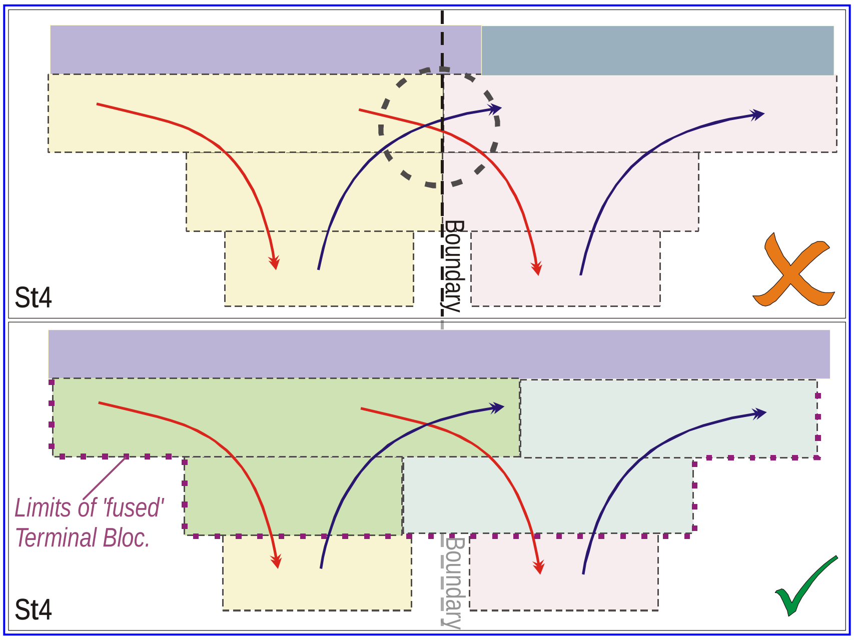


Figure 6- 9: Fused Terminal Airspaces to improve ATM

The circle in the upper diagram of denotes both interacting traffic flows and a potential problem area in terms of crossing routes close to the Terminal Airspace limits, the problem is created by the fact that the boundary has been 'forced' to coincide with another e.g. a national boundary. The lower diagram shows that by creating one Terminal Airspace 'Bloc', ATM can be rendered more efficient by increasing the sectorisation options in the total airspace. See S3, below.

✈ ST5: WHEN NECESSITATED BY OPERATIONAL REQUIREMENTS, CONSIDERATION SHOULD BE GIVEN AS TO WHETHER AND TO WHAT EXTENT, CERTAIN PARTS OF THE AIRSPACE ARE TO BE SWITCHED "ON" OR "OFF" IN ACCORDANCE WITH THE FLEXIBLE USE OF AIRSPACE CONCEPT.

To accommodate such needs, a portion of the TMA can be published with its own identifier e.g. TMA II having its own dimensions, so airspace users and controllers can easily identify that portion of the airspace which is subjected to FUA.

- ST5.1: WHERE AIRSPACE RESTRICTIONS OR RESERVATIONS ARE ESTABLISHED ABOVE OR BELOW TERMINAL AIRSPACE, IT IS ESSENTIAL THAT, DEPENDENT ON THE ACTIVITY CONDUCTED THEREIN, ADEQUATE BUFFERS BE ESTABLISHED ABOVE/BELOW THESE AIRSPACES RESTRICTIONS OR RESERVATIONS, IN ORDER TO ENSURE THAT ATS CAN PROVIDE AN ADEQUATE MARGIN OF SAFETY.

See Sections 1 and 3 of the ECAC Airspace Planning manual which respectively provide *General Guidelines and* guidelines relating to Airspace Restrictions/Reservations in support of the FUA concept.

6.4.3 SECTORS

From a design perspective, the sectorisation of a Terminal Airspace is one of the most common ways in which to distribute workload between controllers so as to ensure the safe and efficient management of air traffic within the airspace volume. Whether Sectorisation is *necessary* is decided – almost exclusively – on the basis of ATC workload which may impact upon safety. Because the frequency and number of air traffic movements constitutes one of the main factors affecting ATC workload, the importance of the selection of a ***realistic traffic sample*** and identification of the predominant ***runway in use*** cannot be over-stressed. As discussed in Chapter 3, the selected traffic sample is one of the major assumptions of the design process. Once it has been properly analysed (as regards *time* and *geographic* distribution), it is assigned to the modified or new Terminal routes which have been designed. Qualitative assessment of the traffic sample supported by Airspace Modelling are common methods used to identify the need for Sectorisation.

***Comment:* Is there a generic rule of thumb that allows designers to *estimate* the need for Sectorisation?** *Airspace designers will be aware that, for the most part, States do not publish capacity figures for Terminal Airspace (or TMA) sectors. There could be several explanations for this e.g. (i) it is too difficult to calculate; or (ii) capacity limitations are 'hidden' by published airport capacity and/or en-route sector capacity; or (iii) capacity figures are not calculated for Terminal Airspace or its sectors. There is a fourth possibility – which is unlikely – and that is that there are no capacity problems in Terminal Airspace sectors in ECAC. Whatever the reason, there appears to be agreement on the fact that capacity is difficult to estimate in a Terminal Airspace – perhaps because it is sandwiched between En route and the airport.*

In order to appreciate the complexity of determining capacity of a Terminal Airspace volume (or sector), it is worth mentioning the variety of factors which affect the number of aircraft that can be handled by a single controller in a given time period. Importantly, **none of these factors can be viewed in isolation***. Each factor is a 'variable' in the overall capacity 'equation.*

- Design of Terminal routes*. The more segregated the routes both vertically and laterally, the less the 'active' the workload of the controller;*
- Use of designated arrival and departure routes such as SIDs/STARs. *Generally, the greater the number of published routes, the less RTF required (Note, however, that an excessive number of SIDs/STARs can create a high pilot workload or introduce errors).*
- The accuracy of the navigation performance of aircraft operating on designated routes. *The greater the accuracy, the less the need for controller intervention.*
- Phase of flight. *Generally, arrivals are more labour intensive than departing flights especially if extensive use is made of tactical routeing as opposed to designated routes such as STARs.*
- The complexity of the instrument approach procedure *: especially in terrain rich areas or for reasons of environmental mitigation, the Radar monitoring workload can be high with respect to complex manoeuvres.*
- The altitude of the airport, ambient temperature and airport infrastructure affect runway occupancy and in-trail spacing interval. *At 'hot and high' airports, holding may be required to compensate for any of these factors – which is work intensive.*
- High mix of aircraft performance and/or aircraft navigation performance*: Generally, the greater the mix, the higher the workload as speed differences and navigation performance differences have to be catered for by the controller.*
- Capabilities and facilities provided by the Radar System and the Flight Planning Data Processing system. *For example, it a controller is required to 'manually' perform the code-call-sign conversion, this creates additional workload.*

In view of the above, it can be seen that it would be difficult to provide a 'rule of thumb'. Where fifteen aircraft an hour in a particular Terminal Airspace may appear – to most – to be indicative that Sectorisation is not required, it could be required if the 'lowest' denominator of all of the points in the bulleted list (above) constitute the 'general' operating conditions. Conversely, where 40 aircraft an hour would suggest a need to sectorise the Terminal Airspace volume, it may prove unnecessary in those instances where the 'highest' common denominator of all of the points in the bulleted list (above) constitute the 'general' operating conditions.

Once the need for Sectorisation has been identified, the next question to be decided is whether sectorisation is possible. This possibility is determined by the available staff holding the appropriate qualifications, the availability of working positions and the capabilities of the ATM system. In this context, 'available' staff/working positions may be included in the assumptions i.e. those that will be available when the project is implemented. If staff and or working positions are not available, designers could plan for sectorisation in the longer term and identify more qualified staff and working positions as enablers.

Having determined that sectorisation is required and possible, the next decision concerns the *type* of sectorisation to be used. Generally, two types of Sectorisation are used in Terminal Airspace. These are –

- Geographical Sectorisation : where the airspace volume is divided into 'blocks' and a single controller is responsible for all the traffic in a single block i.e. sector; or
- Functional "Sectorisation" where divisions of the Terminal Airspace volume is determined as a function of the aircraft's phase of flight. The most common type of Functional Sectorisation is where one controller is responsible for arriving flights in the Terminal Airspace whilst another is responsible for departing flights in the same Terminal Airspace volume.

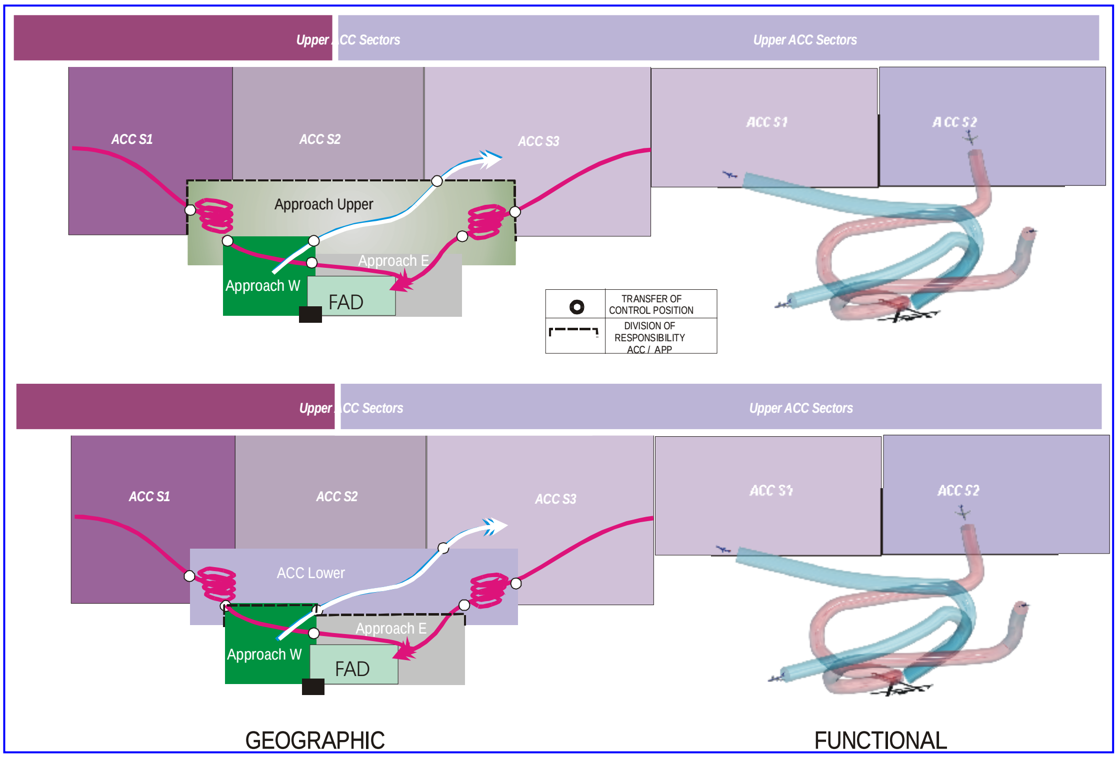


Figure 6- 10: Sectorisation Types

Several points are worth noting concerning sectorisation methods:

- As it is commonly understood, 'Sectorisation' generally refers to geographical Sectorisation. As such, it could be argued that Functional 'sectorisation' is a sub-set of geographic Sectorisation.
- Secondly, there are very few Terminal Airspaces which are sectorised either geographically or functionally. In reality, most Terminal Airspaces use a combination of functional and geographic sectorisation.

- Sectorisation of the Terminal Airspace volume can be demanding in terms of ATC system capability. When (geographic) sectors are stepped or when functional Sectorisation is used, the ATC system should be capable of supporting the sectorisation option e.g. by 'filtering' out traffic that is not under the direct control of the controller responsible for a sector.

6.4.3.1 Geographic Sectorisation

Advantages	Disadvantages
✈ Controller can fully exploit the space available in sector to manipulate best levels for inbounds/outbounds and expedite climb and descent without need for co-ordination. ✈ Easier to balance workload between sectors. ✈ Can be less demanding in terms of the Radar Display and ATC system ✈ Relatively easily to describe operational instructions for ATC areas of responsibility.	✈ Controller handles mixed traffic i.e. arrival, departure and transit traffic. ✈ In instances where the sector division runs along the runway centre-line, departing aircraft departing in different directions may be controlled by different controllers after take-off. (Effective mitigation can be provided by putting appropriate procedures in place). ✈ In cases where an aircraft is required to transit more than one geographic sector in the Terminal Airspace, this can add to complexity by requiring additional co-ordination.

6.4.3.2 Functional Sectorisation

Advantages	Disadvantages
✈ Controller handles one traffic type i.e. either departures or arrivals because sector defined as a function of task. ✈ Usually, *all* Departing aircraft are on the same frequency after take-off. ✈ In some configurations, can prove more flexible to operate.	✈ Vertical/Lateral limits of sector can prove overly restrictive as one (vertical) band is unlikely to cater for all aircraft performance types. ✈ Difficult to balance workload between sectors especially where departure and arrival peaks do *not* coincide. ✈ Can be demanding in terms of the Radar Display and ATC System ✈ Operating instructions for ATC can be difficult to formulate with respect to areas of responsibility;

***Comment*: What is the difference between division of responsibility and areas of responsibility in the context of ATC Sectorisation?** *Usually, the former refers to division of responsibility between the different ATC Units i.e. between the Area Control Unit, Approach Control Unit and Aerodrome Control Unit. In contrast, the latter refers to dividing the workload of any one unit i.e. dividing the workload of the Approach Control Unit into two sectors such as Approach East and Approach West. In those cases where one Area Control sector is responsible for the entire FIR and one Approach Control sector is responsible for the entire Terminal Airspace, the division of responsibility is the 'same' as the sectorisation.*

✈ SE1: TO THE EXTENT POSSIBLE, LATERAL AND VERTICAL DIMENSIONS OF SECTORS SHOULD BE DESIGNED SO AS TO AVOID A REQUIREMENT TO ISSUE STEPPED LEVEL CLEARANCES, ESPECIALLY OVER SHORT DISTANCES.

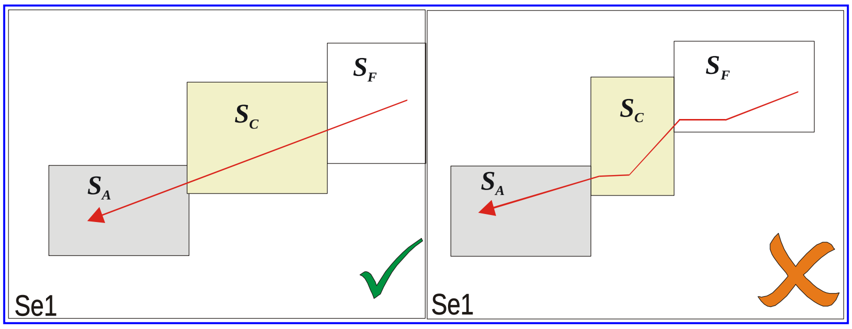


Figure 6- 11: Application Se1

✈ SE2: THE PROTECTED AIRSPACE AROUND A HOLDING PATTERN SHOULD BE INCLUDED IN A SINGLE GEOGRAPHICALLY DEFINED SECTOR.

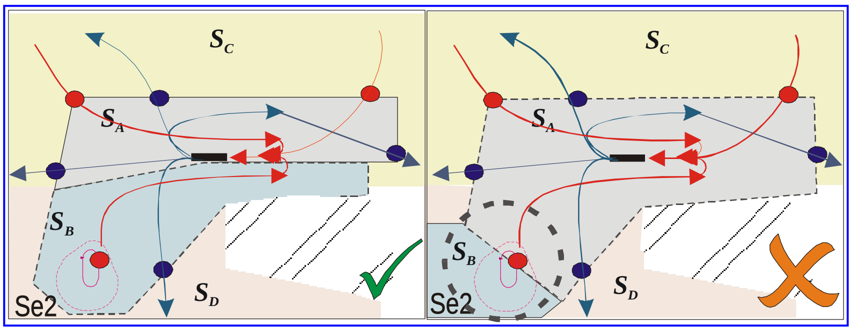


Figure 6- 12: Placement of Holding Areas

✈ SE3:THE PROTECTED AIRSPACE OF A PUBLISHED TERMINAL ROUTE SHOULD BE CONTAINED WITHIN A SINGLE GEOGRAPHICALLY DEFINED SECTOR.

Full Description: WITH A VIEW TO PREVENTING UNAUTHORISED SECTOR PENETRATIONS, THE PROTECTED AIRSPACE OF PUBLISHED TERMINAL ROUTES SHOULD BE CONTAINED WITHIN A SINGLE GEOGRAPHICALLY DEFINED SECTOR WHERE A ROUTE CENTRE IS PARALLEL TO A SECTOR BOUNDARY, OR IT IS INTENDED THAT AIRCRAFT REMAIN WITHIN THE ORIGINAL SECTOR AFTER COMPLETING A TURN.

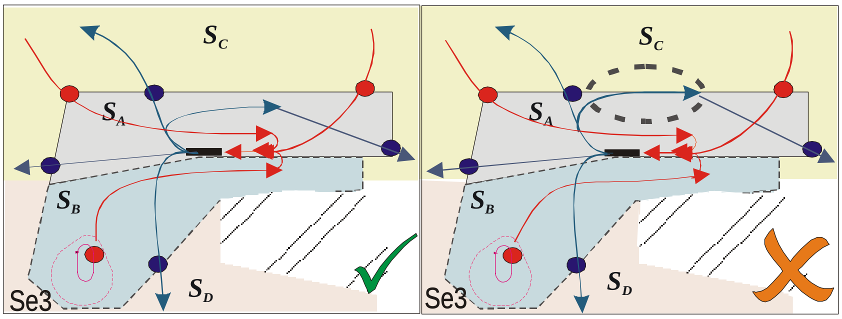


Figure 6- 13: Protected Airspace – Sector Boundary

In those instances where extensive tactical vectoring is expected within a particular sector, it is advisable to place the sector boundary in such a manner so as to minimise the need for co-ordination between sectors.

✈ SE4: WITH A VIEW TO ENSURING MINIMUM OPERATIONAL COMPLEXITY, A SECTOR SHOULD NOT BE DESIGNED IN ISOLATION FROM SURROUNDING SECTORS.

This guideline is complementary to Se1. It is amplified by several sub-guidelines.

- **SE4.1:** TO THE EXTENT POSSIBLE. CROSSING POINTS OF TERMINAL AND/OR OTHER ROUTES SHOULD NOT BE PLACED TOO CLOSE TO A BOUNDARY OF A GEOGRAPHICALLY DEFINED SECTOR SO AS TO ALLOW THE RECEIVING CONTROLLER SUFFICIENT ANTICIPATION TIME TO RESOLVE THE CONFLICT.

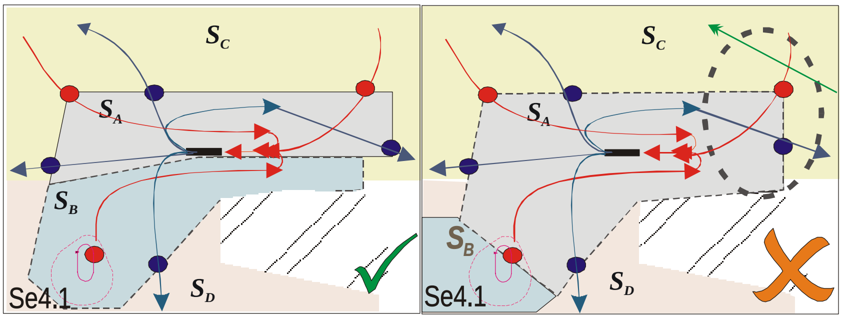


Figure 6- 14: Lateral Sector boundaries and crossing routes

This sub-guideline infers that the *lateral limits* of sectors need not be straight lines.

- **SE4.2:** THE VERTICAL LIMITS OF A GEOGRAPHICALLY DEFINED SECTOR NEED NOT BE UNIFORM I.E. FIXED AT ONE UPPER LEVEL OR ONE LOWER LEVEL, NOR NEED THESE VERTICAL LIMITS COINCIDE WITH THE VERTIAL LIMITS OF (HORIZONTALLY) ADJOINING SECTORS.

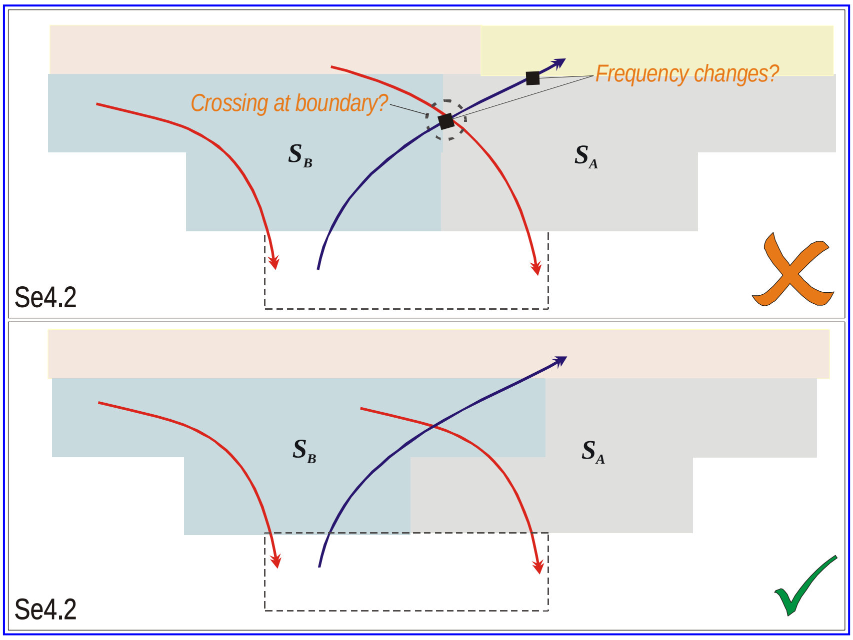


Figure 6- 15: Vertical Sector boundaries and crossing routes

- SE4.3: WHERE AIRSPACE RESTRICTIONS OR RESERVATIONS ARE ESTABLISHED ABOVE OR BELOW TERMINAL AIRSPACE SECTORS, IT IS ESSENTIAL THAT, DEPENDENT ON THE ACTIVITY CONDUCTED THEREIN, ADEQUATE BUFFERS BE ESTABLISHED ABOVE/BELOW THESE AIRSPACES RESTRICTIONS OR RESERVATIONS, IN ORDER TO ENSURE THAT ATS CAN PROVIDE AN ADEQUATE MARGIN OF SAFETY.

This is the ‘equivalent’ of Guideline St.5.1

✈ SE5: POTENTIAL SECTOR COMBINATIONS SHOULD BE TAKEN INTO ACCOUNT WHEN DETERMINING SECTOR CONFIGURATION.

<u>SE 5 FULL DESCRIPTION:</u> POTENTIAL VERTICAL AND HORIZONTAL SECTOR COMBINATONS SHOULD BE TAKEN INTO ACCOUNT WHEN DETERMINING SECTOR CONFIGURATIONS WITHIN A TERMINAL SO AS TO RESPOND MORE REALISTICALLY TO CHANGES IN TRAFFIC DEMAND. ANY SECTOR COMBINATION SHOULD ENSURE THAT OPERATIONAL COMPLEXITY IS KEPT TO A MINIMUM. (For complex sector configurations, see Chapter 7)

SE6: GEOGRAPHICALLY DEFINED PRE-SEQUENCING SECTORS SHOULD BE DESIGNED TO ENCOMPASS THE MAIN ARRIVAL FLOWS WITH A VIEW TO MERGING ARRIVAL FLOWS AS PER GUIDELINE R3 (SEE CHAPTER 5) .

For complex Terminal Airspace sectors, see Chapter 7.

✈ SE7 TO THE EXTENT POSSIBLE, THE CONFIGURATION OF GEOGRAPHICALLY DEFINED SECTORS SHOULD REMAIN CONSTANT IRRESPECTIVE OF THE RUNWAY IN USE. (GEOG ONLY)

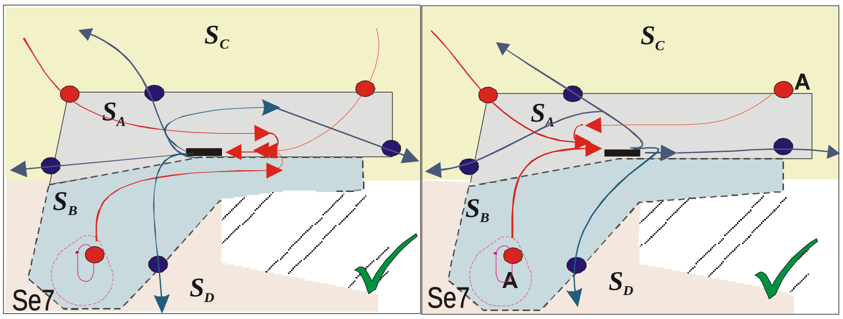


Figure 6- 16: Sector configuration and Runway in Use (I)

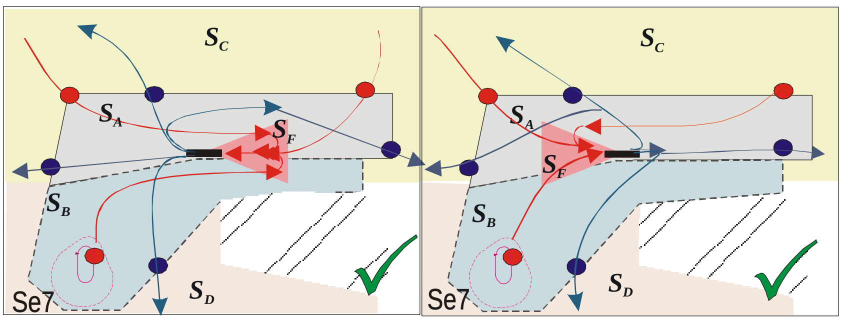


Figure 6- 17: Sector Configuration & Runway in ise (ii)

This guideline is aimed at avoiding unnecessary co-ordination between upstream or downstream sectors and avoiding complex changes to the FDPS and RDPS which may not be capable of accommodating such changes.

Naturally, if a Final Approach director sector exists, this sector would have to be changed when a change is made to the runway in use.

✈ SE8: WHEN NECESSITATED BY OPERATIONAL REQUIREMENTS, THE UPPER LIMIT OF A SECTOR SHOULD COINCIDE WITH THE LOWER LIMIT OF SUPERIMPOSED SECTORS IN ORDER TO PROVIDE PROTECTION TO IFR FLIGHTS.

This guideline is the sector 'equivalent' to Guideline St1.1

6.5 SUMMARY

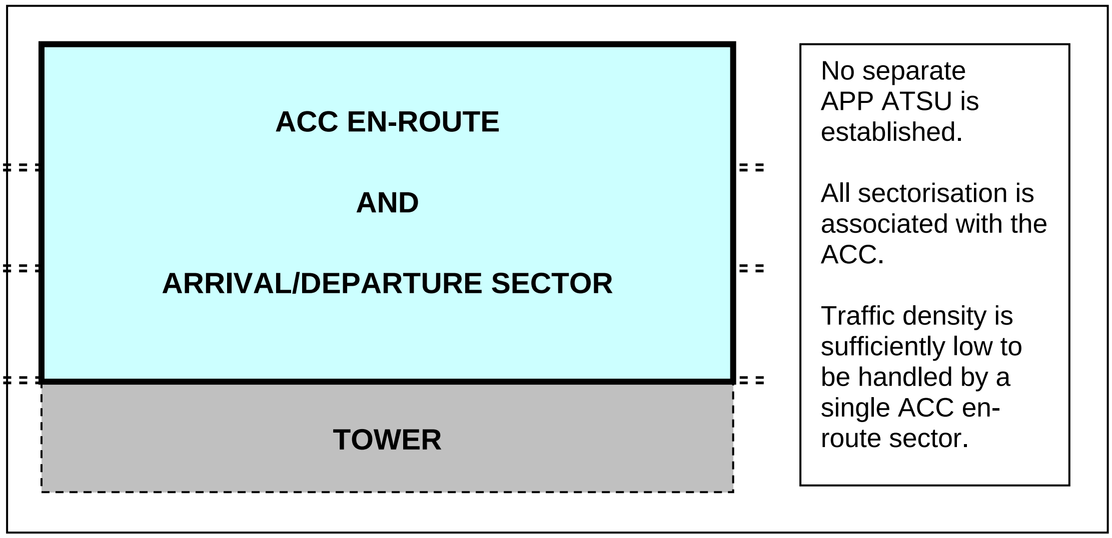
Design Guidelines for the design of Structures and Sectors areas have been presented in this chapter. To the extent possible, designers are encouraged to apply the above guidelines when designing structures and sectors. In most instances, these guidelines are applied in combined form. Where specification situations render it impossible to successfully apply combinations of guidelines, trade-offs are required. (See Chapter 7).
The attention of designers is drawn to the fact that these guidelines **do not** constitute design criteria. It is incumbent upon designers to use the design criteria for Routes and Holds contained, inter alia, in ICAO Doc. 8168 and Annex 11 when designing these routes and holds. A full set of document references pertaining to Terminal Airspace design are located at Part C, Chapter 1 ***Attachment C.1-1.***

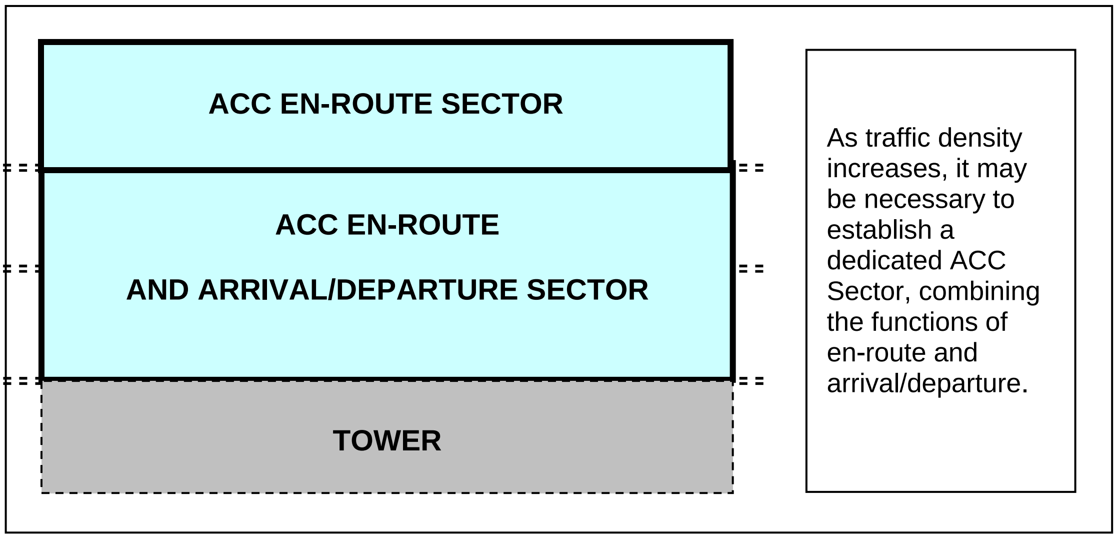
A checklist for undertaking the Conceptual design of Structures and Sectors can be found at Chapter 8, ***Attachment C.8-1.***

Attachment C.6-1

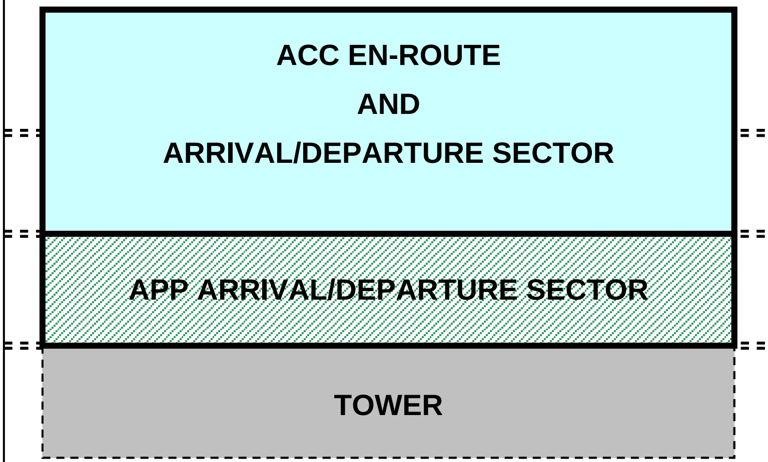
Sample Sector Options & Evolution

OPTION 1



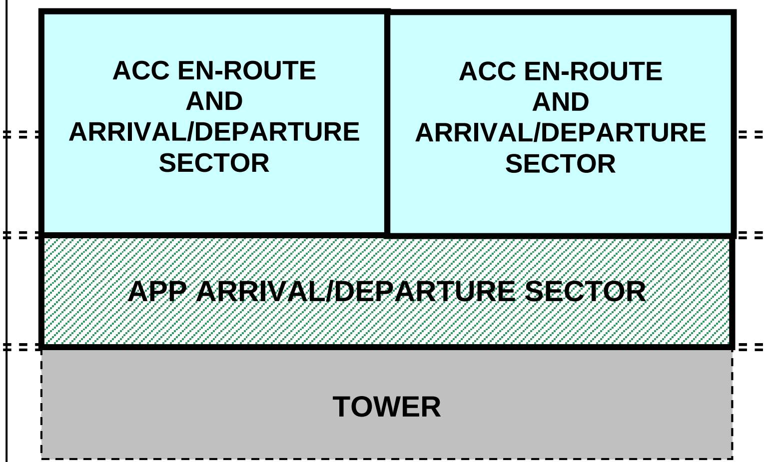


OPTION 2

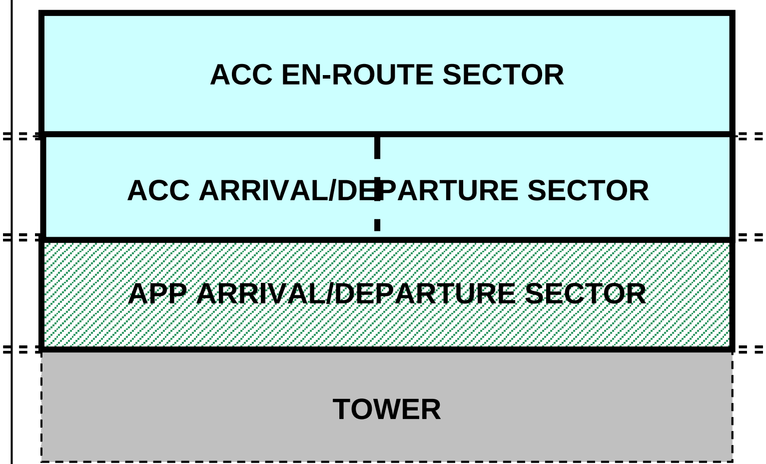


The ACC Sector handles both the En-route function and some of the Arrival/Departure traffic.

Traffic closer to the airport is handled by a separate APP Arrival/Departure Sector.

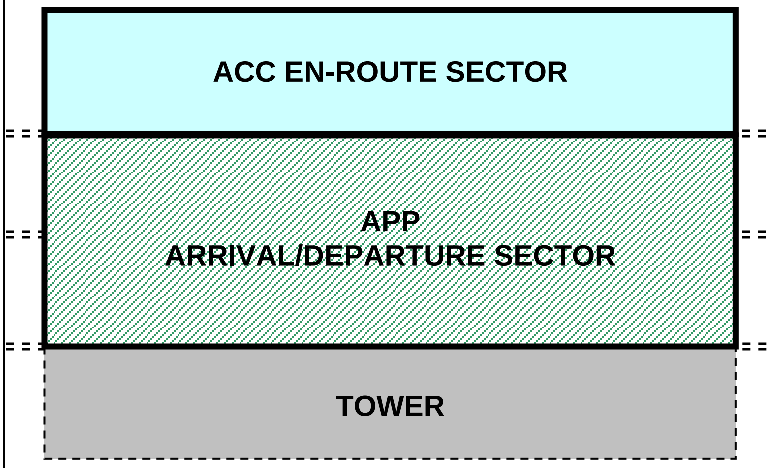


As traffic density increases further, there may be a need for additional sectors within the ACC's area of responsibility. This example shows two ACC Sectors, each with some En-route and Arrival/Departure responsibilities.

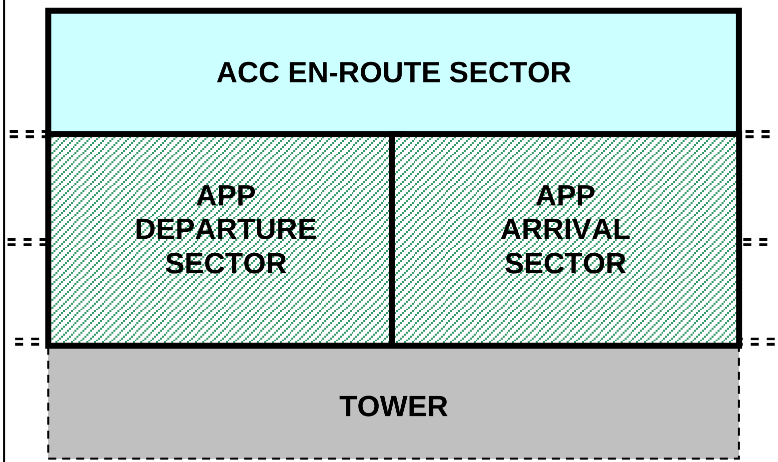


Alternatively, the ACC tasks may be sectorised to provide a dedicated ACC En-route Sector and one or more ACC Arrival/Departure Sectors.

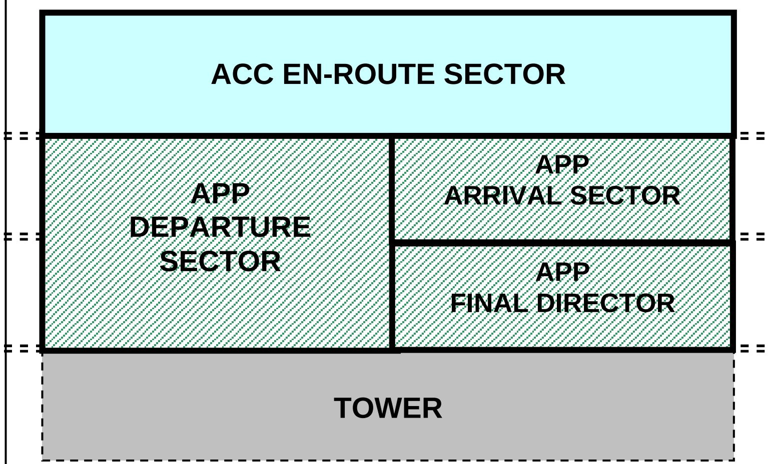
OPTION 3



The ACC is solely responsible for the en-route traffic, while the APP unit controls the Arrival/Departure traffic in a single extended sector. which may be large in both horizontal and vertical dimensions.

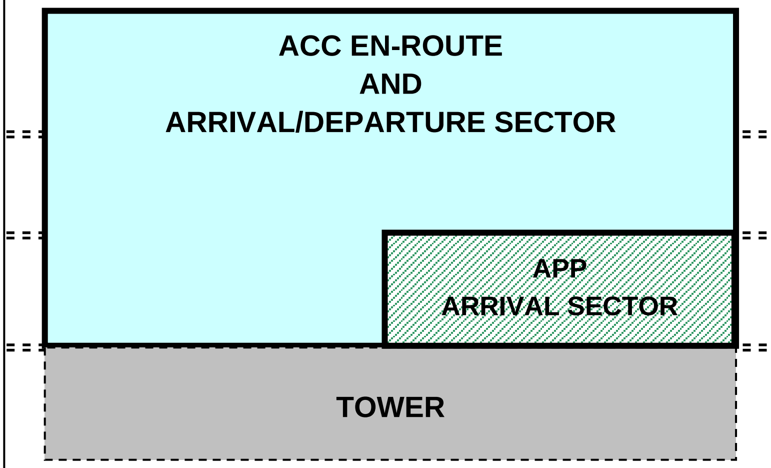


As traffic density increases, it may be necessary to establish functional Arrival and Departure Sectors within the APP area of responsibility.

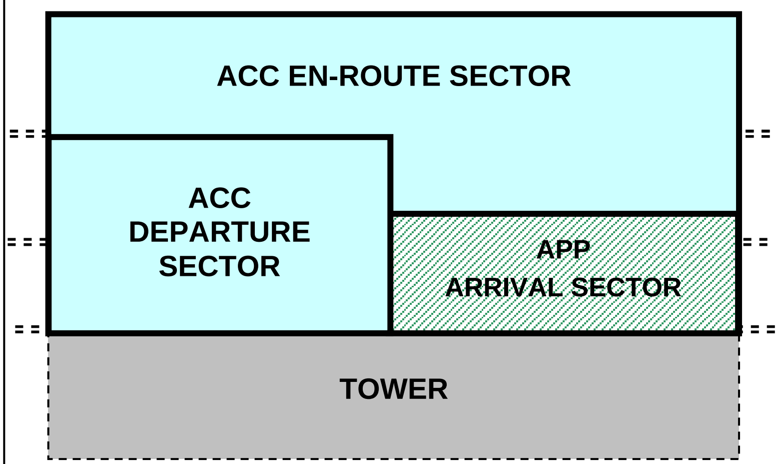


As traffic density increases even further, the Arrival task itself could be sectorised into an (Initial) Arrival Sector and a Final Director (Sector).

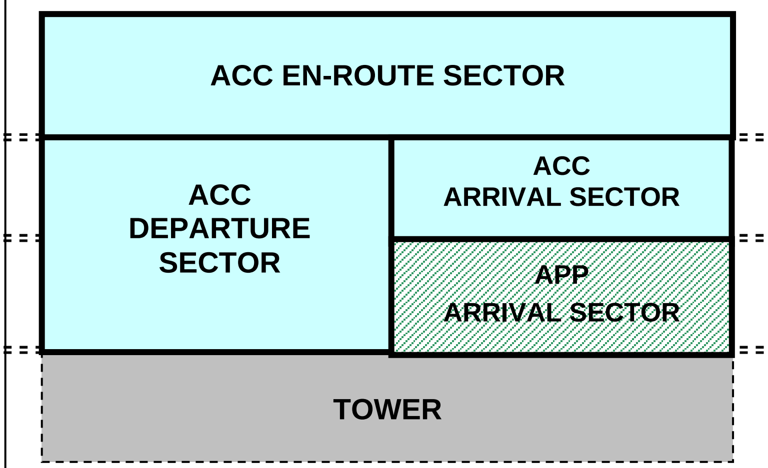
OPTION 4



Whilst traffic density is low, the ACC handles most of the traffic in a combined En-route + Arrival/Departure Sector.
APP is responsible only for the final vectoring of arrival traffic

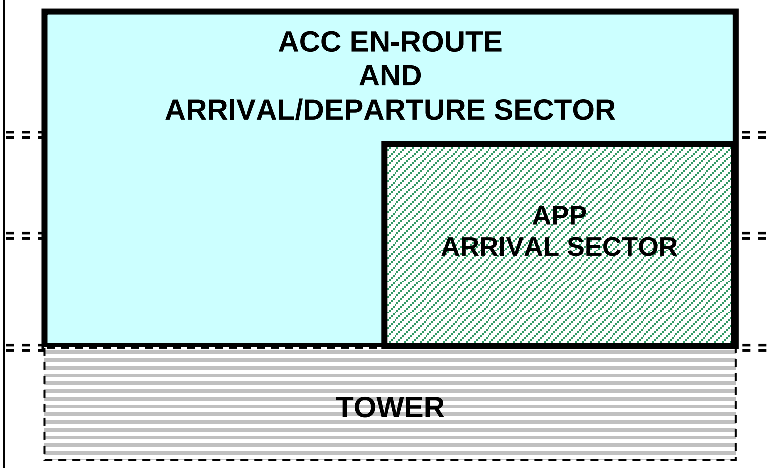


As traffic density increases, it may be necessary to divide the ACC function into two sectors (En-route and Departure).

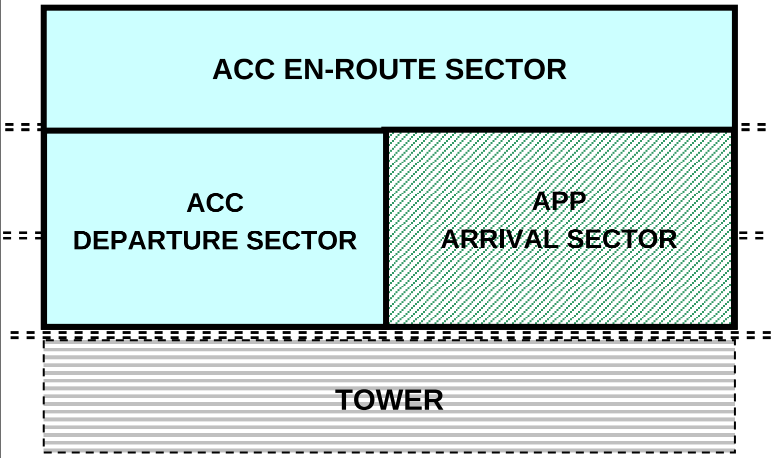


At high traffic density an ACC Arrival Sector is introduced to separate the arrival function from the en-route function.

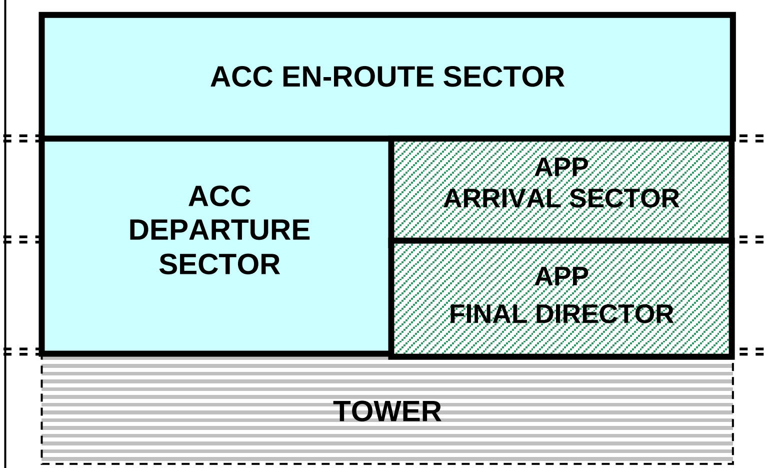
OPTION 5



At low traffic density, the APP unit has responsibility for arriving traffic in the APP Arrival Sector.



As traffic density increases, it may be necessary to establish a functional Departure Sector within the ACC area of responsibility.



As traffic density increases even further, the Arrival task itself could be sectorised into an APP (Initial) Arrival Sector and an APP Final Director (Sector).

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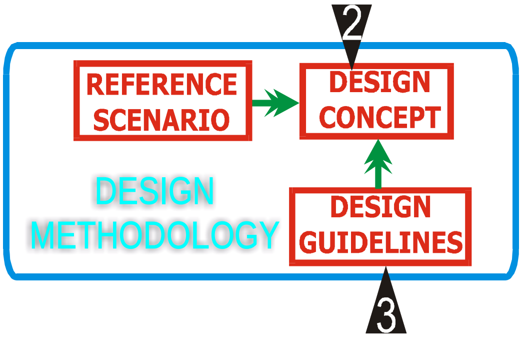
CHAPTER 7

- CONCEPT EVOLUTION -



Contents

7.1 INTRODUCTION

The Design Concept discussed in previous chapters has provided guidelines on the design of Routes, Holding areas, the Terminal Airspace Structure and ATC Sectorisation. Although it has not been explicitly stated in these chapters, most designers will recognise that the explanatory diagrams in Chapters 5 and 6 show airspace that is relatively 'uncomplicated' in that most of the Stages show only one airport within (one) Terminal Airspace. In design terms, this scenario – or that of one *major* airport and two 'minor' airports – is relatively straight forward.

In view of this, it is considered appropriate to focus upon more complex Terminal Airspace. As such, this Chapter primarily discusses the evolution of Terminal Airspaces into what may, for convenience, be described as a Terminal Airspace system i.e. a Terminal Airspace block which is operated as an integrated system when it is no longer feasible to trea as separate entities, several Terminal Airspaces which have grown into each other over time .

7.2 EVOLUTION OF TERMINAL AIRSPACE

The evolution from Terminal Airspace to Terminal Airspace system is almost exclusively a function of increased traffic demand and resultant complexity of air traffic operations. Simplistically, this evolution can be illustrated as follows (and of course, there are possible variations on this theme):

Starting with one 'major' airport that has grown to the extent where it can no longer be expanded (e.g. the maximum number of extra runway or terminal buildings have been added), the airport and its Terminal Airspace become unable to meet the increasing demand. At this point, a second (usually smaller) airport in the vicinity is expanded with its own Terminal Airspace. As traffic grows, and this second airport and its surrounding airspace reaches its limits, a third airport might be built or expanded. Thus over a period of decades, a 'major' Terminal Airspace and neighbouring smaller ones, evolve – each vying for more space with the traffic complexity increasing at each evolutionary step.

This evolutionary process is depicted in Figure 7- 1, Stages 1 to 5, each showing two fictitious airports and their Terminal Airspace. Terminal Airspace **X** surrounds the 'major' airport, and Terminal Airspace **Y** surrounds what is originally the lesser airport. A commentary on these Stages now follows, For simplicity, these Terminal Airspaces are only referred to as X and Y.

Stage 1: 1 Terminal Airspace (as per Stages in Chapters 5 and 6)

Stage 2: Shows that X has three entry points and four exit points, that the arrival and departure routes are fairly well segregated and that the Terminal Airspace is Sectorised. Y, on the other hand, is evidently less complex: it has one arrival point and one departure point. Of interest are the arrivals from the south for both X and Y. Evidently they share one ATS route prior to being split to enter X and Y respectively.

Stage 3: Both X and Y show signs of growth. As regards X, a parallel runway has been added to, a southern holding area has been introduced and X remains sectorised. For its part, Y has a new arrival route from the west, a new exit point and a new merging point in the south of the Terminal Airspace.

Stage 4: X and Y have both grown again. X has now introduced two-phase holding, an additional set of holds have been added inside the enlarged Terminal Airspace. The southern entry point for Y has now had a holding pattern added to it – to sequence traffic. Notably, Y's airport now has an additional runway – a sign of growth.

Stage 5: This stage is a watershed – and a decision to move to this stage is likely to be outside the scope of the design team. In recognising that the traffic density and traffic complexity has increased to the extent that the 'separate' Terminal Airspaces of X and Y can no longer be managed as 'separate' entities, the two Terminal Airspaces have been integrated into a single Terminal Airspace system and this new 'system' block has been re-sectorised. Effectively, X and Y 's Terminal Airspaces have disappeared, as have their respective sectors which were a function of the airports serviced by each Terminal Airspace. In Stage 5, it has become possible to sectorise the whole Terminal Airspace system in the most efficient manner for the total airspace and to create dedicated Final Approach Director sectors for the airports at X and Y respectively. Furthermore, it has become possible to expand the single Terminal arrival points into three Entry Gates for the whole Terminal Airspace system, two to the north and one to the south. In this manner, arrival flows are contained inside the entry gates to facilitate the segregation of SIDs and STARs.

One of the most difficult routes to accommodate in this Scenario is the arrival route from the north-east to Y. One additional point worth noting is how the ATS route system has been developed to the South, where two parallel routes now service the South entry gate.

Note: In accordance with Principle 5, in Part A, Chapter 2, the boundaries of Terminal Airspace systems should not be constrained by State boundaries.

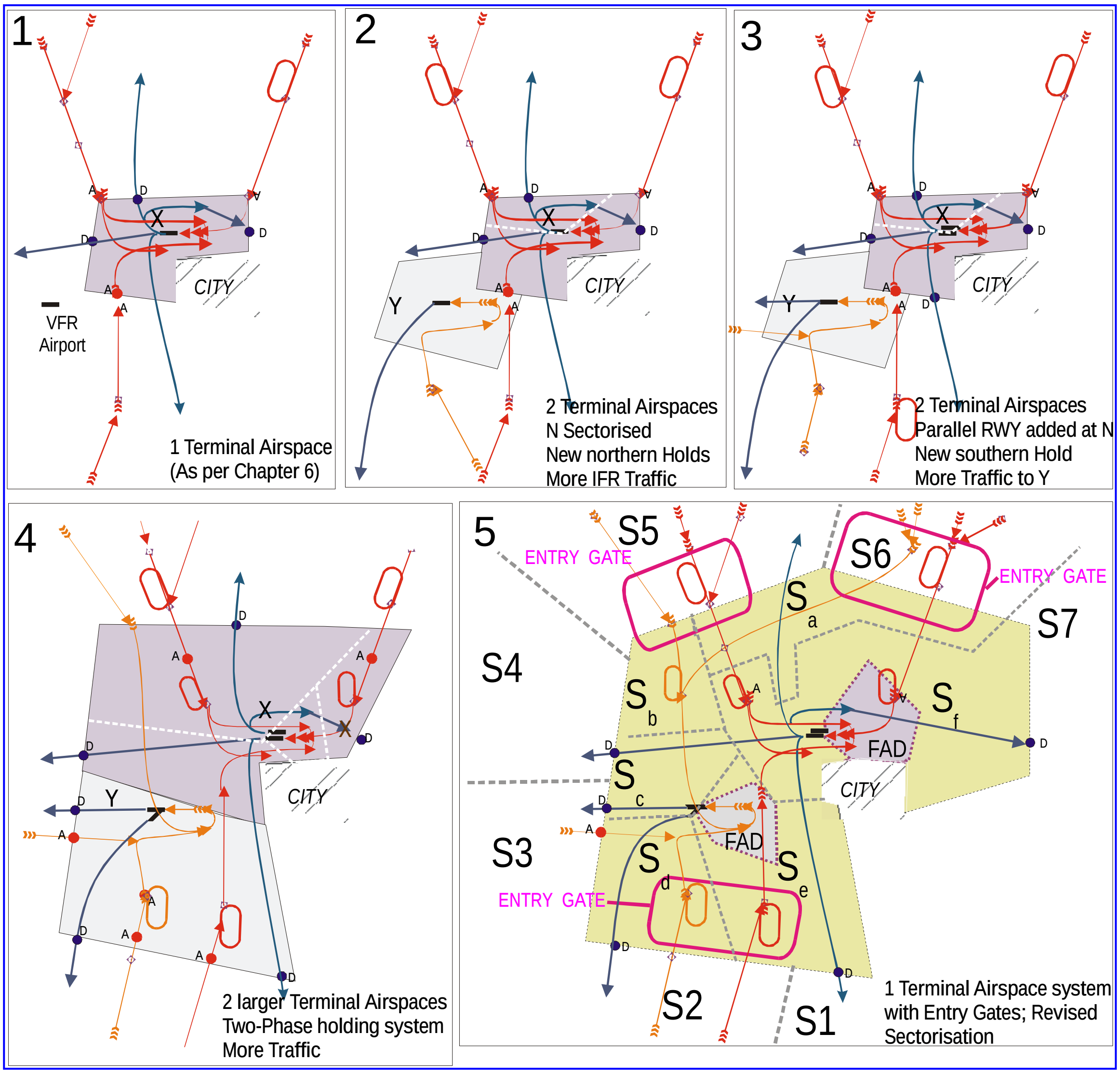


Figure 7- 1: Sample Evolution of Terminal Airspace system

7.2.1 EVOLUTION OF THE APPROACH CONTROL FUNCTION

The evolution of the Terminal Airspace through various stages the vertical dimension also tends to follow a pattern when a Terminal Airspace system is created. This is illustrated in the next diagram which has used Terminal Airspace **X** (above) as an example for Stages 1-4.

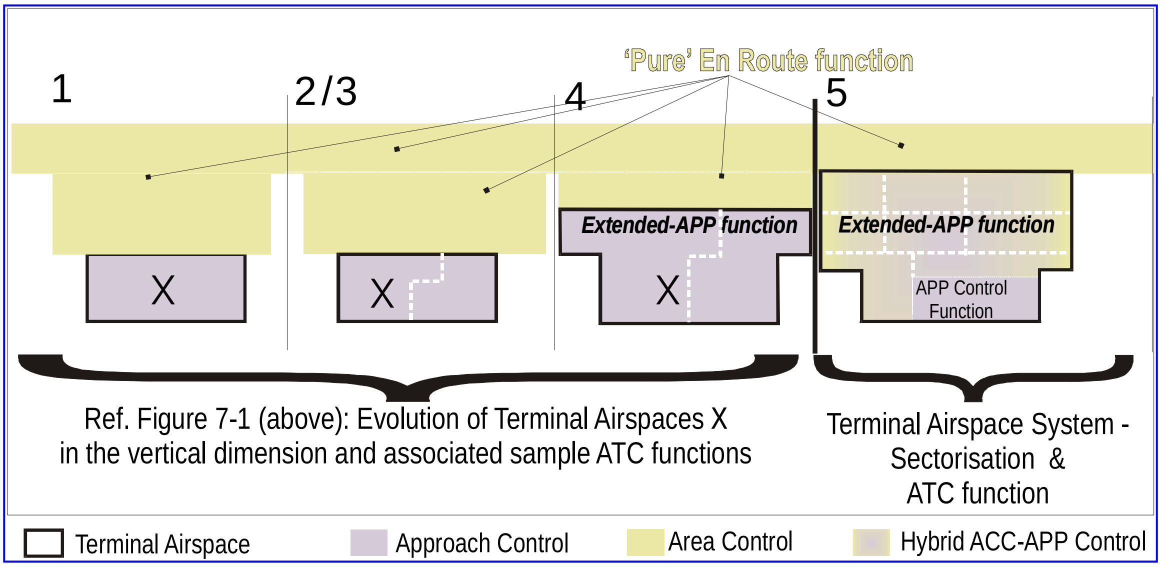


Figure 7- 2: Evolution Terminal Airspace dimensions and ATC 'functions'

Comments on Figure 7-2:

- ATC Sectorisation is frequently the first 'solution' when traffic levels increase significantly in a Terminal Airspace X; this is shown at Stage 2.
- In turn, Stage 3 does not reveal a change in dimensions but as shown in Figure 7-1, the holding system has been increased;
- At Stage 4, the Terminal Airspace has grown in size – both vertically and laterally to accommodate the increased traffic and traffic complexity.
- Significantly, from Stages 1 – 4, the Approach Control function is likely to be carried out by the ATC Unit responsible for X but this is not the case in Stage 5. In this stage, the importance of the Terminal Airspace structure is superseded by the emphasis on ATC sectorisation across the Terminal Airspace system (See Note 2). Here the extended approach function is raised and spread through the greater part of the Terminal Airspace system between an extensive network of sectors and the 'pure' Approach function 'limited' to a small Final Approach Director sector.
- In **Stage 5**, extended-approach functions in a Terminal Airspace system typically involve a hybrid of (Lower) Area Control and (Extended) Approach Function. These can be executed by controllers specially trained for these (hybrid) tasks or ACC or Approach Controllers.

Note 1: In context, 'extended approach function' refers to pre-sequencing, or first phase sequencing prior to sequencing for Final Approach.

Note 2: Whilst ICAO's division of airspace system makes no provision for a change in emphasis from airspace structure to ATC Sectorisation, Terminal Airspace systems in ECAC appear to share this characteristic.

7.3 EVOLUTIONARY CHARACTERISTICS

The evolutionary 'patterns' described in para. 7.2, suggest that (especially large) Terminal Airspaces (Stages 1-4) and Terminal Airspace systems (Stage 5) are likely to share certain characteristics.

7.3.1 GENERAL CHARACTERISTICS

At a general level, shared characteristics (for Stages 1-5) include -

- areas of high population surrounding the airports serviced by the Terminal Airspace (and/or system). This population provides a substantial part of passenger market;
- increasing pressure from environmental groups;
- increasing requirements from diverse airspace users;
- increasing requirements for noise abatement procedures to be implemented which affect departure and arrival flight profiles and an increasing use of Continuous Descent Approaches (CDA) as a method of environmental mitigation;
- significant air traffic density and a complex system of Terminal Routes;
- extensive use of holding areas to sequence traffic;
- increasing airspace requirements and the resultant 'encroachment' of one Terminal Airspace structure on another.;
- complex sectorisation modules;

As regards Stages 4 and 5,

- airspace designers find it difficult to find sufficient space to place holding patterns; as such, one holding pattern (outside the Terminal Airspaces) may be required to serve two airports which limits the regular flow of traffic two the separate airports;
- increasingly, complex sectorisation of the Terminal Airspaces serve to constrain flight profiles which may undo environmental mitigation measures already in place;
- increasing use if made of metering tools to assist pre-sequencing of traffic into the various Terminal Airspaces;

As regards Terminal Airspace systems (**Stage 5**) in particular –

- ATC sectorisation is no longer airport-centred i.e. linked to a particular airport, but rather modular to the entire Terminal Airspace System; and
- The 'importance' attached to the Terminal Airspace *structure* is overtaken by ATC sectorisation of the Terminal Airspace system block.

7.3.2 SPECIFIC CHARACTERISTICS

At a more specific level, certain characteristics – and trends – can be catalogued in the evolutionary process and an overview of these is provided in tabular form below. Specifically, the Table focuses upon, Terminal Routes, the placement of Holding patterns and the Sectorisation type during the Terminal Airspace's evolution. Attention is drawn to the fact that this Table deals with examples of evolutionary trends.

<u>Reading Table 7- 1</u>

In this table, the **Stages 1-4** (top row) match the Stages in Figure 7- 1 & Figure 7- 2. The shaded cells represent Terminal Airspace **X,** (therefore Routes, holds, Sectors in Terminal Airspace **X**), and the white cells refer to the controlled airspace beyond Terminal Airspace X.

Because **Stage 5** represents the Terminal Airspace system, there is no distinction between the (original) Terminal Airspace (X) and airspace beyond it; as such, only one cell (shaded yellow) is shown. Remarks relating to **Stage 5** in Table 7- 1 are stated separately to those related with Stages 1-4.

*Note: In Table 7- 1, under **Terminal Routes,** RV* means that extensive use is likely to be made by ATC of Radar Vectors for both arrivals (ARR) and departures (DEP); ARR RV means that extensive use is likely to be made by ATC of Radar Vectoring for arriving aircraft. RNAV IAP stands for Instrument Approach Procedure based on RNAV, excluding the Final and Missed Approach segment. ATS Routes (beyond X) refers to ATS routes forming part of EUR ARN (and mostly based on B-RNAV in ECAC). In turn, under **Sectorisation;** Geog. indicates geographic sectorisation; Fn indicates functional sectorisation, and G/F indicates a combination of these two methods.*

Stage		1	2	3	4	5
Traffic Density	***X***	Low	Medium	High	Very High	Very High
Traffic Complexity	***X***	Low	Medium	Medium	High	Very High
Terminal Routes	***X***	RV*	RV*	SID/STARs + Rv	SIDs/ARR RV	SIDs/STARS, RNAV IAPs & RV
		ATS Routes	ATS Routes	ATS Routes	STARs/DEP ATS Routes	
'Prevailing' Route System(s)		EUR ARN	EUR ARN	EUR ARN	Terminal	Terminal
Hold Placement	***X***	No	No	No	Yes	Yes
		Yes	Yes	Yes	Yes	
Terminal Airspace Structure	***X***	Lower limit stepped	Lower limit stepped	Lower limit stepped	Lower limit flattens out	Lower limit tends to be flat (see Figure 7-3)
Sectors	***X***	No	Geog.	Geog.	Fn+FAD	Functional and Geographic
		Geog.	Geog.	Geog.	Geog.	

Table 7- 1: Example of Characteristics of an Evolving Terminal Airspace

Commentary on Table 7- 1;

- ***Terminal Routes:*** The less 'busy' Terminal Airspace (Stages 1 or 2), the greater the use made of Radar Vectors inside the Terminal Airspace.
  - Generally, as ATM complexity increases (this is a function of traffic density and other factors such as ATC System, Communication and Navigation Equipment available etc.- see Chapter 4, Attachments C.4-1 and C.4-2) the Terminal Route system tends to become more rigid and therefore **less flexible;**
  - Significantly, STARs associated with **Stage 5** in existing ECAC Terminal Airspace systems tend to commence in the EUR ARN and terminate inside the Terminal Airspace system at a holding stack (see Part C, Chapter 5).
- ***'Prevailing' Route System:*** Generally, the less busy a Terminal Airspace, the more likely the prevalence of the EUR ARN. This means that the Terminal Route connections to the EUR ATS Routes are required to 'fit in' with the requirements of EUR ARN.

- As the Terminal Airspace becomes busier, this prevalence tends to shift from EUR ARN to the Terminal Routes which means that the EUR ATS Routes in the vicinity of the Terminal Airspace (system) are required to fit in with the prevalence of the Terminal Routes. This shift is already in evidence in Stage 4 – and considerable operational difficulties may arise if this swith in prevalence does not occur.

- ***Hold Placement:*** Given the smaller size of the Terminal Airspace in 1 to 3, it is not surprising that most holding (for sequencing purposes) is likely to occur outside the Terminal Airspace. As more airspace becomes available - in 3 and 4 – and more holding is required, holding areas may also be added inside the Terminal Airspace. One of the problems which remains, however, is that there is often insufficient space to create the necessary amount of holds (as mentioned at para. 7.3.1).

  - Given the larger airspace which tends to be provided by the creation of a Terminal Airspace system, the holds tend to be placed inside the Terminal AIrspace system in **Stage 5.**

- ***Sectors:*** The busier an airspace becomes, the more complex the mixture of Geographic and Functional Sectorisation. (see explanations in Chapter 6). This may be explained by the fact that high-density Terminal Airspaces tend to have less prominent Arrival and Departure peaks

  - It is not possible to state which sectorisation type is preferred in **Stage 5.** Usually, the traffic density and airspace complexity is such that sectorisation is decided on the basis of what is safe, efficient and workable from an ATC perspective.

- ***Metering Tools:*** Several types of metering tools are already in use in Europe's major Terminal Airspaces and these tend to facilitate pre-sequencing into the Terminal Airspace to avoid a 'traffic bunching' in an airspace which is naturally constrained in size. Although these metering tools can be tailored to meet the needs of individual airspaces, 4D traffic managers are being developed to improve the sequencing assistance within Terminal Airspace.

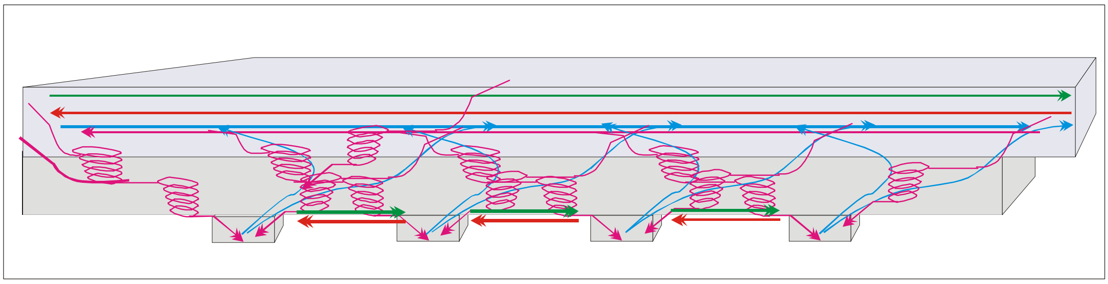


Figure 7- 3: Flattened lower limit of Terminal Airspace 'system' (Example)

7.4 FROM HIGH DENSITY TERMINAL AIRSPACE TO TERMINAL AIRSPACE SYSTEM

Whilst many large Terminal Airspaces co-exist in ECAC, it is seldom that the design and planning of these large Terminal Airspaces are treated as a seamless Terminal Airspace system. This is undoubtedly because the switch from Stage 4 to Stage 5 is not as natural a step as those which evolve from Stages 1-4. Though the operational requirements may signal the need to develop a Terminal Airspace system, these requirements need to be supported by high-level policy decisions given the implications of creating such a system. Examples of such implications may include human resource management, considerable investment in new ATC system architecture, increased requirements for environmental mitigation as public awareness grows of the level of traffic density and complexity.

7.4.1 OPERATIONAL DRIVERS[1]

Given Europe's geography, it is not surprising to find a significant number of large airports and their associated Terminal Airspace in close proximity. But geography in itself is not enough to trigger the need for the development of a Terminal Airspace system. The factors are usually cumulative – the compounding of factors and the accommodation of modern-day realities. These (European) factors include: -

- Co-ordination difficulties between sectors/centres;
- Requirement to mitigate environmental impact;
- Capacity shortfalls;
- Safety 'alert' e.g. frequent airspace violations; aircraft unable to comply with climb profile published in SID;

7.4.2 CORE AREA

Considering the operational drivers above, it is unsurprising that the next 'upward' step in the complexity ladder – beyond the Terminal Airspace System – is that of a cluster of Terminal Airspace systems and /or other high- or medium Terminal Airspaces. This configuration already exists in Europe in what is generally described as the 'Core Area'. Covering the general area of south-east England, the northern half of France, the south-western part of Germany, Switzerland, the Netherlands and Belgium, this Core Area is often colloquially described as a huge Terminal area below (approximately FL285). In the future, it is not impossible to imagine the development of a Core Area System, along the lines of a Terminal Airspace system.

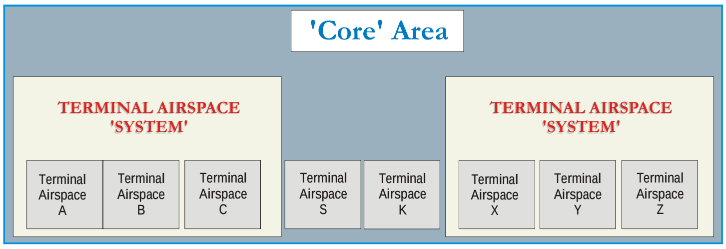


Figure 7- 4: Terminal Airspace 'system' and 'Core' Area

7.4.3 OPERATIONAL REQUIREMENTS

In order to keep *ahead* of the evolution of a Terminal Airspace to a Terminal Airspace system (or beyond), designers should periodically assess their operational requirements and work on their realisation. Given the dependence on aircraft equipage as regards some of these requirements, it may be necessary to define these requirements some 10 to 15 years in advance of the anticipate implementation time-frame. (Readers are referred to Part B, *Planning*, concerning the discussion on *Requirements/Objectives* in C.

7.5 SUMMARY

This chapter has described the evolution of Terminal Airspaces from a simple (single) Terminal Airspace to a complex Terminal Airspace system. It has stressed that whilst he evolution from Stages 1-4 usually occur as a consequence of operational requirements, the move to a Terminal Airspace system requires policy decisions because of the significant implications of this step.

[1] See Also Part B, Chapters 1 & 2

CHAPTER 8

- DESIGN METHODOLOGY: QUICK REFERENCE LISTS -

This Chapter is comprised of one diagram which brings together the elements of the Design Methodology.

It also contains six Attachments; each of which is a quick reference list for various parts of the Design Methodology.

ATTACHMENTS

C.8-0: High Level Project Checklist

C.8-1: Checklist – Writing the Reference Scenario

C.8-2: Checklist – Critical Review of Reference Scenario

C.8-3: Checklist – Performance Criteria

C.8-4: Checklist – Assumptions, Constraints & Enablers

C.8-5: Checklist – Design Concept Routes and Holds

C.8-6: Checklist – Design Concept Structures and Sectors

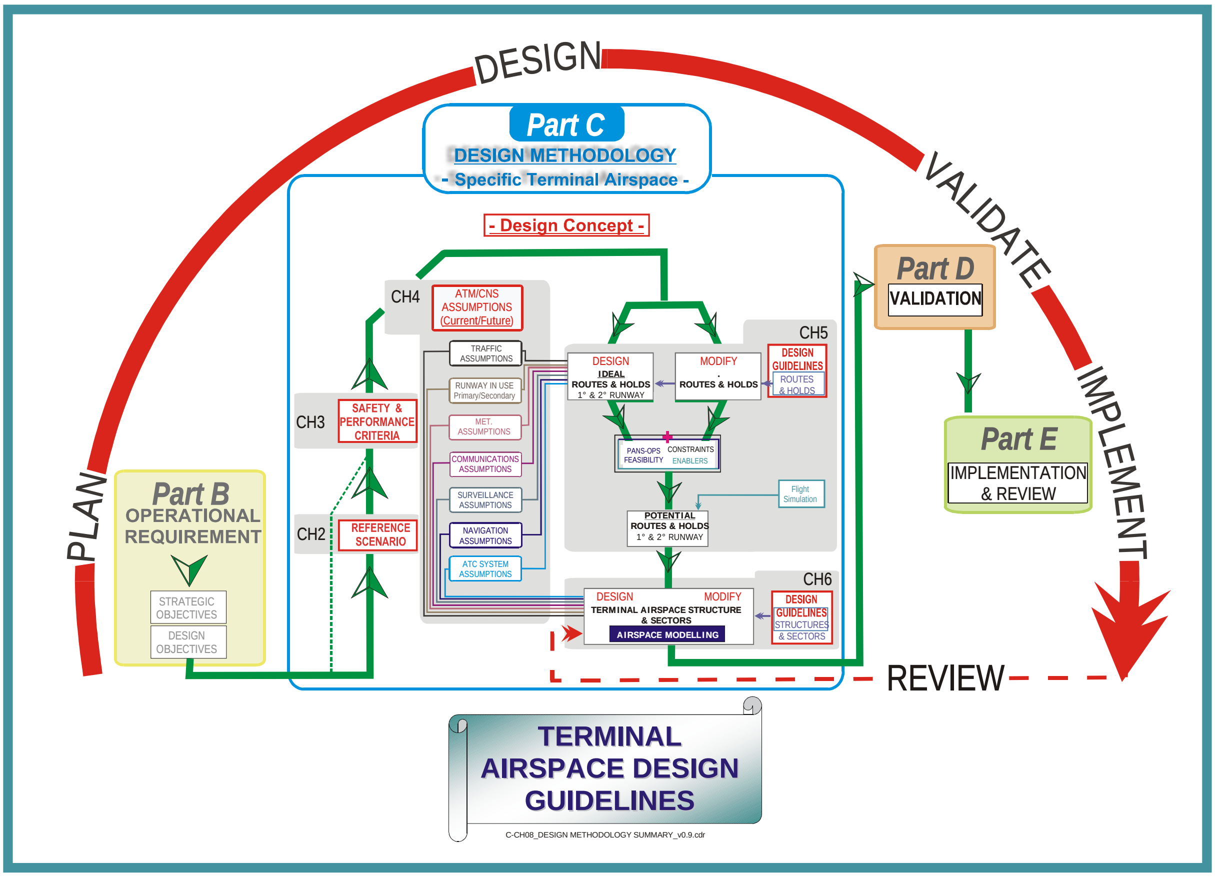


Figure 8- 1: Design Methodology

Attachment C.8-0

Sample High-Level Project Checklist for Terminal Airspace Projects

Note: For completeness, this form has been replicated from Part B because it forms the broad basis for the work schedule undertaken by the Terminal Airspace Design team.

*Note: This form is intended as a high-level quick reference list for Specific Terminal Airspace Projects. Its aim is to ensure that project objectives and scope are appropriately identified and the airspace improvements undertaken in accordance with the appropriate **Airspace Design Guidelines.***

TERMINAL AIRSPACE DESIGN PROJECT (ref. Part B)			
PROJECT NAME:	START: [date]		TARGET ↓IMPLEMENTATION↓ [DATE]
ESTIMATED EFFORT (TOTAL)	END: [DATE]		
BACKGROUND & CONTEXT:			
INTERNAL DESIGN TEAM MEMBERS:	[NAME]	[NAME]	[NAME]
	[NAME]	[NAME]	[NAME]
EXTERNAL TEAM, MEMBERS:	[NAME]	[NAME]	[NAME]
INTERNAL REPORTS TO:	[NAME]	[NAME]	[NAME]

STRATEGIC CONSIDERATIONS
1. OBJECTIVES:

DESIGN CONSIDERATIONS	
1. OBJECTIVES:	2. SCOPE:
3. DEPENDENCIES:	4. RISKS: performance indicators
5. PERFORMANCE INDICATORS: Safety: Capacity: Environmental:	

A. WORKING ARRANGEMENTS	
➢ Members of Terminal Airspace Design Team ➢ Leader of Terminal Airspace Design Team, (if applicable) ➢ Operation Manager, (if applicable) ➢ Project Steering Group, (if applicable) ➢ Additional team members (recruit, latest, after Tasks are identified (see below)	
Number of days required to set up working arrangements	
B. POLICY AND REGULATORY MATERIAL	
➢ Safety Policy ➢ Environmental Policy. ➢ Safety Assessment requirements and guidelines ➢ Environmental guidelines ➢ Approved Airspace Design Methodology ➢ Approved Validation methods (that may be used to validate design) ➢ Relevant International material e.g. ICAO SARPs, PANS etc.	
Number of working days required to identify relevant Policy and Regulatory material	

C. PROJECT DEPENDENDCIES	
➢ Availability of ▪ ATC Training Facilities ▪ Simulation facilities (once validation method selected) ▪ Specialists to undertake specialist/technical studies e.g. Environmental Impact studies. ➢ Tentatively reserve facilities for ATC Training, Simulation; ➢ Prepare draft calls for tender w.r.t anticipated technical/specialist studies ➢ Content and Schedule of other airspace/airport projects ➢ PANS-OPS specialist (availability) ➢ Tentatively reserve services of PANS-OPS Specialist. ➢ AIRAC cycle dates(affects implementation)	
Number of working days required to identify project dependencies and complete (tentative) preparatory work	

D. PROJECT TASKS & RELATED /ACITIVITES

1. Propose design objectives
2. Feasibility Assessment (including Cost Benefit Analysis and Preliminary Safety Assessment)
3. Finalise Design Objectives and Scope
   a) Decide implementation date as a function of Tasks to be completed; <u>or</u>
   b) Tailor Scope/Objective to fit into available time.
4. Firm up Calls for tender w.r.t specialist/technical studies
5. Confirm reservation for ATC training facilities and Simulation
6. Cost Benefit analysis and Preliminary Safety Assessment
7. Statement and Critical Review of Reference Scenario
8. Selection of Performance and Safety Criteria
9. Identification of Assumptions, Constraints and Enablers
10. Development of Terminal Airspace design concept, including
    a) Routes and Holds
    b) Structures and Sectors
    c) Qualitative assessment of concept
    d) Impact assessment of proposed concept (e.g. Environmental impact study)
11. Select Scenario(s) to be Validated
12. Validation of proposed Scenarios and Safety Assessment
    a) Prepare simulation
    b) Run simulation
    c) Data analysis
    d) Write up final report of findings
13. Complete safety assessment documentation as per Safety Policy
14. Finalise outstanding reports
15. Obtain approval for implementation
16. Prepare for implementation
    a) PANS-OPS Specialist to design SIDs/STARs as per PANS-OPS Criteria
    b) AIP and other relevant Publications (NB AIRAC cycle dates)
    c) ATC Training
    d) Amend Letters of Agreement (if required)
    e) Amend local/national ATC Procedures, (if required)
    f) Amend local/national regulations, (if required)

Number of working days required for each identified Task/Activity	

E. TASK ALLOCATION			
Task No:	Responsible Person/s	Due date (Draft Report)	Due Date (Final Report)
1			
2			

ESTIMATED TOTAL NUMBER OF DAYS (A+B+C+D+E)	

Attachment C.8-1

Checklist – Writing the Reference Scenario

WRITING THE REFERENCE SCENARIO (ref. Part C 2.2, 2.3)	
1. Runways	
	Which runways are in use?
2. Traffic Types and Distribution	
	• What is the quantity of the traffic in terms of Arrival, Departure and Transit Traffic in combination with different traffic types? • What are the Traffic Mix in categories (H/M/L) and Navigation Capabilities (Conventional / NAV)?
3. Terminal Airspace	
	• What are the lateral dimensions of the Terminal Airspace? • What are the Airspace Classifications in, <u>and</u> if deemed of interest, outside the Terminal Airspace? • What is the Transition Altitude in the Terminal Airspace? • Are there Airspace Reservations (military/VFR corridors/ recreational flying)? • Are there Airspace Restrictions that have an impact on the Terminal Airspace? • Are there Holding Areas and is there a Minimum Safe Altitude? • Are there Approach procedures published and to what extent are they used? • Are there Departure and Arrival procedures published? • Are there Radar Vectoring Patterns & MRVA defined and/or published?
4. Traffic Management	
	• How is the airspace surrounding the TMA organised? Are there adjacent ACC Sectors, ACC Sectors above and/or adjacent Terminal Airspace(s) and what is their relation with the TMA? • How is the Arrival Traffic managed? • How is the Departure Traffic managed? • How is the Transit Traffic managed? • If applicable, how are Military, VRF and Recreational Traffic managed?
5. Technical Support Infrastructure	

	• What are the System Capabilities and Availability for: Radar Data Processing, Flight Data Processing and HMI? • What are the System Capabilities and Availability for Voice Communication Systems i.e. Radio and Phone? • What are the System Capabilities and Availability for Navigation and Landing Aids?
6. Weather and Terrain	
	• What does the terrain in, <u>and</u> surrounding the TMA Look like? • What are the Weather patterns / thunderstorm activities? • What is the impact of low pressure on FL availability in Terminal airspace (Transition level)?
7. Environmental Constraints	
	• Are there Environmental Constraints in terms of Noise restrictions (time/location/level)?

Outstanding Actions/Issues

Action	Due date	Responsible

Reports

REPORT TYPE	DUE DATE	RESPONSIBLE	CONSULTATION PERIOD
DRAFT REPORT			
REVIEW			
FINAL REPORT			

Attachment C.8-2

Checklist - Critical Review of Reference Scenario

Note 1: The statement of the (Pseudo) Reference Scenario (at A, above) forms the basis of the Critical Review.

Note 2: The first two questions as regards every item of the Reference Scenario could be:

- *Does this {element} work well?*
- *What doesn't work (about this particular {element})?*

*Note 3: **Project design objectives** as well as the **Design Guidelines** for Routes, Holds, structures and Sectors can be used as the benchmark for the Critical Review i.e. to decide whether a particular item is un/satisfactory. To this end, some (additional) sample questions are provided.*

CRITICAL REVIEW OF THE REFERENCE SCENARIO (ref. Part C 2.4)
1. Runways
Which runways are in use?
• *What are the Primary and Secondary Runways in Use in main & adjacent TA?* • *Is the mode of operation of the existing runways likely to change prior to the implementation of the existing project?* • *Are additional runways likely to be in use prior to the implementation of the existing project? If so, in what mode?* • *When was the mode of use for the runways implemented?* • *Have other modes of use been considered – and discounted? If so, why?*
2. Traffic Types and Distribution
What is the quantity of the traffic in terms of Arrival, Departure and Transit Traffic in combination with different traffic types?
• *What is the geographic distribution of the traffic (in %)?* • *What is the time distribution of the traffic (seasonal/daily)?* • *What is the ratio between Arriving and Departing Traffic during peak hours?* • *What is the ratio between IFR/VFR, Military/Civil?* • *Do recreational-type-flying activities take place in the Terminal Airspace?* • *For items (1) to (5) on left, does the future traffic sample deliver the same results as the existing traffic sample used?*
What are the Traffic Mix in categories (H/M/L) and Navigation Capabilities (Conventional / NAV)?
• *Does the future traffic sample deliver the same results as the existing traffic sample used?*
3. Terminal Airspace
What are the lateral dimensions of the Terminal Airspace?
• *Are all IFR Flight paths contained inside controlled airspace?*

	What are the Airspace Classifications in, and if deemed of interest, outside the Terminal Airspace?
	• *Does the airspace classification meet current operational requirements?* • *Is there a high incidence of unauthorised penetrations of the Terminal Airspace? If so, why?*
	What is the Transition Altitude in the Terminal Airspace?
	• *Is the Transition Altitude too low or too high?*
	Are there Airspace Reservations (military/VFR corridors/ recreational flying)?
	• *Are all of these Reserved Airspaces used? If so, Frequently?*
	Are there Airspace Restrictions that have an impact on the Terminal Airspace?
	• *Is each of these Airspace Restrictions still valid?*
	Are there Holding Areas and is there a Minimum Safe Altitude?
	• *What are the minimum holding levels of each hold?* • *What are the maximum holding levels of each hold?* • *Are the holding areas located where they are most needed?* • *What factors have determined these minimum and maximum holding levels? Are these reasons still valid?* • *Would the holding patterns be better placed inside (or outside) the Terminal Airspace?*
	Are there Approach procedures published and to what extent are they used?
	• *To what extent are Approach Procedures used?* • *Why are some Approach Procedures not used?*
	Are there Departure and Arrival procedures published?
	• *Do all SIDs have a common initial published level restriction?* • *Does the initial published level restriction coincide with the transition altitude?* • *Why are some SIDs/STARs not used?* • *Do SIDs/STARs cover all requirements e.g. sufficiently service major traffic flows?* • *Ref. 1, are difficulties created by different initial level restrictions?* • *If the answer to 2 is 'Yes', is there a high incidence of level busts?*
	Are there Radar Vectoring Patterns & MRVA? Defined and/or published?
	• *Is the MRVA chart complex?* • *Can the MRVA be depicted on the Radar Display?* • *Does the MRVA chart need updating?* • *Can it be simplified?*
4. Traffic Management	
	How is the airspace surrounding the TMA organised? Are there adjacent ACC Sectors, ACC Sectors above and/or adjacent Terminal Airspace(s) and what is their relation with the TMA?

	• *Are the crossing points of routes too close to any of the sector boundaries?* • *Does traffic transit unnecessarily through too many sectors?*
	How is the Arrival Traffic managed?
	• *To what extent are existing STARs/Holds used?* • *To what extent are existing CDAs used?* • *Are transfer of control arrangements between adjacent sectors and the Terminal Airspace generally similar? (I.e. does transfer generally occur at a level, or at a point?)* • *Where transfer of control arrangements are affected with an adjacent State, is this covered by an Inter-centre Letter of Agreement?* • *Are there incidences of Level busts?* • *To what extent to Low Visibility procedures impact upon the runway acceptance rate?* • *Why are some STARs or CDAs not used?* • *Can transfer of control arrangements be standardised?*
	How is the Departure Traffic managed?
	• *To what extent are SIDs used?* • *Are there many 'special' SIDs e.g. for use by low performance aircraft or for use in particular circumstances?* • *Are transfer of control arrangements between Terminal Airspace and adjacent sectors generally similar? (I.e. does transfer generally occur at a level, or at a point?)* • *Where transfer of control arrangements are affected with an adjacent State, is this covered by an Inter-centre Letter of Agreement?* • *Are there incidences of Level busts?* • *Why are some SIDs not used?* • *Can transfer of control arrangements be standardised?*
	How is the Transit Traffic managed?
	• *Do transit flights in the TMA operate on published ATS routes?* • *Where transfer of control arrangements are affected with an adjacent State, is this covered by an Inter-centre Letter of Agreement?* • *Why are some published ATS routes in the TMA not used?*
	If applicable, how are Military, VRF and Recreational Traffic managed?
	• *Are parts of the Terminal Airspace 'switched on' (and off) to accommodate the requirements of different users?* • *Are there frequent unauthorised airspace penetrations of the Terminal Airspace? Transfer procedures and LoAs?* • *Does the airspace classification outside the Terminal Airspace affect the incidence of unauthorised airspace penetrations?*
5. Technical Support Infrastructure	
	What are the System Capabilities and Availability for: Radar Data Processing, Flight Data Processing and HMI?

	• *What is the Availability and coverage of the Radar system?* • *What is the Availability of the Flight Data Processing system?* • *What is the Availability of the HMI?* • *Are outages frequent? Is this due to maintenance or technical difficulties?* • *Does the system provide consistent and easy manageable environmental data?* • *Does the system provide timely and accurate flight plan distribution?* • *Does the system provide for tools for sectorisation management?* • *Does the system provide for automatic co-ordination?* • *Does the system provide for Code/ Call-sign correlation?* • *Do maintenance slots affect traffic management?* • *Is there a need to change the maintenance slots?* • *Does the system have a fallback capability?*
	What are the System Capabilities and Availability for Voice Communication Systems i.e. Radio and Phone?
	• *What are the Radio Facilities and what is the coverage?* • *Are downtimes frequent? Is this due to maintenance or technical difficulties?*
	What are the System Capabilities and Availability for Navigation and Landing Aids?
	• *What are the Availability of navigation and landing aids and coverage e.g. VOR/DME/ILS Categories?* • *Are downtimes frequent? Is this due to maintenance or technical difficulties?*
6. Weather and Terrain	
	What does the terrain in <u>and</u> surrounding the TMA Look like?
	• Is the obstacle catalogue up to date?
	What are the Weather patterns / thunderstorm activities?
	• Are the weather trends described?
	What is the impact of low pressure on FL availability in Terminal airspace (Transition level)?
	• *Does low pressure occur more frequently than in the past?* • *Is this a trend?*
7. Environmental Constraints	
	Are there Environmental Constraints in terms of Noise restrictions (time/location/level)?
	• *Are there noise curfews?* • *Are there noise sensitive areas that require conditions for over-flight?* • *Are there limitations on holding areas and lowest available holding level due to environmental requirements such as visual intrusion?* • *Are the noise curfews still valid?*
8. **Specific Questions relating to published regulatory material**	

	• ***ICAO SARPs:*** *Has ICAO been notified of non-compliance with SARPs where required by the Convention?* • ***AIS:*** *Have any inconsistencies/errors been found in AIP/Supplements to AIP e.g. outdated material or wrong co-ordinates. If so, list.* • ***LoAs****:* • *Have any errors been detected in LoAs, if so list these.* • *Do all parties to LoAs have the same version of the LoA? If not, note this.* • ***Local ATC Instructions:*** *Have any inconsistencies/errors been detected in these instructions? If so, list.*

Outstanding Actions/Issues

Action	**Due date**	**Responsible**

Reports

REPORT TYPE	**DUE DATE**	**RESPONSIBLE**	**CONSULTATION PERIOD**
DRAFT REPORT			
REVIEW			
FINAL REPORT			

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Attachment C.8-3

Checklist – Performance Criteria

Checklist: PERFORMANCE CRITERIA (ref. Part , Ch.3)	
ASSESSMENT AND MEASUREMENT (ref. Part C 3.2)	
	• Is the chosen Assessment methodology (qualitative vs. quantitative) the correct methodology for the required measurement? • Do the people that are assigned to the assessment have the suitable background and support tools to do the assessment? • Is the assessment done by people from the project team or by external parties? • Is the assessment done repetitive during the design process?
SAFETY CRITERIA (ref. Part C 3.3)	
	• What has been the motivation to decide on either relative or absolute measurement of safety? • What is the chosen frequency approach on safety assessment (phased vs. once-only) and why was this approach chosen? • What is the chosen support to substantiate the safety assessment; simulations (fast- real-time), analysis and/or expert judgement? • What is the “benchmark” used in the determination of safety criteria?
PERFORMANCE CRITERIA (ref. Part C 3.4, 3.5)	
	• Are the design objectives met? • Depending on the objectives were quality and or quantity measured in order to determine if the objectives are met? • Are there measurement tools used, that would normally be outside the scope of the design project, to measure if the objectives are met (e.g. noise modelling tools)?

Outstanding Actions/Issues

Action	Due date	Responsible

Reports

REPORT TYPE	DUE DATE	RESPONSIBLE	CONSULTATION PERIOD
DRAFT REPORT			
REVIEW			
FINAL REPORT			

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Attachment C.8-4

Checklist – Assumptions, Enablers, Constraints

Checklist ASSUMPTIONS, CONSTRAINTS & ENABLERS (ref. Part C , Ch.4)	
1. What are ASSUMPTIONS, CONSTRAINTS & ENABLERS (ref. Part C 4.2)	
	• Are all the assumptions established after verification with experts on the subject of the assumptions? • Are there assumptions that are based on factors beyond ATM/CNS e.g. weather phenomena? • Is there a sufficient level of confidence in the project team that the assumptions were established cautiously? • Is the traffic sample chosen as the baseline for the design considered as representative? • Are all the enablers that are identified as outside the design scope, adapted by the ANSP and defined as functional requirements? • If the functional requirements derived from design enablers are defined as functional requirements, is action taken to fulfil these requirements (thereby creating the enabler). • Does the planning/project of a functional requirement meet the design project planning (if not, the constraint that is to be mitigated by the requirement/enabler becomes a negative constraint)? • Are all possible ways to mitigate constraints investigated? • Are all the Assumptions Constraints & Enablers derived from the reference scenario?
2. Selecting ASSUMPTIONS, CONSTRAINTS & ENABLERS (ref. Part C 4.3)	
	• Are all the assumptions established after verification of publications in state originated documents such as the Aeronautical Information Publication (AIP)? • Are the Assumptions, Constraints & Enablers linked to a certain date (where appropriate)? • When choosing a representative traffic sample, was the traffic distribution over time taken into consideration? • When choosing a representative traffic sample, was the geographic traffic distribution taken into consideration? • Is the option considered to create two (or more) sets of Terminal Routes to accommodate significant changes in traffic density or distribution? • Is it considered as necessary to sort the geographic traffic distribution by origin and destination so as to identify the raw demand (this is only necessary when doubt exists that the current En-Route ATS route network is not sufficiently refined)? (note: see next bullet) • Has there been a "raw-demand" investigation done by En-Route airspace designers within the greater EUR ARN in the course of a project that is connected to the TMA design project? If so, the previous bullet has become obsolete. • Has there been an assessment of the relative certainty of "triggering event" that may influence Forecast Traffic Samples?
3. When to identify ASSUMPTIONS, CONSTRAINTS & ENABLERS (ref. Part C 4.4)	
	• Where the Assumptions, Constraints & Enablers identified, reviewed and verified at the different stages of the design process as suggested in the guidelines?

Outstanding Actions/Issues

Action	**Due date**	**Responsible**

Reports

REPORT TYPE	**DUE DATE**	**RESPONSIBLE**	**CONSULTATION PERIOD**
DRAFT REPORT			
REVIEW			
FINAL REPORT			

Attachment C.8-5

Checklist – Design Concept Routes and Holds

Checklist ROUTES & HOLDS (ref. Part C, Ch.5)	
1. General	
	• Is there a general consensus on the "geographic" location of a STAR in the flight profile i.e. what is the general approach on where STARS begin and end in relation to the Terminal Airspace? • Are the STARS in the design to be considered Open or Closed?
2. Terminal Routes (ref. Part C 5.4.2)	
	• Are all Arrival and Departure routes as much as possible laterally segregated? • Are all Arrival and Departure routes as much as possible vertically segregated as a function of aircraft performance? • Are all Arrival and Departure routes as much as possible laterally segregated as soon as possible after departure? • Are the missed approach tracks segregated as much as possible from each other and of terminal departure routes? • Are all terminal routes consistently connected with the ATS route network? • Are all terminal routes consistently connected with the ATS route network irrespective of the runway in use? • Are all terminal routes compatible with routes in adjacent terminal airspaces (where applicable)? • Are all terminal routes compatible with routes in adjacent terminal airspaces (where applicable) irrespective of the runway in use? • Is the impact of a change of the runway in use on the operational complexity to the terminal route structure as minimal as possible? • Are the terminal routes merged progressively as they approach the terminal airspace?
3. Holding Areas (ref. Part C 5.4.3)	
	• Are the holding patterns, serving a terminal airspace, located either at an entry point or outside the terminal area? • Are the locations of the holding patterns as such that they create minimum operational complexity for both En-route and terminal airspace and where applicable for adjacent terminal airspaces? • Do the locations of the holding patterns remain constant irrespective of the runway in use? • Are the inbound tracks of the holding patterns closely aligned with the subsequent arrival routes?

Outstanding Actions/Issues

Action	**Due date**	**Responsible**

Reports

REPORT TYPE	DUE DATE	RESPONSIBLE	CONSULTATION PERIOD
DRAFT REPORT			
REVIEW			
FINAL REPORT			

Attachment C.8-6

Checklist – Design Concept: Structures and Sectors

Checklist STRUCTURES AND SECTORS (ref. Part C, Ch.6)	
1. Terminal Airspace Structures (ref. Part C 6.4.2)	
	• Are all terminal routes, holding patterns and their associated protected airspaces contained within controlled airspace? • Does the upper limit of the terminal airspace coincide with the lower limit of the superimposed controlled airspace in order to continuous protection of IFR flight paths? • Is the terminal airspace compatible with the routes and holds that are to be contained within it? • Are both vertical and lateral dimensions of the terminal airspace structure compatible with aircraft flight profiles? • Have obstacle clearances been taken into account while determining if both vertical and lateral dimensions of the terminal airspace structure compatible with aircraft flight profiles? • Is the lateral airspace designated to the terminal airspace restricted to the airspace necessary to contain terminal routes (in order not to constrain the operation of non-participating flights? • Is the lower limit of the airspace designated to the terminal airspace restricted to the necessary airspace to contain terminal routes (in order not to constrain the operation of non-participating flights)? • Is the possibility investigated to fuse adjacent terminal airspaces into one terminal block so as to reduce the operational complexity? • Is flexible use of airspace implemented or envisaged in the design (activation and de-activation of parts of the TMA subject to real-time operational requirements of different airspace users)? • Are buffers incorporated or envisaged in the design with respect to airspace reservations outside the terminal airspace in order to ensure that ATS can provide an adequate margin of safety?
2. Sectors (ref. Part C 6.4.3)	
	• Are the lateral and vertical dimensions of sectors designed as such that stepped level clearances, especially over short distances are avoided to the extent possible? • Are the protected airspaces surrounding holding patterns included in single geographically defined sectors? • Is the design of each sector done in accordance with the design of adjacent, subjacent and superimposed sectors? • Does the design of sectors meet the rationale that crossing points of terminal and/or other routes should not be placed too close to a boundary of a geographically defined sector as so to allow the receiving controller sufficient anticipation time to resolve conflicts? • Is the fact considered that the vertical limits of a geographically defined sector need not be uniform i.e. fixed at one upper level or one lower level, nor need these vertical limits coincide with the vertical limits of (horizontally) adjoining sectors? • Are buffers incorporated or envisaged in the design with respect to airspace reservations outside the terminal airspace in order to ensure that ATS can provide an adequate margin of safety? • Are all potential sector combinations taken into account when determining the sector configuration? • Are the geographically defined pre-defined sequencing sectors designed to encompass the main arrival flows designed with a view to merging arrival traffic progressively as they approach the terminal area? • Is it operationally required that the upper limit of a sector coincides with the lower limit of superimposed sectors in order to provide protection for IFR flights?

Outstanding Actions/Issues

Action	Due date	Responsible

Reports

REPORT TYPE	DUE DATE	RESPONSIBLE	CONSULTATION PERIOD
DRAFT REPORT			
REVIEW			
FINAL REPORT			

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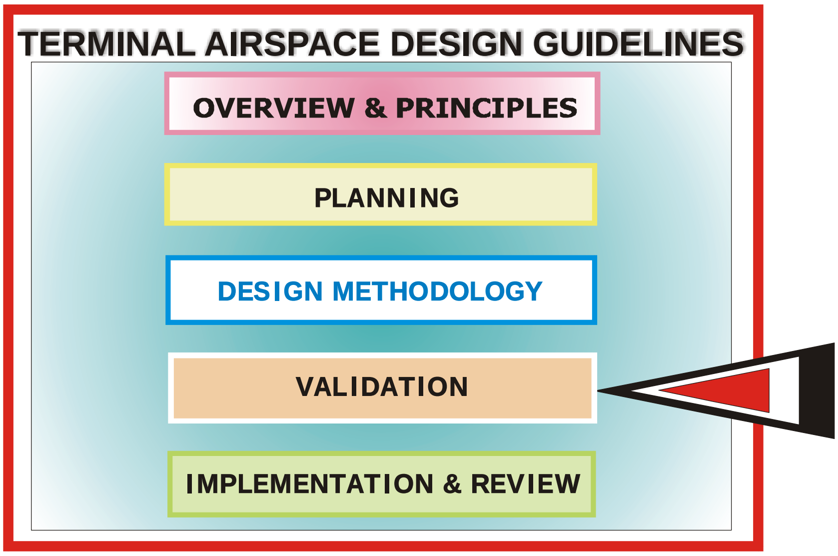
PART D

VALIDATION



CHAPTER 1

– VALIDATION: AN OVERVIEW –

Contents

1.1 INTRODUCTION

This chapter provides an overview of various *Validation* methods in general, and quantitative validation methods (especially simulation) in particular. Qualitative and Quantitative Validation methods include Assessment, Airspace Modelling, Fast- and Real-Time Simulation, Live ATC Trials and Flight Simulation.

In particular, this introductory chapter seeks to emphasise –

- Where Validation 'fits' into the overall Terminal Airspace design project;
- The purpose of Validation; and
- different elements of the processes common to most Validation methods; and
- the fact that different Validation methods are suited to different Validation requirements.

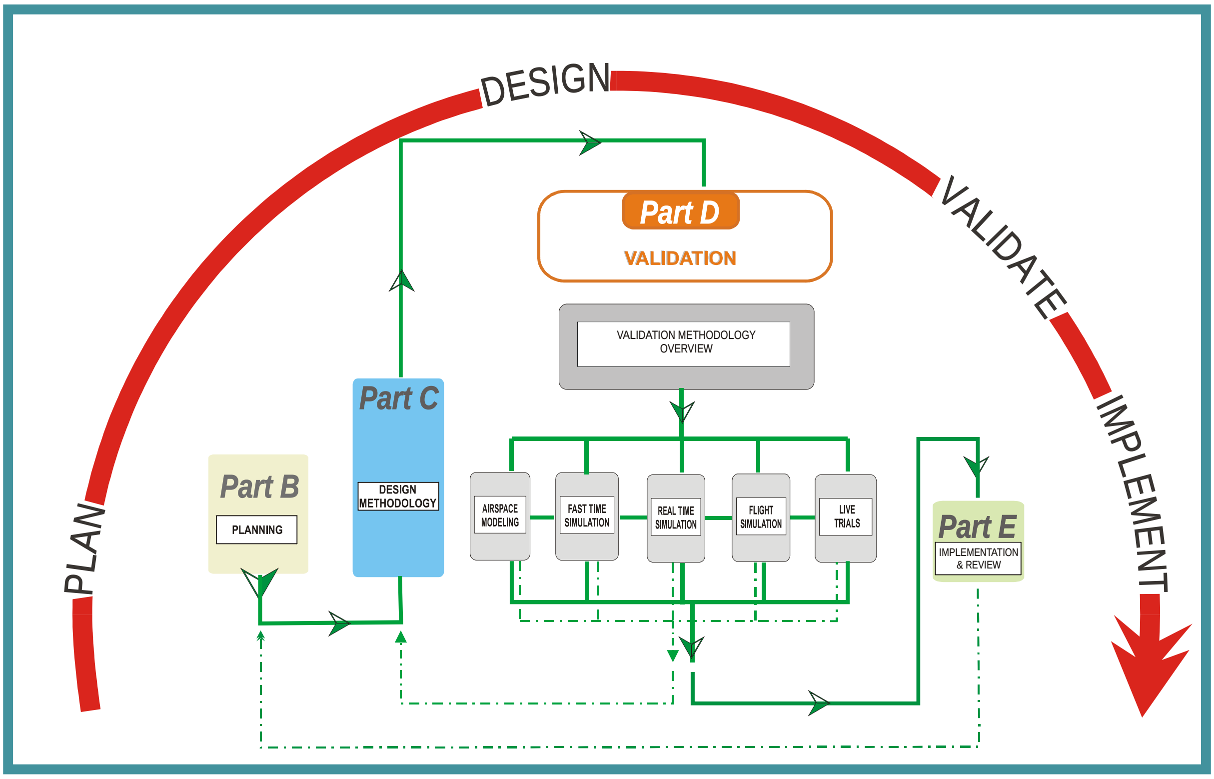


Figure 1 - 1: Roadmap and Validation Methods

Figure 1 - 1, above, shows the place of Validation in the Terminal Airspace design process. Located *after* the completion of the Design Concept and *before* Implementation (and Review), the Validation phase may be viewed as the bridge linking 'theory' and 'practice' (or concept and reality).

1.2 PURPOSE OF VALIDATION PHASE

The main objectives of the validation phase are:

- To prove the operational validity of the Terminal Airspace design concept;
- To assess if the design objectives can be achieved by implementation of the concept;
- To identify potential weak points in the design and to develop mitigation measures;
- To provide evidence and proof that the design is safe i.e. to support the Safety Assessment.

1.2.1 VALIDATION AND SAFETY ASSESSMENTS

Mandatory ICAO and European requirements require states to undertake a safety assessment when making changes to their airspace design. To this end, the member States of ECAC have been required to comply with ESARR/4 since November 2003.

The validation phase of the Terminal Airspace design plays a significant role in the safety assessment process. Most commonly, validation tools are used to provide safety 'evidence' for the safety assessment.

Readers are referred to Part C, Chapter 3 where an overview is provided of the safety case approach to safety assessments.

1.3 VALIDATION TERMINOLOGY

As will become evident, some of the expressions used in Part D differ slightly to those used in previous Parts of the document. These expressions recognise the fact that Validation-specific expressions exist and are used. Even though most of these expressions 'originate' in various validation tools (past and present), their use and meaning have evolved over time and acquired different nuances. Thus there are a variety of expressions in use and most of these are not 'formally' defined.

In recognition of this (Validation) reality, Part D therefore uses a limited set of Validation-specific terms:

Note: *These terms and attributed 'meanings' are* ***not*** *formal definitions, nor does their use suggest that they are the only terms in use. These explanations are provided for reasons of clarity, and additional information is provided at para. 1.3.1.*

- **Base Case** and **Test Case:** Respectively, these terms are the 'validation equivalent' of the Reference Scenario and a Proposed Scenario referred to in the conceptual design phase. The Base Case and Test Case have two components viz. Airspace Organisation and the Traffic Sample.

  Note: The Base and Test Case are created for Validation purposes. They are based upon the Design Concept developed as per the Design Methodology (for example) contained in Part C of this document.

- **Airspace Organisation:** The airspace organisation is made up of five parameters (list below). The first four of these are components of the Base and Test Case - which are based upon the Design Concept following, for example, the guidelines contained specifically in Chapters 5 & 6 of Part C.
  - **Terminal Airspace structure;**
  - **ATC Sectorisation;**
  - **Routes;**
  - **Holds;**
  - **Rules**.

- **Traffic Sample:** The Traffic Sample is made up of three parameters, viz.:
  - **(Air) traffic** which operates in a particular airspace organisation;
  - **Date** e.g. DDMMYY (A Time 'stamp' may also be included;
  - **Rules** of traffic assignment.

  Note 1: See also Part C, Chapter 4 and para. 1.5.4.

  Note 2: A ***Reference Traffic Sample*** *is usually associated with a* ***Base Case****.*

- **Parameters:** An element of either the Airspace Organisation or Traffic Sample.
- **Trajectory/Aircraft Trajectory/Flight Trajectory:** refers to the 4D path of an aircraft through (simulated) airspace.
- **Rules:** Refer to any operational procedure and/or co-ordination agreement that-
  - as regards **Airspace Organisation**, affects the dimensions of the Terminal Airspace structure and/or ATC Sectorisation and/or the definition of or operation along Routes and Holds. Examples of Rules which might affect the operation along Routes and Holds include level/speed restrictions published in SIDs/STARs or inter-sector co-ordination agreements to be replicated on a fast-time simulator.
  - as regards the **Traffic Sample,** affects the way in which the air traffic is assigned to operate, either along pre-defined Routes/Holds or in anticipation of tactical vectoring by ATC.

1.3.1 NAMING BASE AND TEST CASES

In order to trace cause and effect when analysing simulation runs, and as a means of properly recording simulation results, **it is crucial that Base and Test Cases be clearly identified**. More importantly, clear identification is important in order to avoid confusing the vast quantities of numerical data generated by quantitative assessment tools. For this reason, the Terminal Airspace design team (and its Validation counterpart) should agree upon a clear Scenario/Test Case naming convention. As importantly, this naming convention should be systematically used and commonly understood by all participants – see Figure 1 - 2, below, for examples.

It is recommended that such a naming convention should at least provide the following information:

- Coded designator of the **Airspace Organisation** to be used (e.g. Org PR, Org A etc.)
- Coded designator of the **Runway in use and associated Traffic Sample** (e.g. 01-RT means RWY01, Reference Traffic Sample or 01-R24022004, where the numbers after the R are a date-time 'stamp' of the traffic sample.)

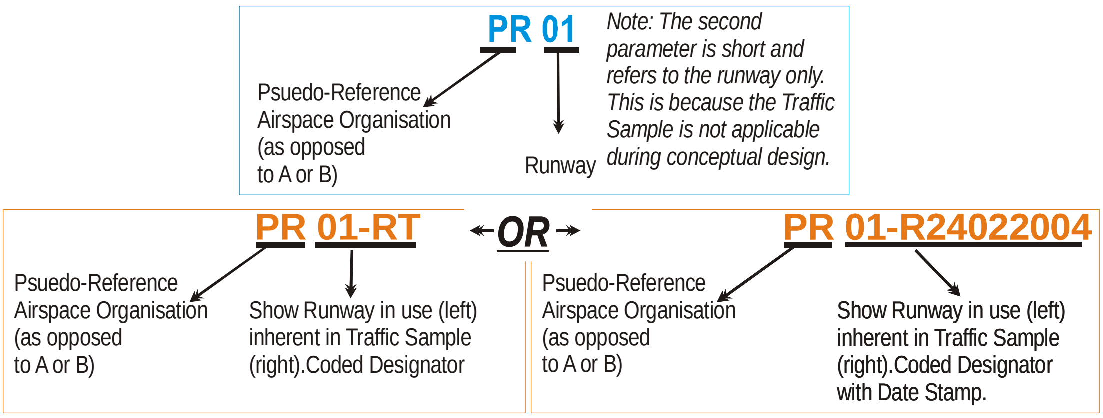


Figure 1 - 2: Sample Coded Identification of Scenarios, Base and Test Cases

The above diagram shows an example of how Scenarios could be named during the conceptual design phase (blue, top) and Validation phase (orange, lower, showing two options). This style of identification is intended to support the contents of Para. 1.5.7, which discusses changing parameters and comparison of Scenarios, Base and Test Cases.

Note: For explanation of 'Pseudo-Reference', see Part C, Chapter 2 – The Reference Scenario.

1.3.2 TERMINOLOGY SUMMARY

Components of a Base or Test Case	
Parameters of Airspace Organisation	**Parameters of Traffic Sample**
❑ Terminal Airspace Structure ❑ ATC Sectorisation ❑ Routes ❑ Holds ❑ Rules (as per para. 1.3)	❑ Air traffic ❑ Time/Date 'stamp' ❑ Rules (as per para. 1.3) .

1.4 DIFFERENCES BETWEEN VALIDATION METHODS

1.4.1 QUALITATIVE AND QUANTITATIVE ASSESSMENT METHODS

In contrast to the conceptual design phase (discussed in Part C) where the design concept is systematically checked and cross-checked primarily by one method i.e. Qualitative Assessment, **Validation is undertaken using both Qualitative and Quantitative Assessment**. **The role of Qualitative Assessment is as important during the validation phase: it is not abandoned in favour of Quantitative Assessment.**

The reason for this statement may be illustrated by a quote from ICAO's ATS Planning Manual, Doc. 9426, Part II, Section 2, Chapter 1, para. 1.1.9. (For '*sound operational judgement*', read '*Qualitative Assessment*'.)

*"In recent years, work on separation minima, between aircraft has, to a growing extent, been based on the mathematical-statistical treatment of data collected on the performance of aircraft. This approach was used to develop models from which valid information regarding the likely safety of proposed measures could be derived. While such work has been extremely useful as a supplementary means of arriving at valid conclusions, it is, however, not a substitute for **sound operational judgement** It therefore appears necessary to approach the issue of mathematical models with caution and to make sure that in each individual case, data collections and their subsequent treatment are likely to yield useful results and do not only confirm the obvious."*

In general terms, Quantitative Assessment refers to validation methods that are numerical. Validation by Quantitative Assessment relies on tools which are primarily – but not exclusively - computer-dependent simulators. Whilst a separate chapter is dedicated to **Qualitative Assessment** (Part D, Chapter 2), it is useful to understand the difference between **Qualitative** and **Quantitative** Assessment/tools. This is shown in the table on the next page.

As will become evident, it is the nature of the design concept or the type of changes to the existing routes, holds, structures and sectors that largely determine the most appropriate validation method or combination of methods to use. Thus where in one case it is appropriate to proceed from Qualitative Assessment to FTS, then RTS prior to implementation, there may be instances where Live ATC trials and flight simulation are the most appropriate validation method together with qualitative assessment.

Although it is sometimes appropriate to exploit all validation methods prior to implementation, the differences between the different methods and the *type* of validation provided means that a step-through of each validation method is may be unnecessary.

	Input	Assessment Bench Mark used	Output	Validation method
Qualitative Assessment	Published & Proposed Terminal Airspace Design (Routes/Holds, Structures and Sectors)	Non-numerical Performance and Safety Criteria based upon ICAO SARPs, Procedures and Guidance material and National/Local regulations and ESARRs.	Mainly textual/ diagrammatic reasoning, argument, justification.	❑ Expert ATM/CNS judgement ❑ Airspace Modelling
Quantitative Assessment	❑ Published and Proposed Terminal Airspace Design (Routes/Holds, Structures and Sectors) usually in computer data format representing Airspace Organisation and Traffic Samples. ❑ surveys - radar data recordings, flight plan recordings, flight recordings, questionnaires ❑ statistics & forecasts - airports operations statistics, meteorological data collections, traffic demand, traffic distribution	Absolute Numerical Performance and Safety criteria based upon Performance and Safety Criteria based upon ICAO SARPs, Procedures and Guidance material and National/Local regulations and ESARRs.	Numerical data (primarily)	❑ Airspace Modelling ❑ FTS/RTS ❑ Live ATC Trials ❑ Flight Simulator ❑ Data Analytical Tools ❑ Statistical Analysis ❑ Collision risk modelling

Table 1 - 1: Qualitative and Quantitative Assessment

1.4.2 SPECIFIC DIFFERENCES

More specifically it is possible to distinguish between the different validation methods on the basis of Cost, Realism, Time and the number of Traffic Samples and Test Cases used. As can be seen in the diagram below, the more complex the simulation method used, the greater the cost, preparation/run time required and the closer to reality the results become. In contrast, and normally for reasons related to cost/time – the number of traffic samples/test cases tend to decrease as the complexity of the simulation method used increases.

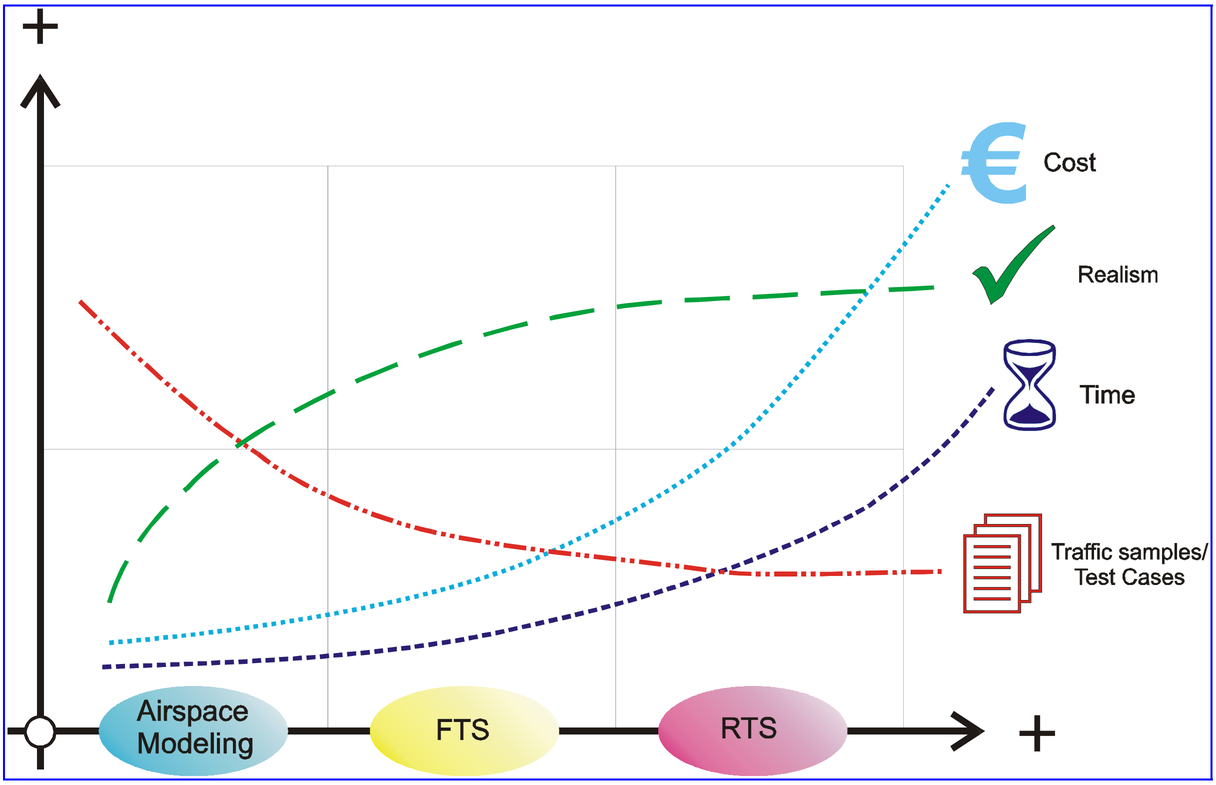


Figure 1 - 3: Specific differences between some Validation methods

Comment: *It is frequently claimed that the results/output from a real-time simulation are more reliable than those from a fast-time simulation on the basis that RTS is closer to reality than FTS. This is not a given: a poorly prepared RTS founded on incorrect assumptions e.g. non-representative traffic sample, is unlikely to return a better result than a properly prepared FTS. Furthermore, recent developments in FTS-technology are such that increasing reliance is being placed upon FTS results.*

1.4.2.1 Time and Resources

The number and extent of validation methods used and their duration is directly linked to the complexity of the Design Concept and the complexity of the Traffic Sample. As more changes are envisaged and the greater their safety and operational impact, the greater the requirement becomes for accurate and detailed investigation to prove their operational benefits and fulfilment of safety criteria.

The diagram below shows that each validation method has its own requirements with regards to time and resource allocation. In general terms, it may be said that the **preparation time and resource demands increase directly with the complexity of the model used**. The representation shown in Figure 1 - 4 reflect the contents of Figure 1 - 1.

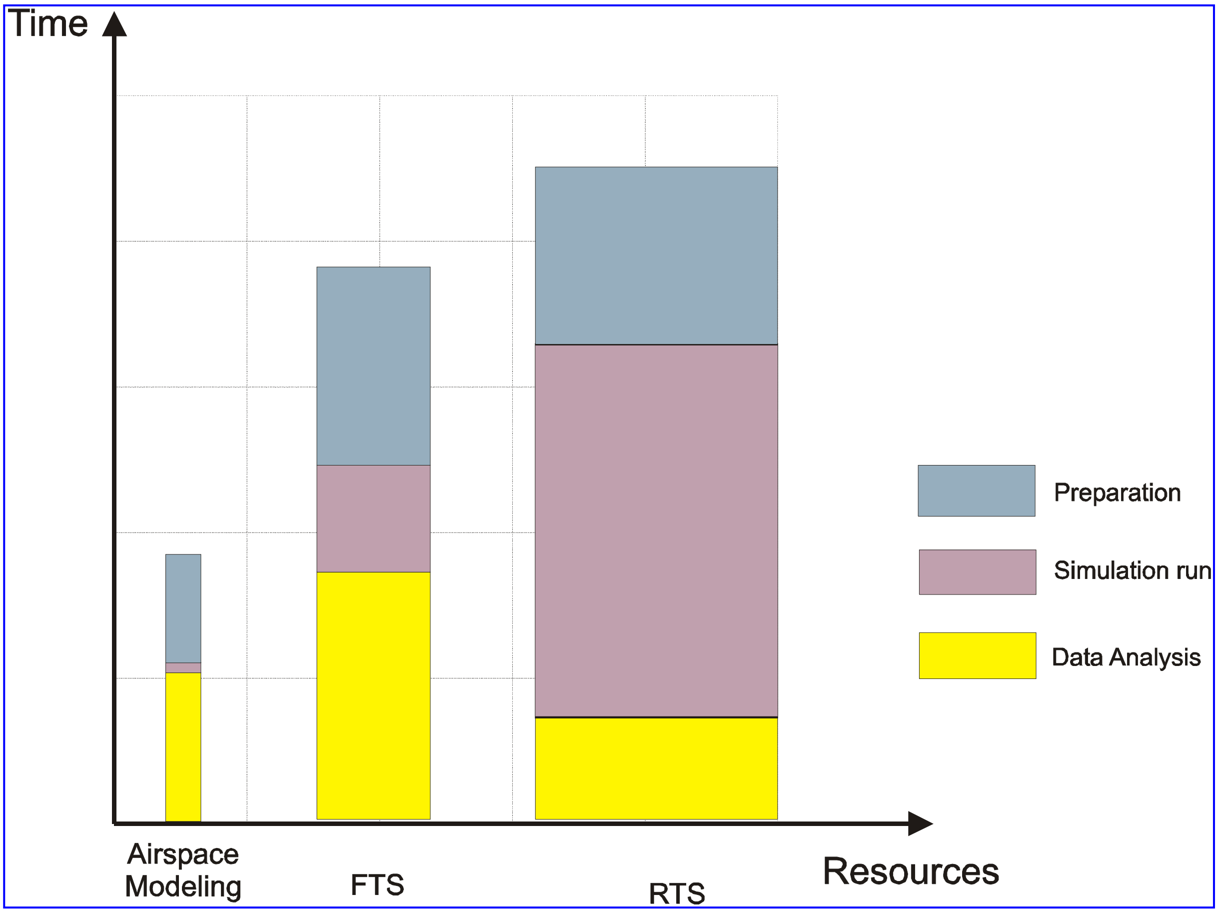


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Figure 1 - 4: Time Requirements

For these reasons, the design team should allocate enough time in the project plan for the appropriate level of assessment (modelling, fast time and real time simulation, live trials – See Part B, Planning). The planning should be made as flexible as possible because the results of one Validation method could heavily impact upon the next Validation step in the sequence or could lead to the suspension of the validation process and a return to the design phase – see Figure 1-5.

Naturally, there is merit in returning to the design phase if the combination of a qualitative and quantitative validation method returns a discouraging result. For a variety of reasons, not the least being cost, it is better to return to the drawing board sooner rather than later. This is shown in Figure 1-6.

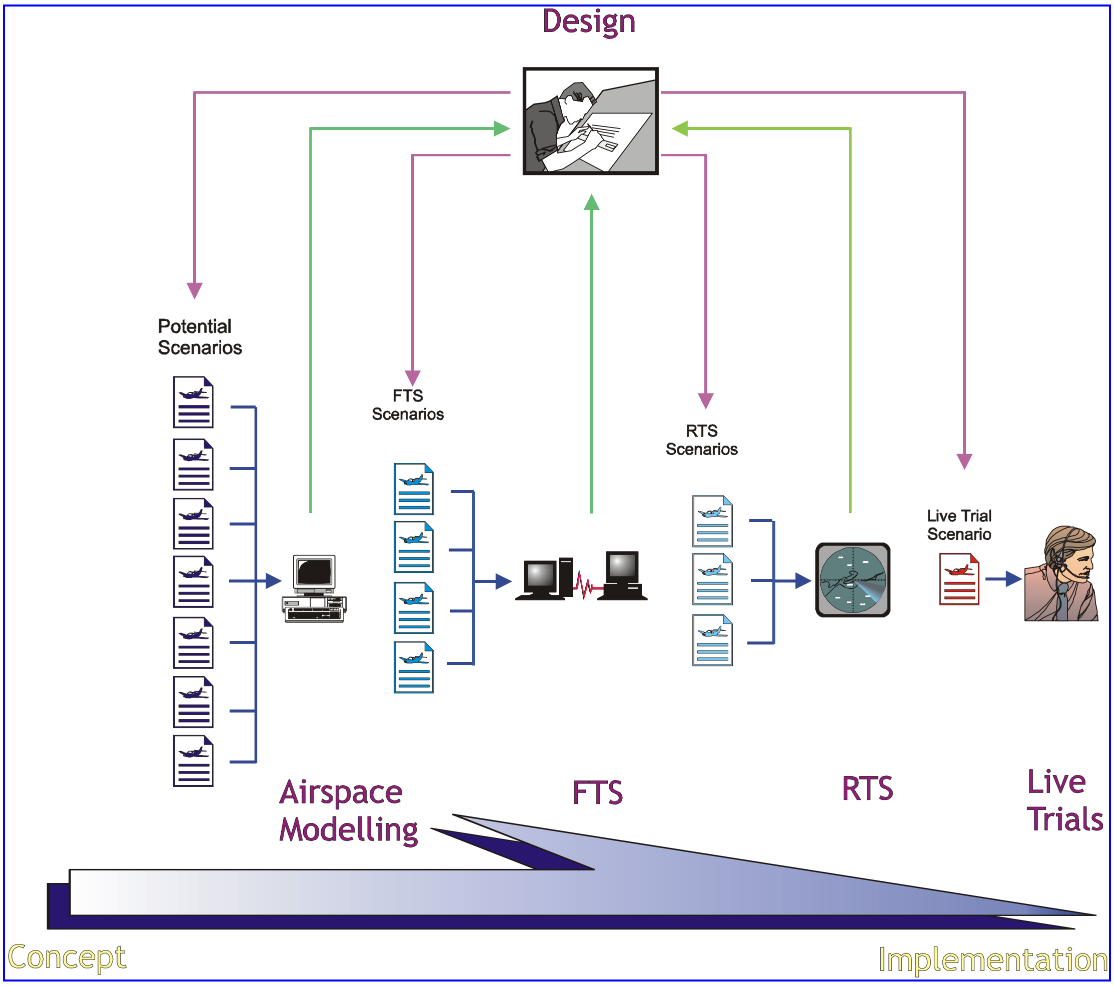


Figure 1 - 5: Knock on effect of validation findings across various methods

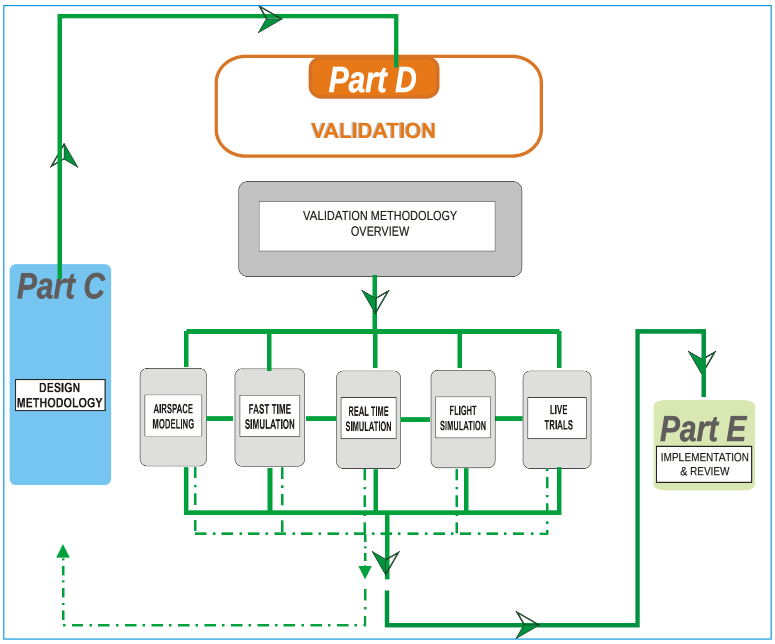


Figure 1 - 6: Return to the design phase – if necessary

1.5 VALIDATION BASICS

As is evident from the preceding paragraph, Validation can be a lengthy and expensive phase of the Terminal Airspace design process and **careful planning and preparation and scheduling of resources is required to optimise the use of the available resources**.

Comment: *Simulations are usually prepared, managed and run by specialists who are experts in a specific type of simulator e.g. fast- or real-time simulator, flight simulator, etc. Nevertheless, it is strongly recommended that the Terminal Airspace design team actively participate in the planning, preparation and running of simulations. Amongst other things, this will help to ensure that the design objectives are maintained, that the* ***Simulation Base and Test Cases correctly reflect the Reference and Conceptual Scenarios on which they are based,*** *and that qualitative assessment is not abandoned during the validation phase.*

In the simulation planning phase the Simulation team leader would, together with the Terminal Airspace design team, be expected to:

- define the generic requirements for the simulations
    - set scope and objectives of simulation
- identify the data flow between the various assessment phases
- establish the milestones and target dates for the validation process
- evaluate the resources required
- ensure the availability of the simulation platforms
- ensure the availability of the qualified personnel (simulation experts, ATC controllers, pseudo pilots, pilots, etc)

1.5.1 SETTING VALIDATION OBJECTIVES

The first step in preparation of the process should be the setting of the objectives by the Terminal Airspace design team together with the Validation Team. More specifically, the simulation objectives should be:

- Based on a specific requirement
- realistic
- achievable
- explicit (oriented to a specific item of the design concept)
- measurable

The objectives of the process will determine which validation method should be used (airspace modelling, FTS, RTS, live trials, flight trials, etc) and the scope of each step. For this reason, the validation objectives can also be influenced by the available simulation platform. After deciding the required succession of modelling and simulations the design/simulation team should develop specific objectives for each step of the assessment/validation process.

1.5.2 SELECTION OF SIMULATION PLATFORM

After the simulation objectives have been set, and the validation process established, the Terminal Airspace design and Simulation teams should select the simulation platforms which will be used for each step of the process. This decision should be based on various factors, the main ones being:

- Suitability for the achievement of the objectives;
- complexity of the objectives;

- required accuracy of results;
- type of required results (statistical data, operational feed-back, etc);
- availability of the simulation platform and support personnel;
- cost of the simulation;
- duration of the simulation process;

1.5.3 CHOOSING DATA COLLECTION METHODS

Each simulation method provides a specific set of the results. The format and type of the output data also varies with each simulation platform. It is very important for the design/simulation team to assess with the simulation experts for each tool to be used in the simulation process, which data can be obtained and how this data is generated and collected by that platform. (See Table 1 - 1, above).

Based on this assessment the design and simulation teams should jointly decide which criteria are to be used for evaluation in order to achieve the simulation objectives and subsequently which data will be collected and analysed during the simulation. (See Part C, Chapter 3).

1.5.4 CHOOSING/CREATING THE TRAFFIC SAMPLE

One of the main distinctions between traffic samples used for validating En Route airspace development as opposed to the Terminal Airspace equivalent concerns the extent to which there is/are predominant Runway(s) or Runway combinations in Use. It is primarily for this reason that the number of traffic samples is determined first by the Runway in Use. If, for example, an Airport has a single Runway 01/19 and each landing/take off direction is used 50% of the time, it will be necessary to have two 'Reference' Traffic samples – one for each landing/take-off direction. If, on the other hand, statistical analysis shows that Runway 01 is used 90% of the time, it could be possible to have one Reference Traffic Sample for Runway 01. Predictably, the number of Reference Traffic Samples increase in a multi-airport Terminal Airspace where each airport may have its own predominant Runway or Runway combinations in use.

For the Base Case(s) it is recommended that a real (Reference) traffic sample be used, (taken from radar data recordings, flight plan system recordings, CFMU database, etc.). A traffic sample should represent real normal operations and traffic distribution on an average day. (See Part C, Chapter 4).

The duration of the traffic sample depends on the objectives and type of the simulation; Usually, a 24 hour traffic sample is used for fast-time simulation and a 1-2 hour traffic sample is used for real-time simulation.

Comment: It is inadvisable to use less than a 1 ½ hour traffic sample for a Real-Time Simulation: Controllers take time to settle into the simulation run and, similarly, it takes time to build up the traffic to required levels.

In order to assess and validate different conceptual design Scenarios, specific traffic samples should be developed, starting from the Reference traffic sample, so as to cover the foreseen changes. These changes in traffic include changes to specific parameters such as:

- Modification to the amount of traffic;
- change of traffic distribution (geographical/time)
- changes to the assignment of air traffic on the Routes/Holds
- changes of aircraft type, aircraft performance characteristics or aircraft operating procedures

Examples of changes made to a traffic sample are tabulated below. Importantly: When a single change is made to a parameter of a Traffic Sample, a separate traffic sample is created (with its own separate identifier – see also para. 1.5.7).

RTS Traffic Sample ID.	Source/Basis	Sample Date	UTC Time Period of Traffic Sample	Special Remarks
01-RT	Radar Data Sectors S_A-S_D	24.9.2004	1700-1900	Traffic Sample is representative of average day (2004) in Terminal Airspace Sectors with 100% traffic (01-RT).
01-1T	Validation Team, Based on 01- RT	24.9.2004	1700-1900	RT + Airspace Organisation A with new Routes/Holds as per 01-1T
01-2T	Radar Data Sectors S_A-S_D	24.9.2004	1700-1900	RT + Airspace Organisation A, with new Routes/Holds as per 01-1T with traffic increase to 120%

Table 1 - 2: Example of Traffic Samples developed from a Reference Traffic Sample

Note: In this case, the differences between the traffic samples are based on different routes (RT & 1T) and, in the case of 2T, traffic increase over 1T.

1.5.5 SETTING UP THE RULES

Each simulation method and each simulation platform has a unique way of describing the way in which the airspace is used, the way in which air traffic management is performed and the interactions between ATC and pilots.

The way in which these Rules are translated in the Test Cases is specific to each simulation platform, but the following items should be taken into consideration in the Test Case development:

- letters of agreement;
- published level/altitude restrictions (level capping, SID/STARs profiles, etc)
- published speed restrictions;
- standing agreements & operational arrangements;
- operational procedures;

For those simulation platforms which make use of automated functions to replicate the actions of air traffic controllers or pilots, the design/simulation team should ensure that the correct values for the parameters are used (such as separation minima, turn rates, speeds, etc) and that those functions perform in a way which correspond to real operations.

1.5.6 TEST CASE DEVELOPMENT

Development of Scenarios is an iterative process during the conceptual design process, and this is equally true of Test Cases during the validation process. As explained in Part C and Chapter 2 of Part D, the initial Design Concept can lead to large number of potential directions for development (depending on the complexity of the changes required to the actual situation), each described by a potential Scenario.

In moving towards more detailed and accurate evaluations and assessments, only the Scenarios / Test Cases meeting the performance criteria will be kept and further developed. Thus, as the refinement of Scenarios / Test Cases increases, the number of Scenarios/Test

Cases reduces – and ultimately, this leads to the solution which is developed for implementation.

The design/simulation team should ensure the consistency of Scenarios/Test Cases throughout the process. Continuity can be assured by use of Test Cases which have been validated by one simulation method as a basis for the development of new Scenario / Test Case for the following assessment phase (using, perhaps, a different simulation method). This continuity also reduces the probability of errors – and divergence from design objectives. Furthermore, duplication of effort is avoided; this ensures that both cost and duration do not become excessive.

1.5.7 COMPARING TEST AND BASE CASES

In order to be able to make robust comparisons between Base and Test Cases and/or between Test Cases, these cases should bear sufficient resemblance to each other. If too many changes are incorporated (e.g. changes are made to several parameters of either the Airspace Organisation or Traffic Sample) it becomes difficult to evaluate the impact of each modification and may even make comparison impossible or, worse, produce misleading conclusions.

Therefore, the basic rule for making comparisons can be expressed as follows

"CHANGE ONE PARAMETER AT A TIME"

In view of the number of parameters attached to each of the two components of a Test Case, it is evident that 10 or more Test Cases could be created i.e. for 10 or more Traffic Samples run through the same Airspace Organisation in order to determine the effect of changing one Traffic Sample parameter. This stresses the importance using a naming convention to identify Base and Test Cases.

Thus, for example, in order to compare different airspace organisations, the same traffic sample should be used on different Airspace Organisations. This is shown in the Table below using as a starting point the Pseudo Reference Scenario coded **PR 01-RT**.

Base/Test Case Ident.	Airspace Organisation	Traffic Samples (Coded Identification)			What is being compared?
PR 01-RT	PR (Pseudo-Reference)	01-RT (100% traffic)	01-1T (120% traffic)	01-2T (150% traffic)	Assess Org PR against traffic increase
A 01-RT	A	01-RT (100% traffic)	01-1T (120% traffic)	01-2T (150% traffic)	Assess Org A against traffic increase
B 01-RT	B	01-RT (100% traffic)	01-1T (120% traffic)	01-2T (150% traffic)	Assess Org B against traffic increase
		Compare Org PR with A and B, and compare Org B with C	Compare Org PR with A and B, and compare Org B with C	Compare Org PR with A and B, and compare Org B with C	What is being compared?

Table 1 - 3: Detailed view of Sample Scenario Comparison

In the Table above, note that the difference between traffic samples is based (across) on a traffic increase (a single parameter, the *amount of traffic* in the Traffic Sample, has changed). In contrast, the downward comparison refers to a changing Airspace Organisation using the same Traffic Sample.

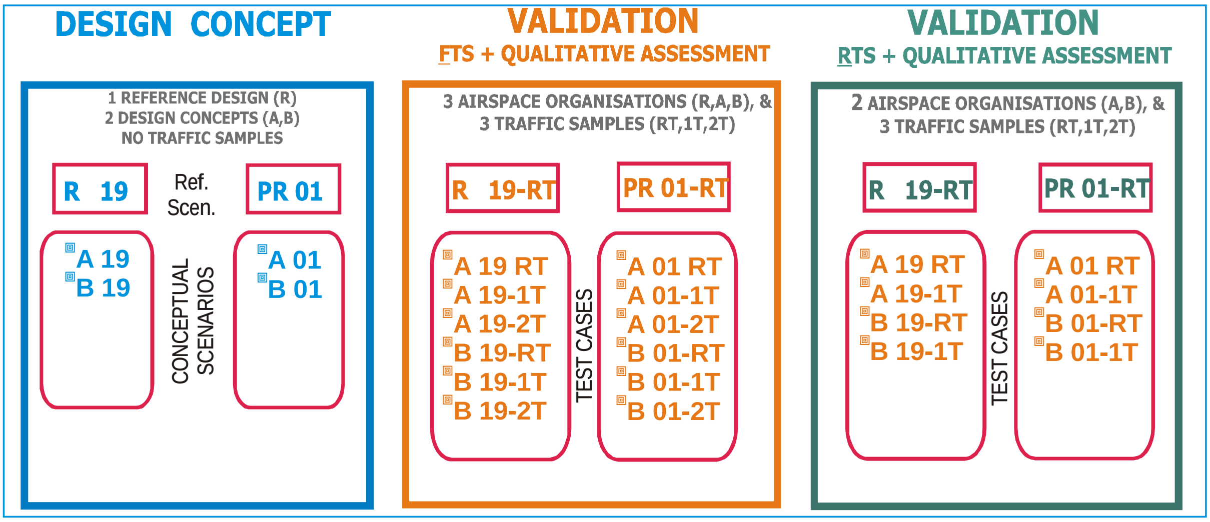


Figure 1 - 7: High Level overview of Scenario & Test Case Comparison

In the above Figure, for each Validation method, every Scenario/Test Case shown in the red rounded-edged box is compared with the Reference/Base Case in the red square box above it.

At the end of the simulation, comparisons and evaluations can be made using absolute values derived from the data collected as workload, capacity figures, etc.

1.5.8 ANALYSING RESULTS

Results obtained from both qualitative and quantitative assessments need to be analysed. In most cases, data obtained from quantitative assessment-type Validation methods need expert analysis e.g. Statisticians. Nevertheless, **it is imperative that numerical data and analysis thereof is also subjected to qualitative assessment** so that the overall impact of the results may be understood.

1.6 SUMMARY

This chapter has introduced Validation in the context of Terminal Airspace design and has explained its purpose and basic principles. In particular, this chapter has stressed the importance of preparation and planning, qualitative analysis and the proper naming and analysis of Scenarios and Test Cases.

Most importantly, this chapter has stressed that when comparing Base and Test Cases, it is imperative that only one parameter be changed at a time so that the effect of the change can be measured.

CHAPTER 2

- QUALITATIVE ASSESSMENT -

Contents

2.1 INTRODUCTION

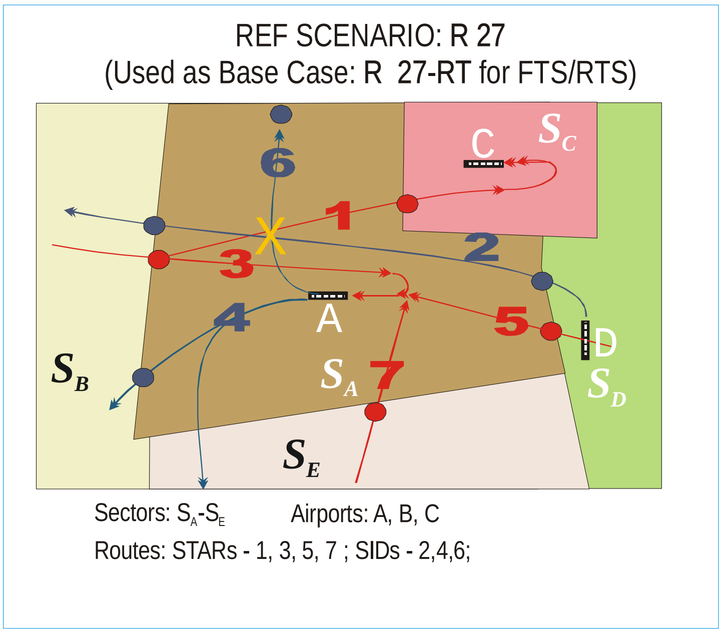
Unlike the topics discussed in other chapters in Part D, (e.g. fast- and real-time simulation), Qualitative Assessment is not a stand-alone method of validation. Indeed, ‘assessment’ is not exclusive to the validation phase which is why qualitative and quantitative assessment were introduced under the Design Methodology. Assessment - particularly Qualitative Assessment – is a ‘constant’ through the entire life-cycle of the Terminal Airspace design project i.e. during project planning, the conceptual design phase, validation and implementation/review phase .

For this reason, Qualitative Assessment is not discussed in an exclusive (validation) context in this chapter. Nor is quantitative assessment separated from it. This is because, in the Validation phase, qualitative and quantitative assessment cannot be separated as they can be during the conceptual design phase. (During the conceptual design phase, it is possible and indeed advisable, in some cases, to undertake a Qualitative Assessment prior to embarking upon a quantitative assessment. (See Part C, Chapter 3 and Part D, Chapter 1, para. 1.4.1).

2.2 PRINCIPLES

In order to demonstrate the synergy between Qualitative and Quantitative Assessment, an example is provided using fictitious airspace. This example covers the life-cycle of a small project and illustrates the indivisible relationship between Qualitative and Quantitative Assessment. Because the examples are fictitious, readers should not be surprised should they identify alternative solutions to those proposed.

2.2.1 SAMPLE QUALITATIVE ASSESSMENT



The figure (left) shows a Sample Reference Scenario of a fictitious Terminal Airspace. At the centre is Sector S_A with routes numbered 1-7. S_A is surrounded by four sectors: S_B, S_C and S_D. Airport A lies in S_A, Airport C in S_C and D in S_D.

The Operational Manager has asked the Terminal Airspace design team to investigate complaints of S_A controllers concerning excessive workload in S_A during peak hours, especially in the vicinity of the crossing point X (marked in orange, at left).

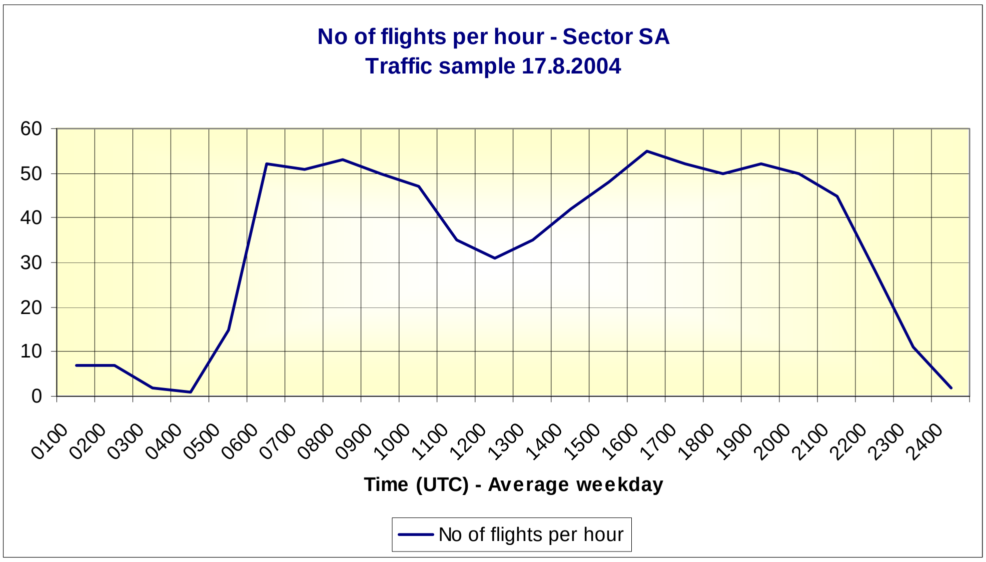
Figure 2 - 1: Sample Reference Scenario/Base Case

Preliminary Qualitative Assessment

As per the process described in Part C, the Terminal Airspace design team first describes the Reference Scenario (i.e. sector S_A as it is today) and then critically reviews this sector. To help them, the Terminal Airspace design team invites comments from air traffic controllers who normally manage Sector S_A. During the critical review, it is confirmed that the crossing point X is perceived as the main problem area and the cause of unacceptably high workload during peak periods. (These 'discussions' are, in themselves, qualitative').

Quantitative and Qualitative Assessment.

To further assess the problem, the Terminal Airspace design team uses a spreadsheet (or airspace modeller) to analyse traffic in S_A. What is established is that S_A handles 52 flights in a typical peak hour (see ***Graph 2 - 1***), and that that 30 of these flights cross at X as – see Table below. (Note: 30/52 is quantitative).



Graph 2 - 1: Sample Traffic Distribution (Time)

No. of flights	Route	No. of flights	Route
10	**Route 1 [RNAV/STAR to A]**	**12**	**Route 2 [RNAV/SID from D]**
10	Route 3 [RNAV/STAR to C]	5	Route 4 [RNAV/SID from A]
4	Route 5 [RNAV/STAR to A]	**8**	**Route 6 [RNAV/SID from A]**
3	Route 7 [RNAV/STAR to A]		

Table 2 - 1: Sample Traffic Distribution (Geographic)

The above information does little more than confirm the accuracy of the controllers' assessment and reinforce the concerns of the Operational Manager (which is essential to ensure that all parties understand "the problem").

Continuation of Qualitative and Quantitative Assessment

To better analyse the situation in Sector S_A, the Terminal Airspace design team continues its assessment (both qualitative and quantitative), using primarily, information obtained during the critical review.

(a) Use an airspace modeller to study the actual profile of flights operating on Routes 1, 2 and 6. (See Part D, Chapter 3).

(b) Use a flight simulator of the most representative aircraft type to determine the unconstrained profiles for flights operating on Routes 1, 2 and 6 (see Part D, Chapter 6).

(c) Study transfer of control and communications agreements between sector S_A and adjacent sectors are studied;

(d) Check the traffic sample to establish the point of origin for most flights that use Routes 1 and 3;

(e) Investigate whether the early left turn on RNAV/SID Route 2 is efficient or whether it causes difficulties between sectors S_A and $S_{D.}$

(f) Assess whether the merging of routes on final approach RWY 27 at A is generating a high workload is assessed;

Sample findings

The data produced by the investigation of items **(a)** and **(b)** reveals that actual flight profiles are very close to unconstrained flight profiles. For example, traffic on –

- Route 1, crosses X at FL60 or below;
- Route 2, crosses X at above FL50;
- Route 6, crosses X between FL40 and 50

What this finding shows is that the problem at crossing point X has not been 'created' by imposed flight level restrictions e.g. prescribed by ATC. Thus, as the problem is not in the vertical plane, this may indicate that the solution lies in relocating some of these routes.

Whilst information from **(c)** reveals no special difficulties (apart from transfer arrangements concerning RNAV/SID 2, information obtained from enquiry **(d)** reveals that traffic using Route 1 has a point of origin that is due west of airport C. This suggests that Routes 1 and 3 are unnecessarily merged to meet at the arrival point of sector S_A – and then split for destinations C and A. (A VOR is located at this merge point which suggests that this merge point is more a historical legacy than a requirement).

As regards **(e),** it would seem that the controllers of sector S_D believe that the amount of time available to effect a proper transfer of control and communication from sector S_D to sector S_A is inappropriate, given the current positioning of the sector boundary.

In turn, investigations concerning **(f)** suggest that the traffic merging on final approach is manageable because aircraft on RNAV/STAR 3 are often extended on down-wind by ATC (which explains the extra space in the eastern part of sector S_A.

Proposed way forward

Based on the above information, the Terminal Airspace design team decides that they have several alternatives. After considerable debate (i.e. a qualitative review of the options), they are left with two viable options:

[i] re-design RNAV/SID 2 so that aircraft will be 'forced' to cross X at a higher level than is currently the case; or

[ii] re-design RNAV/SID 2 so that it does not proceed over X; (this will require a new entry point to be created for S_A) **and** a new route for RNAV/STARs 1 & 3 (which also avoids unnecessary merging at the western entry point).

Because (ii) is considered the better option by the Terminal Airspace design team, this Scenario is selected for further development as a Test Case – see diagram below.

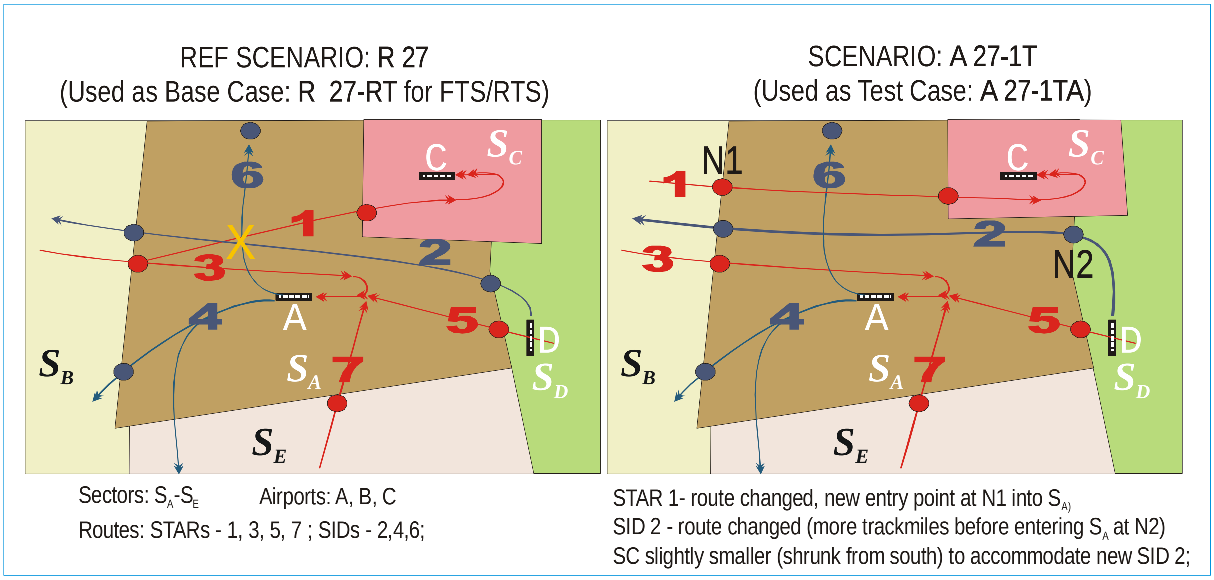


Figure 2 - 2: Potential Solution Scenario T.1

Development of Scenario A-27 / Test Case A 27-1TA reveals the following:

- Even though the traffic at crossing point X has lessened, a new crossing point has been created between RNAV/SID 6 and RNAV/STAR 1, north of X; whether or not this crossing is viable or efficient (as per Part C, Chapter 5), remains to be explored.
- Because of the new placement of RNAV/SID 2, the problem between Routes 1 and 2 has been resolved.

As a next step, it is necessary to examine the new crossing point between RNAV/SID 6 and RNAV/STAR 1. What can be expected is that it is unlikely that aircraft operating on these routes will cross each other at the same levels they did when they crossed at X. Again, the Terminal Airspace design team makes use of a flight simulator to examine the unconstrained profiles on RNAV/SID 6 and RNAV/STAR 1. What the flight simulator analysis reveals is that most traffic on RNAV/SID 6 will be above FL90 at the new crossing point, and that on an unconstrained profile, most aircraft on RNAV/STAR 1 would be at FL60 or below.

Given this promising result, the Terminal Airspace design team decides to test by real-time simulation (RTS) as Test Case A 27-1T – See Part D, Chapter 5. For the most part, the RTS confirms their findings. However, when the RTS results are closely scrutinised, the team realises that the solution presented by Test Case A 27-1T will only be viable as long as traffic increases do not exceed 20% in sector S_A.

In view of this, the Terminal Airspace design team asks for a statistical analysis to be undertaken using a forecast traffic sample (See Part B, Chapter 4) and this reveals that it will take seven years for traffic to increase by 20%.

Sample conclusion

Given the above, the Terminal Airspace design team decides to plan for implementation of the new proposals included in Test Case A 27-1T as validated using RTS and Qualitative Assessment. One year later, the Terminal Airspace design team re-opens the dossier in order to prepare the groundwork for a time when the new capacity once again does not meet demand.

Comment: *Note the importance of the critical review of the Reference Scenario. This is an essential step for two reasons: (i) it ensures that the appropriate/correct problem is identified so that the link between cause/effect is properly made; and (ii) it permits the problem to be thoroughly analysed before deciding upon a solution. Importantly, therefore, no assumptions should be made as to what the problem is, or the extent of the problem. Note also, that 'solutions' to problems require account to be taken of future developments. To this end, future traffic samples were used in the fictitious Scenario T.1 so as to determine the point at which/beyond which the solution presented would no longer meet future demand. Recognition of a need for future developments is an essential element of the assessment/validation process.*

2.3 ADVANTAGES & LIMITATIONS

As stated several times, qualitative and quantitative assessment complement each other in the validation phase. They cannot be separated.

If undertaken properly, Qualitative Assessment can prevent time and money being wasted on the preparation and running of (expensive) fast- and/or real-time simulation. Qualitative Assessment is an inexpensive way of critically determining whether a particular Terminal Airspace design solution is viable. It also provides the most freedom – especially because the relative costs of changing one's mind are negligible when compared to changing a simulation specification – or worse still, a simulation already in progress.

Inasmuch as it is inadvisable to undertake a quantitative assessment without a corresponding Qualitative Assessment, it is generally inadvisable to proceed to implementation on the basis of a Qualitative Assessment alone. This is because of the disadvantages associated (particularly with stand-alone) Qualitative Assessment i.e.

- Tendency for assessment to be subjective as opposed to objective;
- Because it's usually takes the form of debate/discussion, it is possible that
  - particularly in an hierarchical Terminal Airspace design team, the Qualitative Assessment could reflect the most 'authoritarian view' (which may not necessarily be the 'best'); or
  - that the scope of solutions suggested by members of the Terminal Airspace design team could be limited to 'pre-determined' solutions (which may be

inefficient in that they resolve the perceived as opposed to the real problem).

- Because the value of 'qualitative' assessment is often doubted (for lack of numerical 'proof'), its 'findings' may be dismissed or ignored. (Note, however, that this effect can be mitigated by providing clear rationales substantiated with simulations.)
- Business Plans normally require justifiable, accountable figures on cost benefit analysis.

2.4 SUMMARY

This chapter has sought to explain the difference between quantitative and Qualitative Assessment, particularly in the validation phase. It has stressed that these two forms of assessment complement each other.

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CHAPTER 3

- AIRSPACE MODELLING –

Contents

3.1 PURPOSE OF AIRSPACE MODELLING

This chapter discusses Airspace Modelling as a Validation method. As with all other validation methods, it is seldom used in isolation to validate a Terminal Airspace design, but tends to be one of several validation methods used to validate a design.

The extensive development of simulation tools has meant that it is quite unusual to find a 'stand-alone' airspace modeller i.e. one whose functionalities are 'limited' to those described below. Most often, airspace modeller functionality is likely to be included amongst those of a fast-time simulator. This means that calculation of basic sector loads and the visualisation of these are part of the FTS package. Nevertheless, it is useful to provide a general overview of Airspace Modellers, and for designers to be aware that the material in this chapter should be considered complementary to that contained in the chapter discussing Fast-Time Simulation (see Chapter 4).

3.2 PRINCIPLES

Airspace modelling tools can be considered as "scaled down" version of Fast Time Simulators. Their main usage is to create a crude representation of the routes and airspace structures (sectors) together and their interaction with a selected traffic sample. The tool generate simplified 4D trajectories (position + time) for the aircraft according with the flights plans described in the Traffic Sample (with its Rules) in a particular Airspace Organisation (with its Rules). This process is called traffic assignment. These trajectories are used together with the airspace blocks to calculate a series of statistical data as: sector loading, route segment loading, conflicts, etc. Some more advanced airspace modelling tools can derive more refined data with regard to the workload and sector capacity.

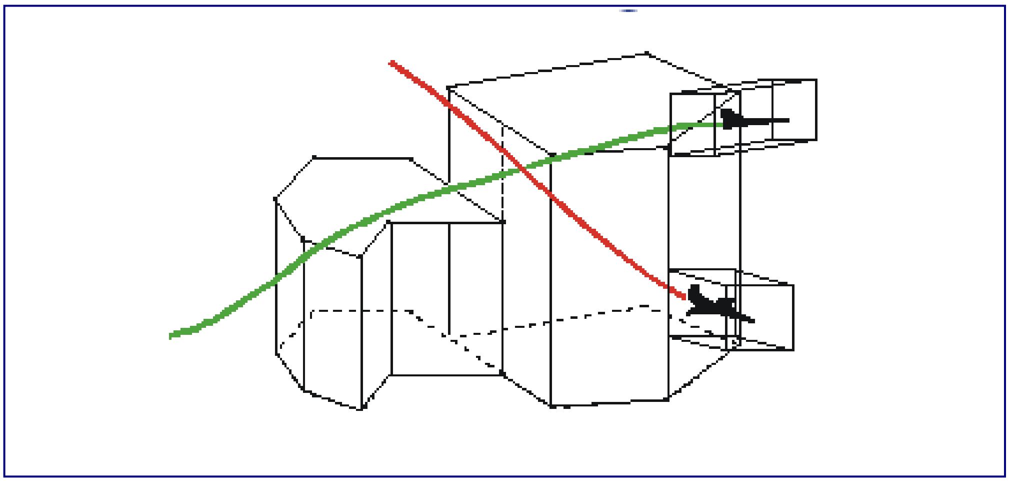


Figure 3 - 1: Simplified Airspace Organisation on an Airspace Modeller

Usually the airspace modelling tool consists of a series of software modules which are used according to the designer need:

- graphical tools - used to define the Airspace Organisation for visualisation in 2D or 3D;
- trajectory manipulation tools -used to process the traffic sample (route assignment, time distribution, 4D trajectory generation, etc);
- data analysing & processing tools (traffic distribution queries, sector loading, conflicts evaluation, etc);

3.3 ADVANTAGES & LIMITATIONS

3.3.1 AIRSPACE MODELLING ADVANTAGES

- unlimited scope and great flexibility
- simple to assess various alternatives
- easy Scenario adaptation and generation of Test Cases
- easy to create and assess "what if" Test Cases
- easy to test large number of traffic samples
- can use data derived from real traffic and ATC environment

3.3.2 AIRSPACE MODELLING DISADVANTAGES

- crude representation of real environment
- can provide only high level statistical data
- cannot replicate tactical controller interventions
- basic aircraft performance
- simplified trajectories
- no representation of meteorological conditions
- results accuracy depends heavily on the assessor ability and experience
- high degree of subjectivity
- difficult to involve users

3.4 SETTING SIMULATION OBJECTIVES

Because of the theoretical nature of this method, the simulation objectives should be achieved by analysing statistical recorded data such as: capacity, sector and segment load, workload, number of conflicts, etc.

The design team should take consideration of the following principles when setting up the simulation objectives. Objectives should -:

- be high level
- address specific issues
- be measurable

3.5 PREPARATION

3.5.1 PREPARING SCENARIOS

3.5.1.1 Airspace Modelling

The first step in assessment and validation process is to build a adequate model of the analysed situation i.e. Base Case or Test Case from the Reference or Conceptually developed Scenario, with regard to the tools used for evaluation. These models approximate the Airspace Organisation, and their degree of realism depends of the capabilities of the simulation tool used. The airspace design team should work in close co-operation with the simulation team/experts in order to ensure that the representation of the airspace design in the simulated environment is accurate enough and adequate for the purpose of this assessment/validation phase.

3.5.1.2 Aircraft profiles

The airspace modelling tools generally use simplified aircraft trajectories, called aircraft profiles. Those profiles are usually extracted from more complex data collections such as traffic samples recorded from real life operations.

For the Base Case it is recommended to use as much as possible a real traffic sample (radar data recordings, flight plan system recordings, CFMU database, etc) as a basis for extracting aircraft profiles. A good traffic sample should be representative of the real operation, preferable an average day traffic sample, with normal operation and traffic distribution. It is preferably to use 24h (or longer) traffic samples (if it is feasible with respect to the simulation objectives). The use of short interval samples bears the risk to be non-representative for daily operation or to miss significant events.

For Test Cases, the aircraft profiles should be developed according to the simulation objectives. It is very important to ensure that the traffic distribution (origin/destination, route assignment, hourly/daily distribution, runway in use) is realistic, e.g. it is similar to reality. Whilst for the Base Case it is generally easy to set up a realistic traffic sample, for the Test Case it can be very difficult to forecast the traffic distribution, particularly in the situation when new runway/airports are tested or major changes in the traffic demand are expected. In these conditions, it is recommended to develop more options so as to cover the most probable possibilities.

3.6 DATA ANALYSIS

After the Test Cases have been prepared, which means that the routes, holds and airspace structures are defined and the traffic sample is assigned, data can be extracted by running a series of queries.

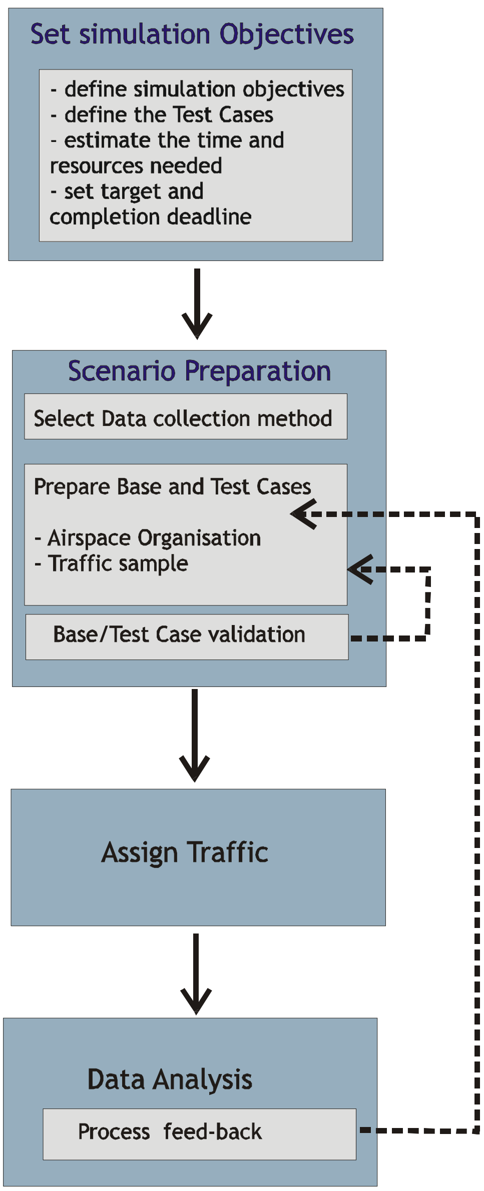
The output from airspace modelling includes a large amount of data which can be clustered into several groups:

- Generic statistical data
  - sector load
  - routes/segments load
  - point load
- ATC related data
  - workload
  - conflicts

- aircraft data related to flight profile e.g.
  - flight time
  - flight distance

Those data can be used directly for initial estimation or can be processed using various tool and produce more refined result in form of statistical data, charts and graphs. Such data can provide valuable statistical information, but to assess the performance of the various Test Cases, all figures should be filtered and qualitatively assessed.

3.7 SUMMARY OVERVIEW



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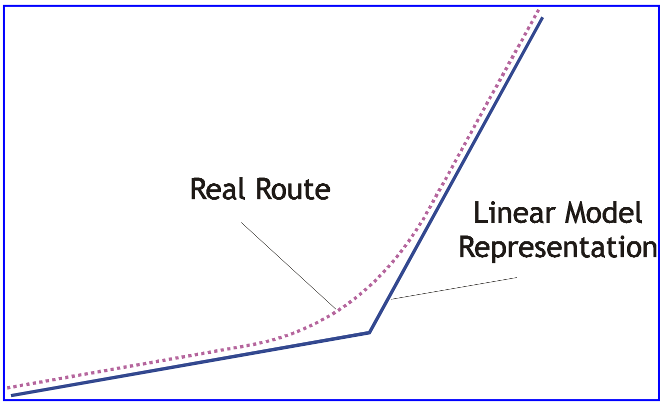
Attachment D.3.1

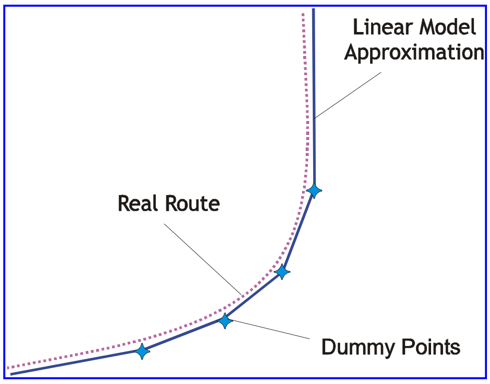
Airspace Modelling

Routes, holds and sectors modelling

The first step in airspace modelling is to translate the design developed by the team into a simplified, computer based representation i.e. the Airspace Organisation and Traffic Sample.

In most of the cases, routes are described as a 2D network of linear segments. These segments could have associated proprieties such as orientation (eastbound/westbound/bi-directional), type (arrival/departure/cruise), etc.

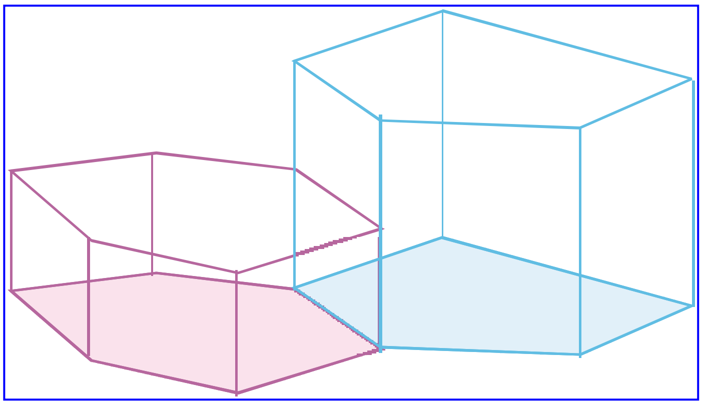




These modelling tools usually do not use curved segments and aircraft models have no turn capabilities. However, in order to describe more accurately the SIDs and STARs, the curved segments of the procedures can be approximated by linear segments.

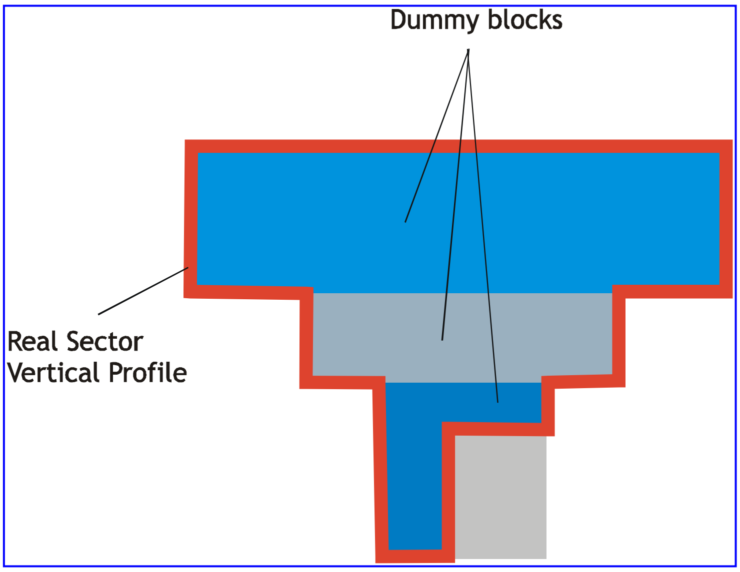
Similar methods can be used to describe (approximate) the holds. However, the airspace modelling has a very limited application in holds evaluation, due to the limitation of the aircraft model and because the tactical interventions of the ATC normally cannot be described by the tool.

The sectors are represented as airspace blocks defined by their horizontal shape and height.



The horizontal shape of the sectors is described by closed polygons; in the situations when the horizontal shape of the sectors is defined by curves segments these can be approximated by linear segments (as for the routes).

In the situations where the sector has a complex vertical shape it is necessary to "decompose" it in basic geometric blocks (dummy airspace blocks) which will be linked together for analysis purposes.



After the modelling is complete, the designer should check that the sector configuration is depicted correctly and that are no "gaps" between the sectors at their common boundaries (in the horizontal and the vertical planes).

CHAPTER 4

- FAST-TIME SIMULATION –

Contents

4.1 PURPOSE OF FAST-TIME SIMULATION (FTS)

As a methodology, Fast-Time simulation is a valuable and frequently used way of validating a proposed design and it may also be used as a way of demonstrating that the safety objectives have been met.

Very often, designers use fast-time simulation as a first step in the validation process i.e. prior to real-time simulation, but also it might be the only step used to validate the concept. Because fast-time simulation is less demanding than real-time simulation in term of human resources, this is often a preferred method for improving the proposed design, identifying flaws in the design concept, and/or preparing the path to real-time simulation or direct implementation.

4.2 PRINCIPLES

As with all simulation tools, Airspace Organisation and Traffic Sample need to be defined for the simulated environment using specific computer language and conventions. To simplify the explanation which follows, various parameters of the Airspace Organisation and Traffic Sample are discussed under separate headings.

4.2.1 ROUTES

Usually, **any route** in a FTS is defined by linear segments between points. The aircraft model follows the planned turns in the route according to the aircraft performance defined in the aircraft performance database used by the Traffic Sample. Because FTS flight trajectories are computer generated models, all aircraft naturally follow, *with maximum accuracy*, the planned flight trajectory unless, deviations are specifically programmed into the trajectory.

Additionally, routes in the FTS have associated vertical constraints used to model a realistic behaviour of the aircraft in the vertical dimension (These are types of Rules in the Traffic Sample). These constraints could be generally applicable to all aircraft or defined on a flight-by-flight basis. For their part, tactical manoeuvres (e.g. radar vectors) are replicated by the creation of a set of fictional routes which are designed to overlap the tactical allocated paths.

Some simulators can use imported real-radar data and the extracted trajectories can be used in simulation.

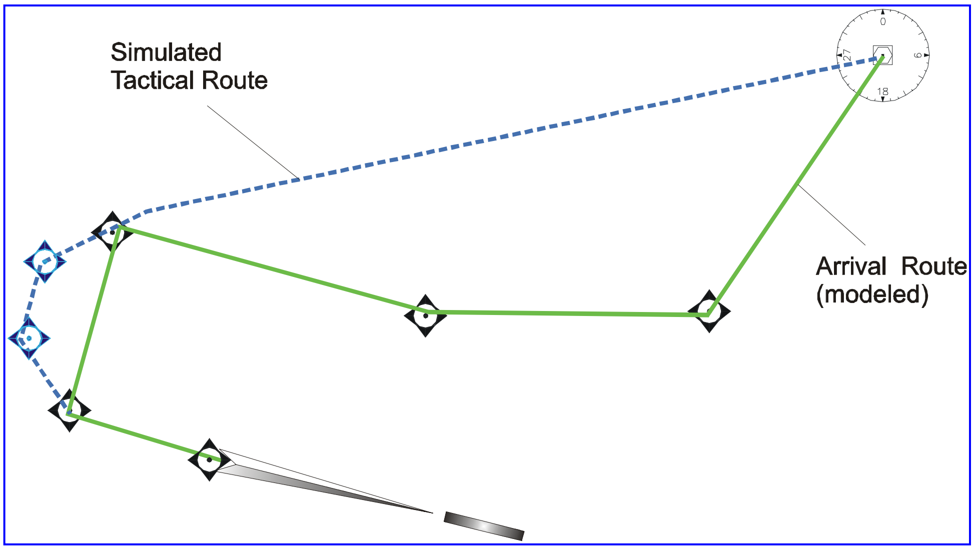


Figure 4 - 1: Sample FTS Route definition

4.2.2 TERMINAL AIRSPACE STRUCTURES AND SECTORS

The same logic is applicable to the airspace modelling of Terminal Airspace Structures and ATC Sectors: the airspace is represented by blocks defined by a horizontal shape and height. In this respect, functional sectors are difficult to model. A way around is to define fictional blocks of airspace for each functional sector and assign the specific controller task to each one.

4.2.3 RULES

In a FTS the behaviour of aircraft is dictated by a series of rules which are generally defined for some or all Test Cases or specifically for each block of airspace, route segment or waypoint. Without these rules, the simulated aircraft will fly their optimum profiles according to their flight plan which seldom reflects real life operation.

Rules are used by the simulator engine to mimic pilots and ATC actions, such as:

- tactical routes assignment
- vertical manoeuvres
- conflict detection and conflict solving
- sequencing and metering

The Rules are based on data emerging from the following sources:

- LoAs
- Route Availability Document restrictions
- SID/STARs vertical profiles
- speed restrictions
- operational practices

4.2.4 HOW IT WORKS

The simulator engine generates 4D trajectories (position + time) for each aircraft based upon flight plan information and rules stated in the Test Cases. The system checks each trajectory for certain predefined events. Examples of such predefined events may include conflicts (remembering that defining the parameters of what constitutes a conflict might need to be written into the rules – see para. 4.2.5), level changes, routes changes, sector entry or exit. When such an event is detected, the system increments the defined counters and trigger tasks parameters linked to the event. For example, if the system detects that an aircraft has crossed a sector border, it will increase by one the number of aircraft counted in that specific sector and will trigger as active the tasks assigned to the controllers (such as hand-over, transfer of communication, identification, etc).

In the simulator model, controller actions are described by **task**. These tasks are basic ATC actions, which are triggered by specific events and have a time value associated with it. This value is the time required in real life for the controller to fulfil the specific action.

The simulator adds the values of the task parameter for a given Test Case and the result value gives an indication of controller workload. Usually, a controller is considered not to be overloaded if this figure does not exceed 70% of the total time of the Test Case.

The precision of workload indication is higher when the ATC *modus operandi* is better known and formalised, e.g. it could be described by basic task with clearly identified trigger events and well determined time parameters.

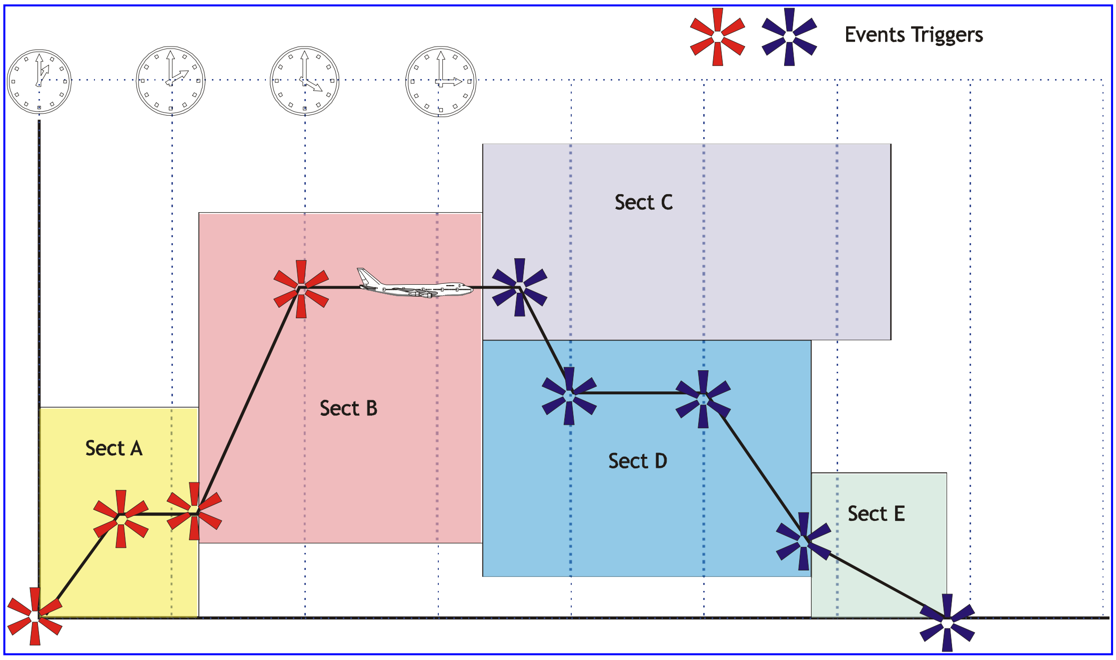


Figure 4 - 2: Event Triggers in FTS

4.2.5 CONFLICT DETECTION AND RESOLUTION

Based on values used in each sector for vertical and horizontal separation the simulator builds around each aircraft a protected volume (which can be assimilated usually with a cylinder). The system will detect a conflict when one aircraft's protected volume touches or intersects another aircraft's protected volume.

Because the FTS is based only on mathematical calculation the careful setting of the separation value is of paramount importance for the accuracy of the modelling. For example if the separation value is set for 2.999 Nm for aircraft flying on parallel routes spaced at 3 Nm the system will record no conflict, but if the separation is set at 3 Nm all the aircraft on those routes will be in conflict for the simulator.

After detecting a conflict, the simulator can handle the situation in two different ways:

- the conflict is recorded and the trajectories of the involved aircraft are not affected
- the simulator tries to "solve" the conflict by altering the trajectories of the involved aircraft at the appropriate moments. The way the simulator modifies the trajectories is dictated by the conflict solving rules, which should be set up before hand.

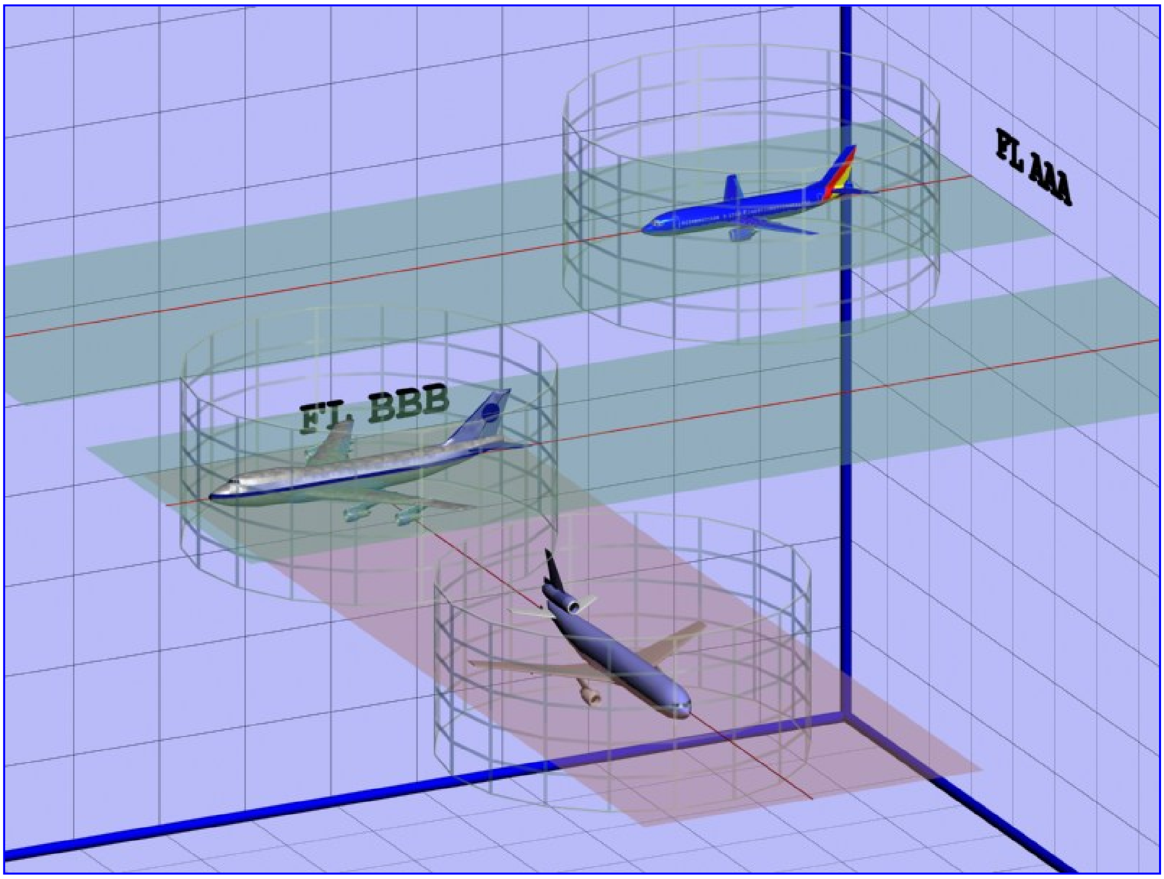


Figure 4 - 3: Airspace Protected Volumes

4.3 ADVANTAGES & LIMITATIONS

4.3.1 FAST TIME SIMULATION ADVANTAGES

- one of the most frequently used methods for sector capacity assessments
- gives opportunity to collect quality data
- relatively unlimited scope and great flexibility
- relatively simple to assess various alternatives
- relatively easy Test Case adaptation
- relatively easy to test large number of traffic samples
- can use real traffic and environment data
- good acceptance of the results
- can evaluate the achievement of the TLS (Target Level of Safety)
- can inform safety case development

4.3.2 FAST TIME SIMULATION DISADVANTAGES

- simplified model of "real" operation
- can provide only statistical data
- cannot replicate tactical controller interventions
- quality of results depends heavily on the accuracy of the model
- limited aircraft performance and simplified aircraft behaviour
- low representation of meteorological conditions
- difficult to involve users

4.4 SETTING FAST TIME SIMULATION OBJECTIVES

Because of the theoretical nature of this method, the simulation objectives should be achieved by analysing statistical recorded data such as: capacity, sector and segment load, workload, number of conflicts, etc.

The design team should take consideration of the following principles when setting up the simulation objectives. Objectives should :

- be specific and limited
- be measurable
- not aim to test too many things in one simulation

After deciding on the simulation objectives the design team should complete the following actions:

- define the Base and Test Cases in general terms and ascertain their feasibility.
- decide on the number of assessments required
- estimate the time and resources needed
- set target and the completion deadline

4.5 PREPARATION

4.5.1 ESTABLISH DATA COLLECTION METHOD

Prior to Test Case definition it is necessary to decide which parameters and performance indicators will be used to assess the simulation and what method will be used to collect the required data.

The output from a fast-time simulation includes a large amount of data which can be clustered into several groups:

- generic statistical data
  - sector load
  - routes/segments load
  - point load
  - airport/runway acceptance rate
  - airport/runway departure rate

- ATC action related data
  - workload
  - conflicts
- aircraft related data
  - flight time
  - flight distance
  - delays
  - fuel consumption

4.5.2 PREPARING TEST CASES

4.5.2.1 Set up routes, holds and sectors

As explained in the para. 4.2, the representation of the routes, holds and sectors inside the simulator is subtly different from the one depicted on the drawing board of the design team.

The design team should ensure that for each Test Case the translation between the real airspace (existing or the new designs) and simulation Test Case airspace is done accurately.

4.5.2.2 Traffic sample

For the Base Case it is recommended to use as much as possible a real traffic sample (radar data recordings, flight plan system recordings, CFMU database, etc). A good traffic sample should be representative for the real operation, preferable an average day traffic sample, with normal operation and traffic distribution. It is preferably to use 24h (or longer) traffic samples (if it is feasible with respect to the simulation objectives). The use of short interval samples bears the risk of being non-representative for daily operation or of missing significant events.

4.5.2.3 Set up ATC Task parameters

The appreciation of the ATC workload and sector capacity evaluation is based on the assessment of the required time for the controllers to complete specified tasks. Air traffic controllers' actions in real life are described in the simulation environment by various tasks. These tasks are basic actions which are triggered by specific events and have a time value associated with it (the nominal time required to the controller to perform that specific action).

The accuracy of the FTS result is directly related to how well the real life ATC actions (ATC *modus operandi*) can be described in a formalised way within the simulator protocols and of the accuracy of time values associated with the tasks.

The modalities to determine the task and their associated time values are:

- expert judgement based on experience
- operational controller interviews
- real life data collection (by observing and timing real life operations)

4.6 DATA ANALYSIS

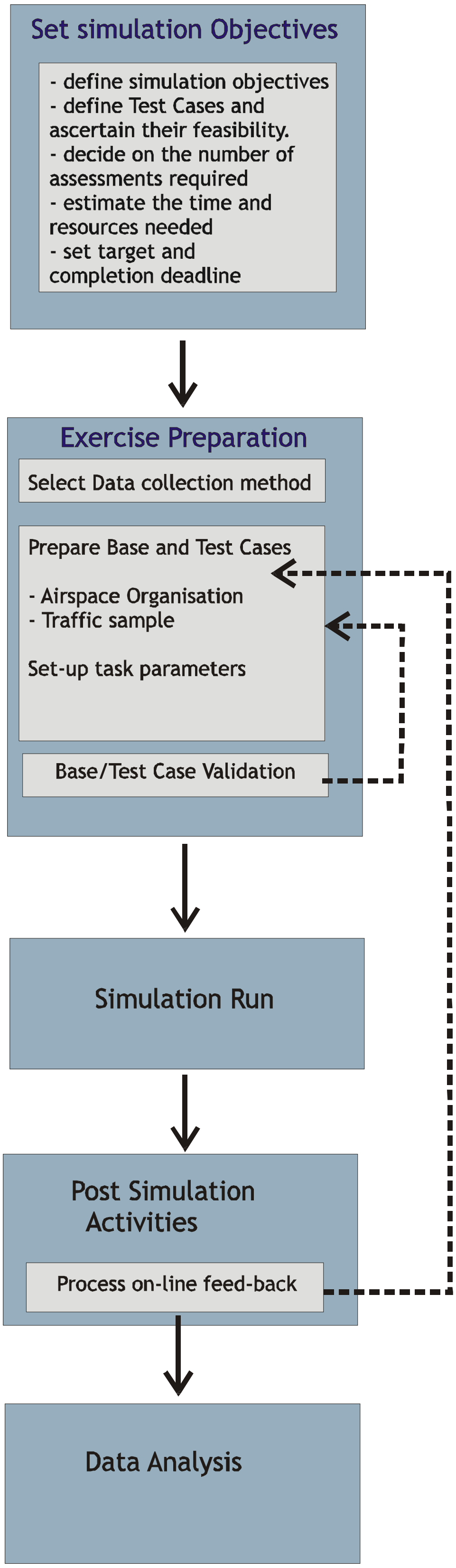
After running the FTS a large amount of data is collected:

- Airport movements/delays.
- Sector movements/workloads
- Global Flight Data Record - 4D Position data
- Events logs (conflicts, sector changes, level changes, etc)
- Message File (Records terminations, errors reports, etc)

This data can be used directly for initial estimation or can be processed using various tool and produce more refined result in form of statistical data, charts and graphs.

The statistical data collected by FTS does not constitute a final product by itself. In order to have a realistic view of the performances of Test Cases assessed, all data resulted from FTS should be subjected to a qualitative assessment by ATC experts. The acceptance or rejection of one particular airspace design cannot be based only on the numerical data resulting from FTS without considering the ATC perspective on that particular case.

4.7 SUMMARY OVERVIEW



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CHAPTER 5

- REAL-TIME SIMULATION –

Contents

5.1 PURPOSE OF REAL-TIME SIMULATION (RTS)

As a methodology, Real-Time simulation is used in the later stages of the validation of a proposed design and it may also be used as a way of demonstrating that both the safety objectives and operational objectives have been met.

Often, the real-time simulation is used as a final check of the design and as the preparatory step for the implementation. This method is used mainly because it provides live feedback from the operational air traffic controller and for it's potential high degree of realism.

5.2 PRINCIPLES

The Real Time Simulator tries to replicate as accurately as possible the real working environment of involved air traffic controllers. The main components of a RTS platform are:

- simulator engine
- active controller positions
- pseudo pilots and feeder sectors
- data recording system

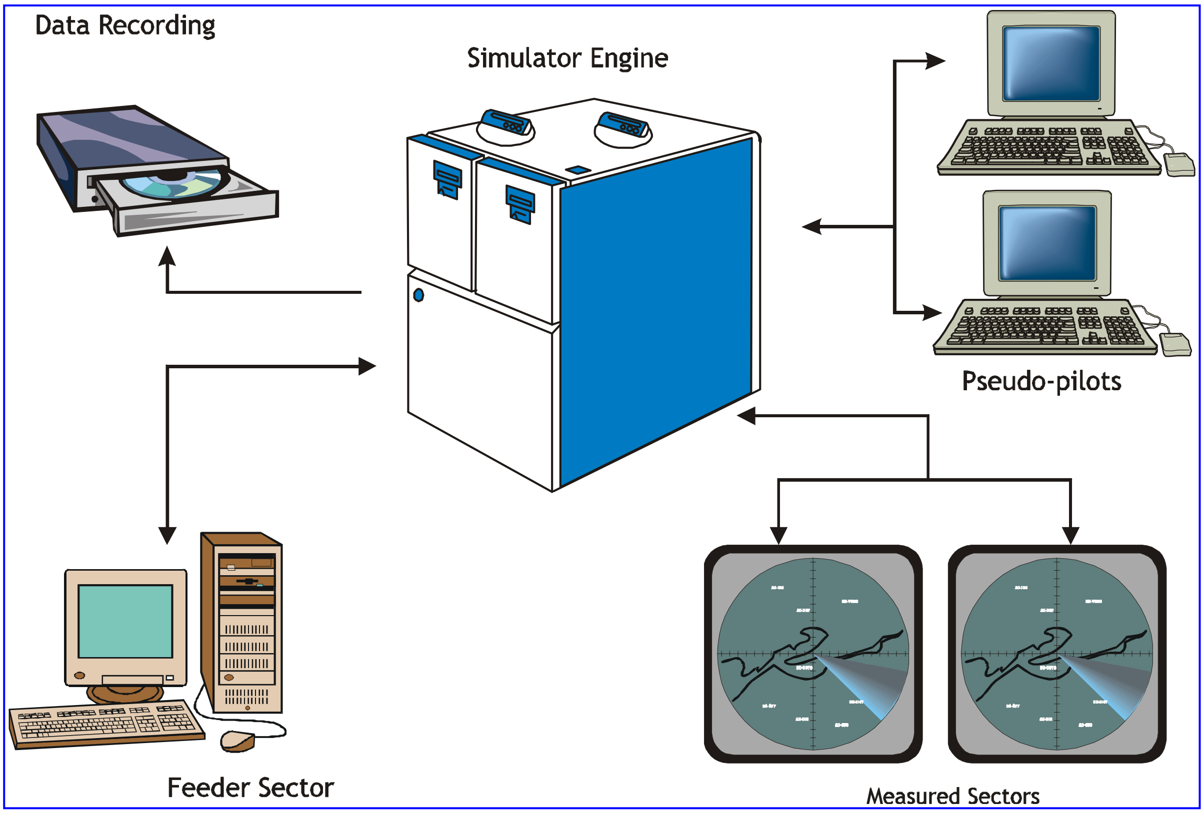


Figure 5 - 1: Components of an RTS Platform

The simulator engine process the flight plans and the inputs from the pseudo pilots and controllers and provide all positions with the relevant data as do real RDP (Radar Data Processing System) and FDP (Flight Data Processing System) systems.

5.3 ADVANTAGES & LIMITATIONS

5.3.1 REAL TIME SIMULATION ADVANTAGES

- closest simulation method to the live ATC trials which can be used to asses and validate simulation objectives
- gives opportunity to collect high quality quantitative and qualitative data
- feed-back from controllers, based on operational experience (further qualitative assessment)
- feed-back from pseudo-pilots (depending on their expertise and simulation conditions)
- can indicate and assess human factor related issues (further qualitative and quantitative assessment)
- automatic data collection (for quantitative assessment)
- unlimited scope and greater flexibility compared to the live trials (further qualitative assessment)
- no risk to the live operation
- allow testing of contingency procedures and hazard analysis (qualitative and quantitative assessment)
- simple to assess various alternatives
- on-line feed-back and scenario adaptation (qualitative assessment)
- can use real traffic and environment data (quantitative input)
- good acceptance of the results by the controllers (wide scope qualitative assessment)
- can be part of a safety case

5.3.2 REAL TIME SIMULATION DISADVANTAGES

- sterile environment: limited HMI (Human Machine Interface) capabilities, artificial RT, limited radar performance
- limited aircraft performance and simplified aircraft behaviour
- not realistic aircraft behaviour due to pseudo-pilots without, or with limited, aviation experience
- pseudo-pilots cannot replicate real crews performance
- low representation of meteorological conditions
- human factor related drawbacks:
  - controller mind-set
  - exercise/scenario learning curve
  - subjectivity of assessment (mainly with regard to workload)
  - macho attitude
- controllers feed-back clouded by historic experience
- cost and time demanding
- potentially resource intensive
- difficulties related to the operational controllers availability for simulation

- difficult to involve users directly

5.4 SETTING REAL TIME SIMULATION OBJECTIVES

Because of the great flexibility and potential accuracy of this method the range of the possible simulation objective is extremely large (from capacity and feasibility evaluation to sophisticated human factor and safety measurements). For this reason, the design team should take consideration of the following principles when setting up the simulation objectives. The objectives should -:

- be specific and limited
- be measurable and realistic
- not aim to test too many things in one simulation

After deciding on the simulation objectives the design and simulation teams should complete the following actions:

- define the scenario in general terms and ascertain their feasibility.
- decide on the number of assessments required
- estimate the time and resources needed
- set target and the completion deadline

5.5 REAL TIME SIMULATION PREPARATION

5.5.1 DATA COLLECTION METHOD

After setting up objectives the design team should decide which parameters should be analysed in order to achieve the simulation objectives. There are two types of data collection methods available for the real-time simulation:

- manual data collection (debriefing, questionnaires, survey)
- automatic data collection (recordings and statistics of RT, radar tracks, controllers and pseudo-pilots inputs, etc)

Usually, both methods are used in conjunction and the comparison of the results is very useful in order to eliminate biases. Simulation teams should be aware that a real time simulation could generate vast amount of information and if recording and storage are not issue, the processing of this data could be a long, laborious and work intensive process. Based on the simulation objectives, the team should decide which data are needed for evaluation/recording. The amount required should be kept within practical limits and available time.

5.5.2 EXERCISE PREPARATION

The real simulation consists of a Base Case and a series of Test Cases. Each case contains:

- Airspace Organisation and Traffic Sample
- ATC environment
- scripts

The number of Test Cases is directly determined by the simulation objectives: complex and ambitious simulation objectives require a large number of variable Airspace Organisations or Traffic Samples, a great number of Test Scenarios will be required to achieve these objectives.

The Simulation team leader should take into consideration that each Test Case should be run multiple times and the controllers should change their position on each run in order to eliminate as much as possible the biases and to obtain reliable results.

5.5.2.1 Traffic sample preparation

General assumption regarding the traffic samples used in RTS:

- aircraft entering in the measured sector are free of conflict
- all aircraft exiting the measured sectors are accepted without restriction by the receiving sectors (if complying with LoAs)
- all the measured sector should be loaded evenly (if practicable, without affecting the credibility of the Traffic Sample)
- a traffic build up period should be provided at the beginning of each exercise

For the Reference Traffic Sample, real data (e.g. RDP/FDP recordings) can be used; however in most of cases this data will require manipulation in order to fulfil the above assumptions.

For the Test Cases, the Traffic Samples should be re-aligned to reflect the modification foreseen in each exercise for:

- the route scheme (new routes, new runways, etc)
- traffic level (increase of traffic, change of the distribution of traffic, etc)
- aircraft performance/equipment

In order to reduce the cost and time required for traffic sample preparation it is recommended to use in real time simulation the traffic samples tested before in Fast Time Simulation process.

5.5.2.2 Simulation ATC environment preparation

The simulation environment is defined by:

- The Airspace Organisation and its Rules, with particular attention paid to the configuration of Feed and Measured Sectors.
- HMI configuration (establish availability of safety nets, automated tools, etc)

The Base Case environment should reflect as much as possible the existing situation as regards the Airspace Organisation and its Rules.

5.5.2.3 Exercise validation

Prior to running the Real Time Simulation a recommended step is to verify the correctness of the exercises. The main checkpoints could be:

- traffic sample:
  - appropriate traffic distribution for measured sectors
  - traffic pattern is according to specification (time and geographic)
  - the sector sequence is correct
  - aircraft are free of conflict when entering in the measured sector – in accordance with inter-sector agreements
- ATC environment:

- the HMI is according to the specification
- the sectors are displayed correct on HMI
  - the sectors are connected correctly
  - the RT links are correct
- Data collection
  - Confirm if data collection tools are in place and are recording the desired data

5.6 TRAINING

The training phase is very important in order to achieve the simulation objectives. Training is undertaken by both controllers and pseudo-pilots, and could involve:

- training documentation (maps, procedures, rules, CBT, etc)
- briefings
- training session

Training goals include -

- to present the simulation objectives
- to make the participants familiar with:
  - simulation assumptions
  - simulated airspace organisation
  - traffic in the Traffic Sample
  - rules and specific procedures
- to make participants familiar with the simulation platform

When human factor related issues are to be analysed by RTS, part of the simulation objectives may not be revealed to the participant controllers in order not to affect the accuracy of the results.

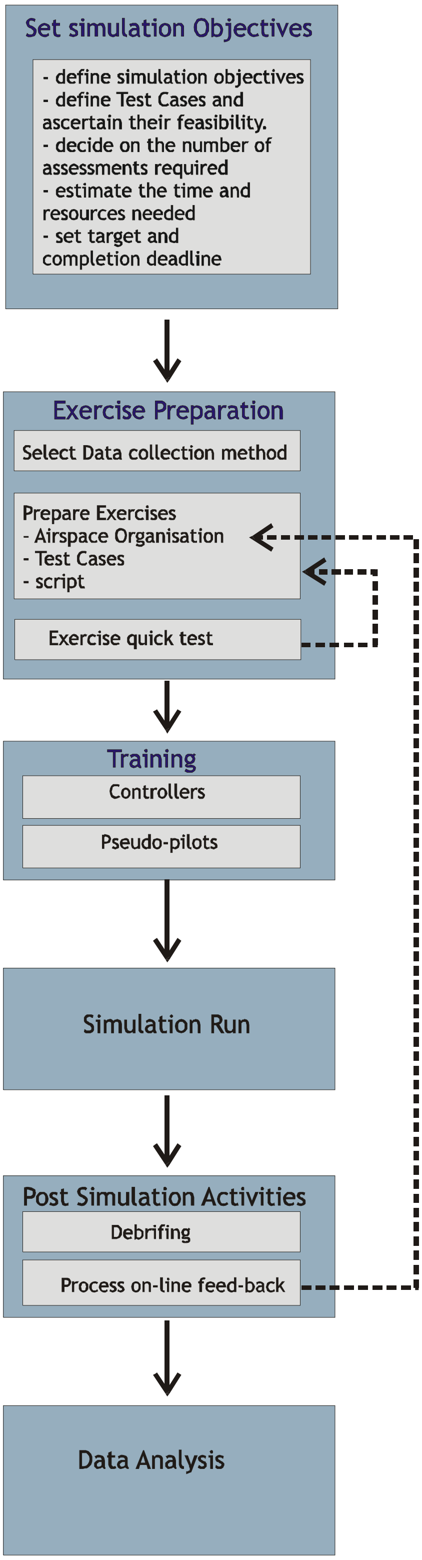
5.7 DATA ANALYSIS

After running the RTS a large amount of data is collected:

- automatic collected data (recordings and statistics of RT, radar tracks, controllers and pseudo-pilots inputs, etc)
- questionnaires and debriefings
- direct feed-back collected during the simulation

The analysis and interpretation of the data collected by RTS can be a resource intensive and complex process. Depending on the simulation complexity, a multi-disciplinary team may be required to analyse the data: ATC experts, simulation experts, data analysts and human-factor specialists.

5.8 SUMMARY OVERVIEW



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CHAPTER 6

- LIVE ATC TRIALS –

Contents

6.1 PURPOSE OF LIVE ATC TRIALS

Live ATC Trials are probably the least used validation method. Generally, this is because it is perceived as carrying the highest risks despite providing what is probably the highest degree of realism. When used, Live Trials tend to be aimed at assessing a very specific factor such as a SID or STAR, a new Terminal Area Procedure or a new Sector design with a very limited traffic sample.

6.2 PRINCIPLES

Live trials take place and are part of real-time air traffic operations using new/re-designed procedures (routes, airspace, etc) for a selected number of participants, in restricted condition and under a close supervision.

6.3 ADVANTAGES & LIMITATIONS

6.3.1 LIVE TRIALS ADVANTAGES

- it is the most accurate validation method
- real data are collected
- gather feed-back from all users
- good acceptance of the results by the users

6.3.2 LIVE TRIALS LIMITATION

- safety implication
- very detailed required
- limited scope
- limited flexibility

6.4 SETTING OBJECTIVES

In this particular case the objectives are directly linked to the feasibility of the design implementation and they should follow the next principles:

- objectives should be specific
- objectives should be measurable
- a clear deadline should be set for the completion of trials

6.5 PREPARATION OF LIVE TRIALS

6.5.1 PREPARE DATA COLLECTION

Data collection method available for live trials:

- debriefings, questionnaires, interviews
- data recorded by ground systems (noise monitoring system records, radar tracks records, RT records, etc)
- data recorded by airborne systems (flight recorders, etc)

6.5.2 PREPARATION OF LIVE TRIALS

Because live trials take place and are part of live operations, the preparatory phase is very important if objectives are to be achieved without compromising required levels of safety.

The preparation phase should involve all the participants and specific tasks and safety responsibility should be acknowledged by each of them.

- National Regulator:
  - establish legal framework (liabilities, certification, other legal aspects)
  - safety related issues
- ATM Service provider
  - design routes and airspace
  - develop operational procedures
  - develop fall back and contingency procedures
  - prepare the ATM system
  - test procedures in simulators
  - develop training material
  - ensure regulatory approval
- Users (aircraft operators, general aviation, military. etc)
  - develop operational procedures
  - develop fall back and contingency procedures
  - prepare/update airborne systems
  - test procedures in simulators
  - develop training material
  - ensure regulatory approval
- Other participants (airport authorities, civil organisation, etc)
  - develop specific procedures
  - prepare participants

6.5.3 NOTIFY LIVE TRIALS PARTICIPANTS

- **Who:**
  - ATC staff (operational + support)
  - neighbouring ATC units
  - ATC support units
  - users (aircraft operators, general aviation, etc)
  - airport authorities
  - military authorities

- **How:**
  - aeronautical publications
  - NOTAMs
  - workshops & briefings

6.6 TRAINING PARTICIPANTS

Because live trials are part of live operations, the proper training and preparation of all participants is crucial. The training phase should be geared to ensuring that all participants -

- know the simulation objectives
- are familiar with the new procedures
- know their responsibilities
- know the trials' programme
- know the contingency procedures

The training can be achieved by:

- seminars and workshops
- individual training (documentation, CBTs – computer based training)
- training sessions in simulators (for pilots and ATC controllers)

6.7 DATA ANALYSIS

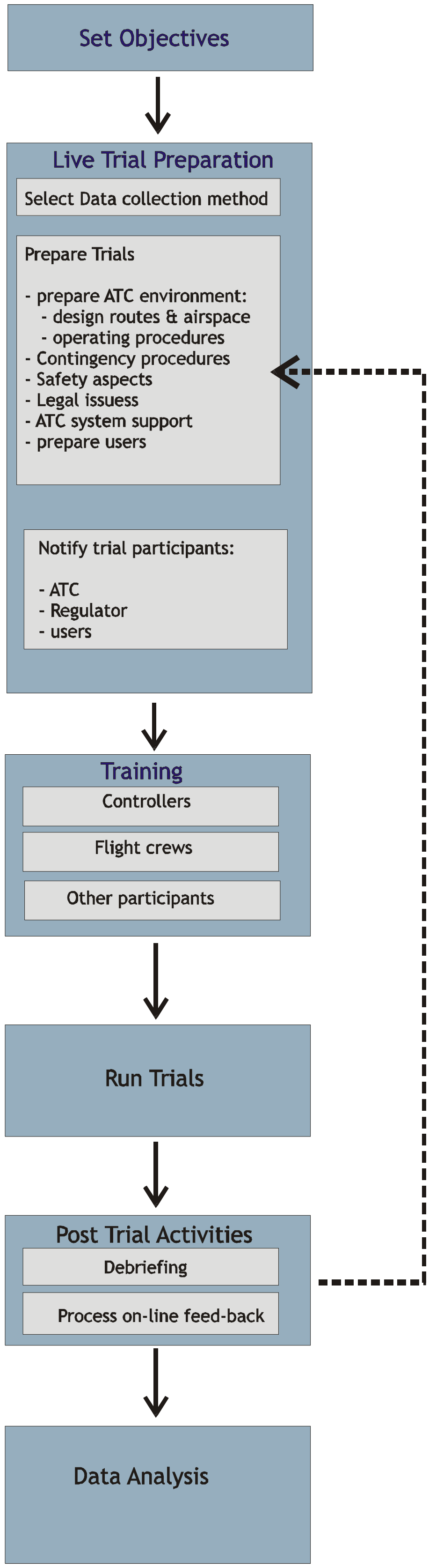
Data from live trials is gathered from various sources:

- automatic collected data from ground & airborne sources (radar data recordings, noise monitoring, performance monitoring, flight recorder data, etc)
- questionnaires and debriefings from all participants
- direct feed-back collected during the trials

All data should be analysed, balanced, filtered and collated in order to obtain a full picture of the operations.

The data collection process could be lengthy and some intermediate data processing and analysis could occur. A multi-disciplinary team can be set up to monitor the trials and to analyse the resulting data. This multi-disciplinary team can be made up of ATC experts, pilots, aerodrome operation experts, safety experts, data analysts and human-factor specialists.

6.8 SUMMARY OVERVIEW



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CHAPTER 7

– FLIGHT SIMULATION –

Contents

7.1 INTRODUCTION

Full flight simulators are renowned for their superior realism and accuracy in reproducing all of the operational characteristics of a specific aircraft type. Normal and abnormal situations, including all of the environmental conditions encountered in actual flight, can be precisely simulated. The use of simulators has increased due to advances in technology and the significant cost savings provided by flight simulation training, compared with real flight time. Today's commercial flight simulators are so sophisticated that pilots proficient on one aircraft type can be completely trained on the simulator for a new type before ever flying the aircraft itself.

7.2 WHAT IS A FLIGHT SIMULATOR?

The main elements of a flight simulator are the cockpit, motion system, visual system, computer, and instructor/operator station. The cockpit provides a suitable environment for the crew in terms of the location, appearance, and feel of controls and displays. All modern simulators are mounted on a hydraulically operated motion platform, capable of imparting to the crew the impression of aircraft movement, adding to the fidelity of the observed response to flight control inputs and external disturbances. Motion cues are particularly important in critical handling tasks, and during instrument flight. The visual system presents the view seen by the pilot of the external visual scene. Advanced technology is needed to achieve representative scene details over a large field of view. The computer must process in real time the mathematical models which represent the aircraft, its systems, and the operating environment. It receives signals from the cockpit, and provides inputs to the other elements in the simulation.

7.3 USES

In addition to the training of pilots in flying the aircraft, flight simulation has an invaluable role to play in other aeronautical areas, such as research, accident investigation, aircraft design and development, operational analysis, and other activities such as space flight. Research areas include new concepts, new systems, flying qualities, and human factors. Most aircraft manufacturers use research simulators as an integral part of aircraft design, development and clearance. Major aeronautical projects would now be impractical without the extensive use of flight simulation, on both cost and safety grounds.

7.3.1 SPECIFIC VS. GENERIC

The current pilot shortage is likely to last some time and there will be a continual need for pilots to move up from small piston aircraft via turboprop commuters to jets. The transition from propeller aircraft to jets may be aided significantly by the use of generic simulators. The basic cockpit layout will need to be fixed in hardware terms, but some variation in performance and handling qualities could be possible by the use of different software. In this way the implications of large speed ranges, the ability to think more quickly and the very different handling qualities at high altitudes and lower speeds can be taught and demonstrated cost-effectively. If this potential requirement is accommodated, then the knock-on effect for ATM and airspace evaluation would be beneficial.

7.3.2 SPECIFIC AIRSPACE PROJECT USE

A significant amount of the planning task for Terminal Airspace Design can be achieved by the other assessment methods shown in this section and flight simulators, the primary use of which is for the training of pilots, were not originally designed to play a role in ATM evaluations per se.

However, there are several areas in which the use of a flight simulator can assist in the successful completion of Terminal Airspace projects. One example is in the achievement of credibility. In addition to the well known noise and emission effects on operations on and around runways, whether in existence or planned, environmental issues are now influencing the positioning of routes (and their associated altitude) within the whole of Terminal Airspace at an increasing number of locations throughout ECAC.

Of course, environmental matters are paramount in the importance of many interested parties such as local residents' associations, environmental lobby groups, airport management to name but a few. It has become clear that it can be very difficult to convince these bodies that their environmental concerns have been addressed fully by the use of mathematical models and/or fast-time simulations.

This is where the flight simulator comes into its own. Using representative aircraft (simulators), the various options for airspace can be extensively flown and data recorded, such as airframe configuration (which affects the noise produced by the aircraft), fuel burn, track miles flown, altitude and so on. Depending on the requirements of a project and how sophistication of the data which is gathered, the results can be fed into analysis software for such parameters as aircraft noise and emissions.

Apart from intensive, expensive live flight trials which are difficult to integrate with on-going operations, the use of the flight simulator is the closest to reality. The credibility factor is further enhanced if operational line pilots are used to fly the flight simulator. Once the data has been analysed, it can then be presented in the most appropriate way for the target audience.

<u>EXAMPLE 1</u>

Use of a flight simulator for airspace projects can range from simple to highly detailed. Example 1 describes a simple use. For this hypothetical project, it was necessary to assess which of the alternative arrival tracks (at FL100 - Option 1 and Option 2) had least effect on an uninterrupted climb of the most common aircraft at this particular location. Altitude measurements were to be taken at specific distances from the departure end of the runway. In order to carry out the measurements across the widest spread of weight and temperature conditions, the aircraft was first operated at maximum take-off weight in the highest ambient temperature experienced at the location in question. This produced the lowest climb rate. The second parameter measured was when the aircraft was very light and the temperature was very low – thus producing the best climb rate. This was repeated several times to ensure that the results were not anomalous and the data was inserted in Table 7 - 1. (The figures shown here are representative only).

	LIGHT AND COLD	HOT AND HEAVY
5	4000 ft	2000 ft
10	6250 ft	3900 ft
15	FL100	5000 ft
20	Extrapolate	5800 ft
25		6250 ft
30		FL75
35		FL80
40		Extrapolate

Table 7 - 1: Rate of Climb data under different conditions

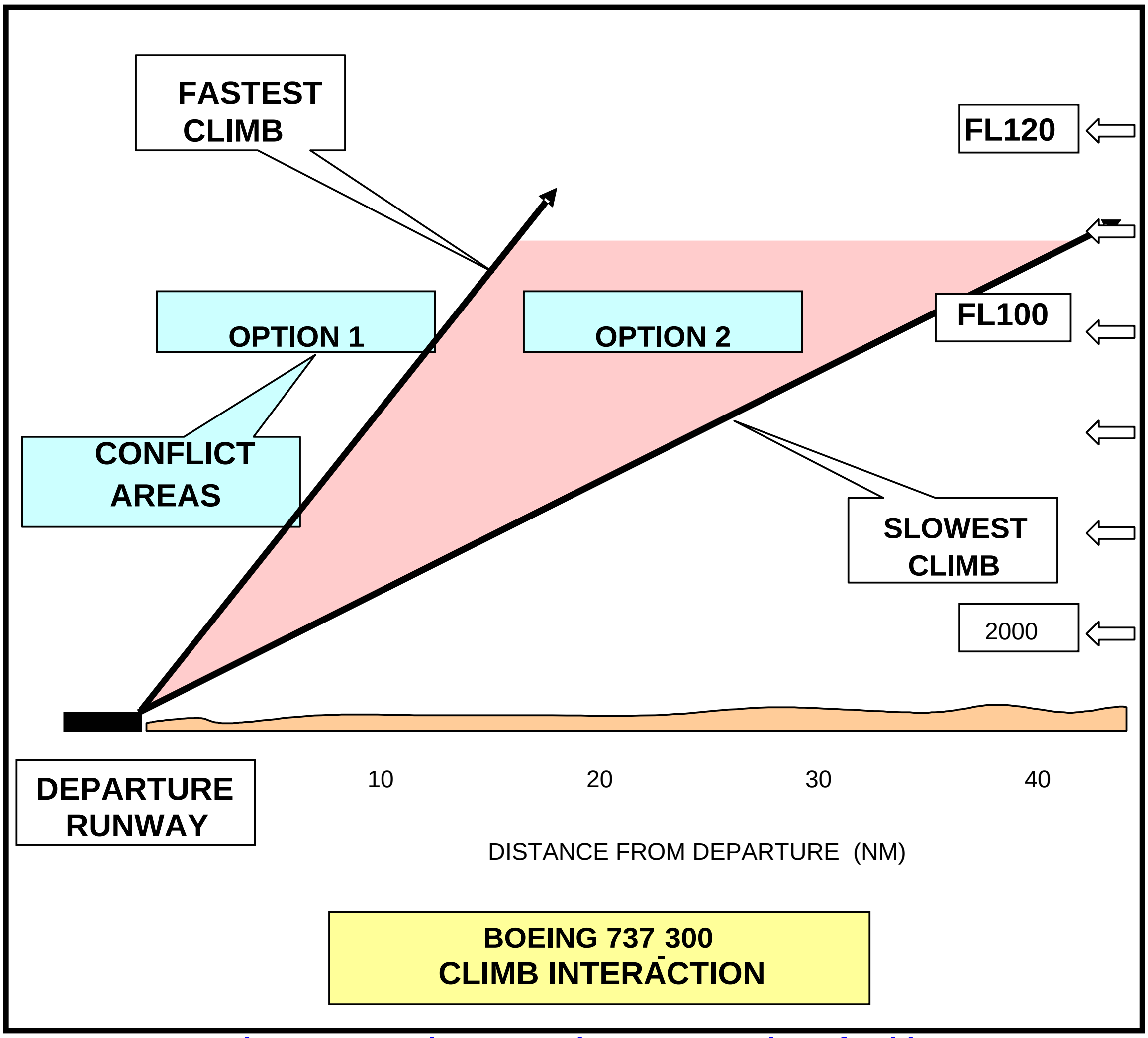


Figure 7 - 1: Diagrammatic representation of Table 7-1

By plotting the position of the two alternatives (Option 1 and Option 2) at the appropriate distances from the runway end, it can easily be seen that, whilst the climb profile range of the aircraft entirely encompasses Option 2, Option 1 is almost entirely outside the climb performance of the 737-300 used for the simulation. Therefore, from an aircraft point-of-view, selection of Option 1 as the arrival track would, in almost all circumstances, allow unrestricted climbs to be achieved by this aircraft type. Clearly, aircraft performance is not the only criterion to be assessed when selecting the route placement, but it is a valuable aid to the decision-making process.

EXAMPLE 2

A more complex assessment would group several of the measurement metrics together. In this example, the assessment includes altitude and time at a given point, track miles flown and fuel burn. One recent large-scale project required the use of both a medium category aircraft simulator (Boeing 737 type) and a heavy category (Boeing 747 type). Example 2 details an assessment of three different arrival profile proposals and Table 7 - 2 reflects the data gathering exercise for the Boeing 747 runs.

OPTION A	AFC	TP 1	END D/W	FAWP	LANDING	FUEL	TOTAL	TOTAL
		N57 35.0	N57 44.0	PT R074		BURN	FLIGHT	ROUTE
		E00155.0	E002 56.7	D11.9			TIME	LENGTH
	11000	*11000*				*KGS*	*MINS/SECS*	*NM*
	11000	11000	6295	3986				
FUEL	*8020*				*7299*	***721***		
ELAPSED TIME	*0:00*	*6:09*	*14:07*	*17:15*	*21:02*		***21:02***	
TRACK NM	*0*	*35.1*	*76.4*	*90.3*	*102.3*			***102.3***
OPTION B	AFC	RER	MELPO	FA	LANDING	FUEL	TOTAL	TOTAL
			PRMR134	PT R074		BURN	FLIGHT	ROUTE
			D10.0	D18.0			TIME	LENGTH
	11000	*11000*	*9000*	*5000*		*KGS*	*MINS/SECS*	*NM*
	11000	10977	9000	4984				
FUEL	*8014*				*7195*	***819***		
ELAPSED TIME	*0:00*	*5:40*	*11:40*	*18:15*	*23:59*		***23:59***	
TRACK NM	*0*	*40.9*	*71.8*	*101.9*	*116.9*			***117***
OPTION C	AFC	EM	DESC PT	FA	LANDING	FUEL	TOTAL	TOTAL
			PT R163	PT R074		BURN	FLIGHT	ROUTE
			D17.2	D12.0			TIME	LENGTH
	11000	*11000*				*KGS*	*MINS/SECS*	*NM*
	11000	11000	10605	3983				
FUEL	*8028*				*7324*	***704***		
ELAPSED TIME	*0:00*	*5:24*	*8:55*	*15:20*	*19:40*		***19:40***	
TRACK NM	*0*	*39.3*	*58.6*	*87.5*	*99.5*			***99.5***

Table 7 - 2: Grouped Measurement Metrics

The data was then converted onto easy-to-read charts and the various parameters evaluated in turn. Chart 7 - 1 to Chart 7 - 3show the presentation style used for this example.

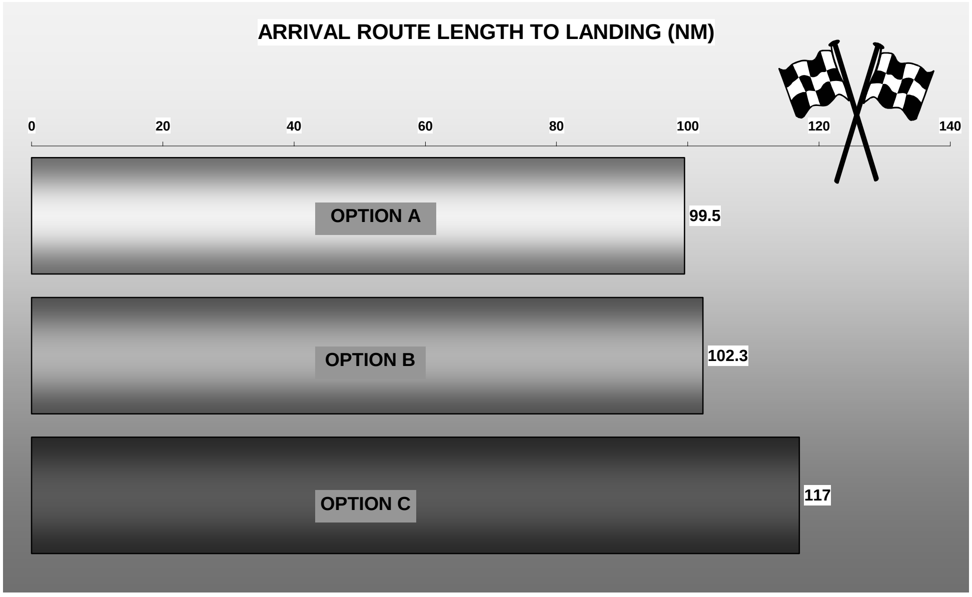


Chart 7 - 1

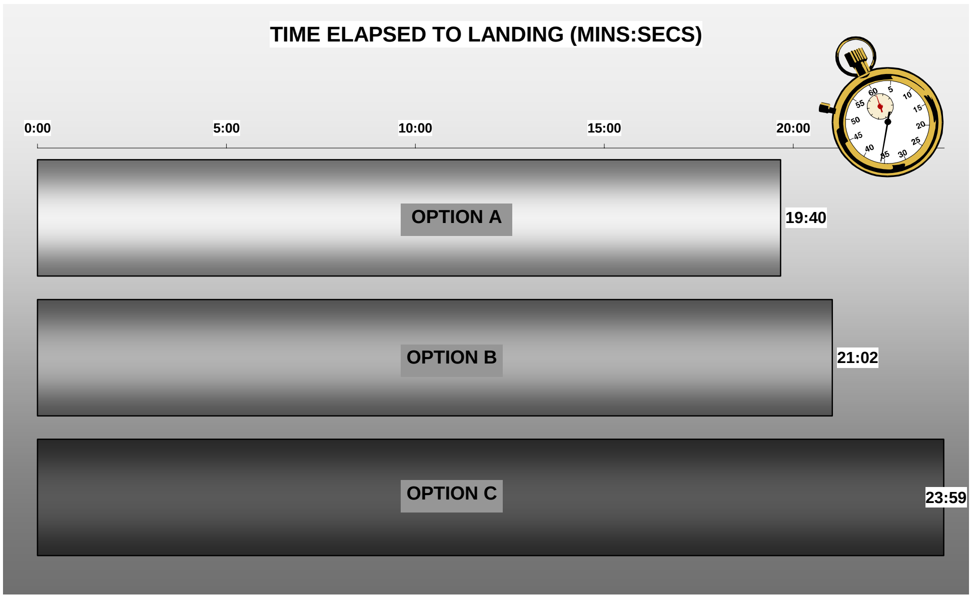


Chart 7 - 2

CHAPTER 8

– ANALYTICAL TOOLS –

Contents

8.1 INTRODUCTION

This Chapter provides an overview of three analytical/assessment tools viz. Collision Risk Modelling, Monte Carlo Simulations and Noise Modelling. Of these three, only Noise Modelling is the only tool which is likely to be used by the Terminal Airspace design team during the life-cycle of a Terminal Airspace project as envisaged in Part C. In contrast, Collision risk modelling (CRM) and Monte Carle Simulations are tools used primarily by researchers/mathematicians/statisticians seeking to estimate and evaluate risk when, for example, new ATM concepts or IFR separation standards are being developed or when new technology is to be introduced into ATM system.

Given the scientific nature of these models, only a brief overview is given here. Nevertheless, these overviews are included with a view to making Terminal Airspace designers aware as to the existence and purpose of these analytical tools.

8.2 COLLISION RISK MODELLING[1]

8.2.1 INTRODUCTION

In Part C, Chapter 3, discussions concerning Safety Criteria explained the difference between Absolute and Relative methods of evaluating safet in the context of requirements for ATS authorities to undertake safety assessment as per ICAO Annex 11. In Chapter 3, it was explained that safety can be evaluated using one of two methods viz. the Comparative method (by comparing a Reference System to a Proposed System) or the Absolute method (by comparing a Proposed system against an Absolute threshold. It also explained when it is necessary to evaluate (safety) against an absolute threshold.

8.2.2 HOW IT WORKS

Collision Risk Modelling (CRM) is a useful way of assessing complex interactions in the ATM system and determining whether these interactions are safe. Its use is associated with the evaluation of a proposed system's risk against an absolute threshold (of maximum tolerable risk).

Viewed diagrammatically, the evaluation of risk against an absolute threshold can be depicted as follows:

Evaluate a system risk against an absolute threshold

Estimate risk of collision and compare it to the maximum tolerable collision risk (right)

e.g. Maximum tolerable risk of collision not to exceed 5 **f**atal **a**ccidents (or 2.5 collisions) **p**er 10^9 **f**light **h**ours (fapfh). This is normally expressed as a **T**arget **L**evel of **S**afety (TLS) e.g. $5x10^{-9}$.

Figure 8 - 1: Risk Evaluation against an absolute threshold

The idea is that if the estimated risk is less than the maximum tolerable risk and can remain so during the anticipated lifetime of a proposed system, then the proposed system can be considered safe. In order to evaluate system risk against a threshold, ICAO has developed a

[1] Material in this section has been derived from [1] ICAO Doc. 9689 – *Manual on Airspace Planning Methodology for the Determination of Separation Minima* and [2] ICAO Doc. 9426, the *ATS Planning Manual*.

process which is detailed in Doc. 9689 – *Manual on Airspace Planning Methodology for the Determination of Separation Minima.* This process envisages the following sequence of steps:

[i]	Define proposed system	e.g. airspace structure, proposed separation minima, complexity of airspace, airspace classification. COMM/NAV/SUR capability and their error rates, physical parameters of aircraft, aircraft navigation performance etc.
[ii]	Set evaluation criteria	e.g. Maximum tolerable risk of collision not to exceed 2.5 collisions or 5 fatal accidents per 10^{-9} flight hours.
[iii]	HAZID	i.e. Identification of all possible hazards, frequency estimation and consequence modelling (the last two provide overall risk estimates, below at [iv])
[iv]	Risk Estimation	is the result of frequency estimation and consequence modelling.
[v]	Risk Evaluation	is the process where by the estimated risk [iv] is compared to the evaluation criteria [ii]*. Risk evaluation involves the construction of mathematical models, which use detailed information about the system to estimate collision risk. i.e. **collision risk model**

**Note: If the calculated risk does not meet the evaluation criteria, then risk reduction measures are examined to see how risk can be reduced.*

Table 8 - 1: Evaluating System risk against a threshold

As regards [iii] in Table 8 - 1, it can be seen that CRM relies very heavily upon Cause-Consequence Modelling which effectively provides the basis for the Hazard identification process. Cause-Consequences modelling, which uses decision trees, operates on the assumption that truly independent variables contribute to occurrences and outcomes; i.e., independent events must occur to bring about an event. Cause-consequence analysis looks at the possible outcomes of these events by -

a) Identifying the sources of the potential hazard.

b) Identifying the events that could initiate such hazard occurring (fault trees).

c) Establishing the possible sequence of events that could result from such occurrences (event trees).

d) Quantifying - in probability and frequency terms - the likelihood of b) and c).

e) Determining the overall risk by aggregating all the known quantified hazards.

Predictably, collision risk modelling (and therefore risk estimation and evaluation, [iii] and [iv] in Table 8-1), takes account of the following parameters -

- Exposure of one aircraft to another (with aircraft operating on parallel ATS routes, this refers to passing frequency);
- Navigation performance in the lateral, longitudinal and vertical plane;
- Effects of surveillance and communication (e.g. effectiveness of ATC capability to detect aircraft on conflicting. This effectiveness is determined by the efficiency of the surveillance and communication capability available to ATC).

As can be seen, Collision Risk Modelling is not intended for direct use by the airspace designer as envisaged within the context of this document. Nevertheless, the ATC perspective and input is critical in the setting up of correct assumptions on which the CRM is based, and during the HAZID process.

8.2.3 USE OF COLLISION RISK MODELLING

CRM is frequently to provide evidence for safety assessments. As explained in Chapter 3 of Part C, CRM – measurement against an absolute threshold – is only required when the proposed system does not bear sufficient resemblance to the reference system. This would be the case, for example, where RVSM is to be introduced (i.e. the 'reference' system is predicated conventional vertical separation minima, CVSM).

8.3 MONTE CARLO SIMULATIONS

8.3.1 INTRODUCTION

Monte Carlo Simulations rely upon the use of random numbers and probability statistics to solve mathematical problems. Although these methods were originally developed for the Manhattan Project during World War II, they are now applied to a wide range of problems, including nuclear reactor design, econometrics, stellar evolution, stock market forecasting - .

8.3.2 HOW MONTE CARLO SIMULATIONS WORK

These simulations take their name from the capital of Monaco – a city whose main attractions include casinos. Roulette, dice and slot machines feature in these casinos, and each of these games provide entertainment by exploiting the random behaviour of the roulette wheel, dice or slot machine.

Similarly, Monte Carlo methods randomly select values to create scenarios of a problem. These values are taken from within a fixed range and selected to fit a probability distribution [e.g. bell curve, linear distribution, etc.]. This is like rolling a dice. The outcome is always within the range of 1 to 6 and it follows a linear distribution - there is an equal opportunity for any number to be the outcome.

In Monte Carlo simulations, the random selection process is repeated many times to create multiple scenarios. Each time a value is randomly selected, it forms one possible scenario and solution to the problem. Together, these scenarios give a range of possible solutions, some of which are more probable and some less probable.

When repeated for many scenarios [10,000 or more], the average solution will give an approximate answer to the problem. Accuracy of this answer can be improved by simulating more scenarios. In fact, the accuracy of a Monte Carlo simulation is proportional to the square root of the number of scenarios used.

8.3.3 USE OF MONTE CARLO SIMULATION

Monte Carlo simulation is advantageous because it is a "brute force" approach that is able to solve problems for which no other solutions exist. Unfortunately, this also means that it is computer intensive and best avoided if simpler solutions are possible. The most appropriate situation to use Monte Carlo methods is when other solutions are too complex or difficult to use.

8.4 NOISE MODELLING

8.4.1 INTRODUCTION

Noise Modelling is used to determine the noise distribution over a predetermined area as generated by a specific traffic pattern.

8.4.2 HOW NOISE MODELLING WORKS

Noise Modellers use an advanced form of fast-time simulator which are capable of calculating noise contours over a pre-defined area. These 'noise-modelling' functionalities are added to typical functionalities (such a flight trajectory calculation) included in 'standard' fast-time simulators.

In order to generate the noise contours for each simulated aircraft in addition to the flight trajectories, the noise modeller determines (according to the aircraft model) the estimated speed and engine power setting/thrust. Based on these data and taking into account the terrain contours and other environmental conditions (time of the day, meteorological condition, etc), the simulator calculates the noise distribution and noise level at predetermined check points.

The accuracy of the results very much depends upon the realism of the aircraft models used by the simulator and on the model used for calculating noise distribution. Aircraft trajectories can be directly derived from recorded Radar data from real-live operations. Even so, modelling individual aircraft is difficult even when using advanced computational technologies. Movements are allocated to different aircraft 'types' and aircraft that are noise 'significant' (by virtue of their numbers or noise level) are represented individually by aircraft type, e.g. B747-400. Some 'types' are grouped together with those having similar noise characteristics. For each 'type', average profiles of height and speed against track distance are calculated from an analysis of radar data. These average profiles are subdivided into appropriate linear segments.

Average ground tracks for each route are calculated based on radar data. Accurate noise exposure estimation requires a realistic simulation of the lateral scatter of flight tracks actually observed in practice. This is done by creating additional tracks which are a number of standard deviations either side of the central average track. The standard deviations and the proportions of traffic allocated to each route are determined by analysis of the radar data.

8.4.3 USE OF NOISE MODELLING

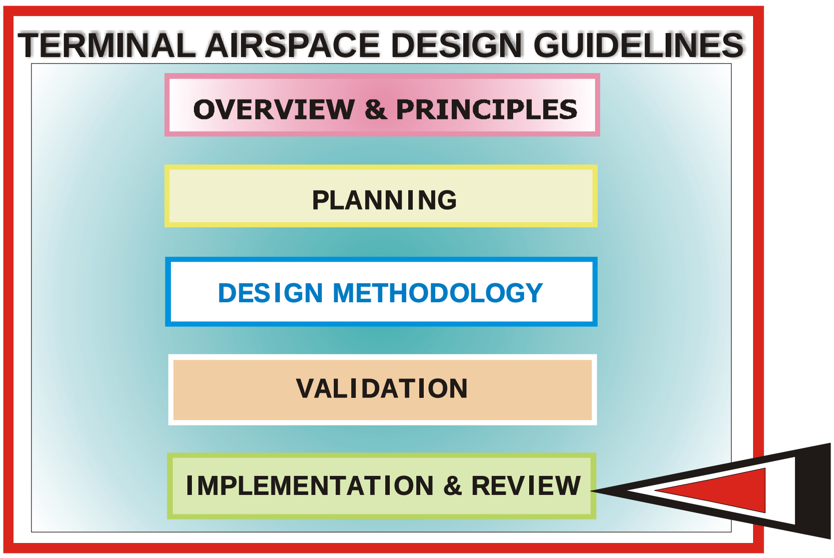
Noise modelling has many analytical uses, such as assessing –

- changes in noise impact resulting from new or extended runways or their configuration,
- new traffic demand and fleet mix,
- revised Terminal routing and airspace structures and
- alternative flight profiles or modifications to other operational procedures.

Noise modelling outputs can include noise contours used in land-use compatibility studies, noise impacts by aircraft on individual flight tracks, and user-defined point analysis of noise impacts.

PART E

IMPLEMENTATION & REVIEW



CHAPTER 1

– IMPLEMENTATION AND REVIEW –

Contents

1.1 INTRODUCTION

This Chapter constitutes the only chapter in Part E – and the conclusion of the Terminal Airspace Design guidelines. It provides an overview of Implementation and Review – which together mark the 'end' of a Terminal Airspace design project.

Most Terminal Airspace designers will admit to having had at least one Implementation experience that they would prefer to forget. Although the reasons for this are numerous, the two items (bulleted below) are amongst the most frequently listed during the 'lesson learned' review of a Terminal Airspace design project.:

- Insufficient Implementation Planning
- Omission or overlooking of some critical factor.

Whilst these two inter-related factors appear anecdotal, they unfortunately and undoubtedly reflect the reality of some implementation efforts.

For this reason, this chapter focuses on **Implementation Planning**: because it is the **planning for implementation** that makes successful implementation possible. It will be seen, that implementation planning includes **Review** and that Review is the final 'full-stop' in the post-implementation phase.

This requirement to organise and plan is not new in the Implementation and Review phase: it is equally in evidence during Project Planning – Part B, development of the Design Concept – Part C, and during the validation Phase – Part D.

1.2 PLANNING FOR IMPLEMENTATION

Each ANSP should have a concrete Implementation Planning Process. In recognition of the fact that ANSPs will either already have or develop their own process, this section will first provide a high level overview of implementation planning followed by a quick reference list of the factors that should be accounted for prior to Implementation.

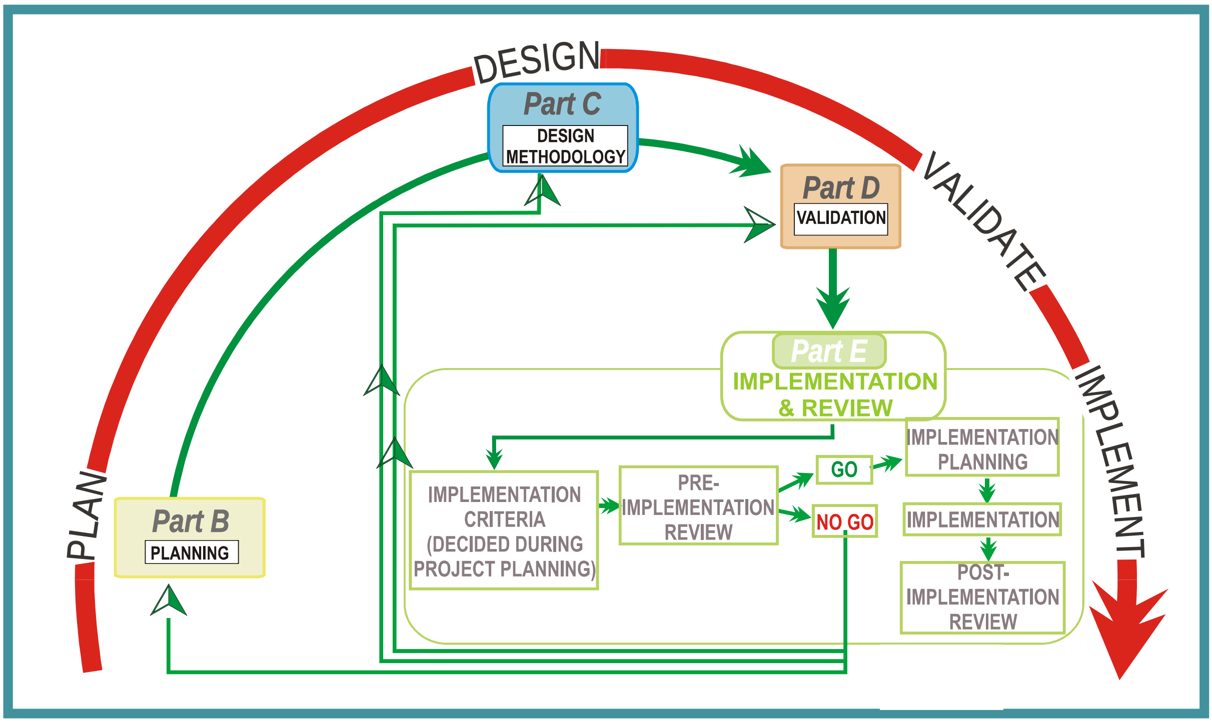


Figure 1 - 1: Overview of Planning for Implementation

1.2.1 IMPLEMENTATION CRITERIA

It is usually during the validation process that it becomes evident whether the proposed design can be implemented. (This was alluded to in Chapter 1 of Part D). The decision to go ahead with implementation needs to be decided at a particular date in the life-cycle of a project.

The decision of whether to go, or not to go ahead with implementation is based on certain deciding factors i.e. **Implementation Criteria,** not the least of which are whether Safety and Performance Criteria have been satisfied (see Part C, Chapter 3). But there is more than satisfying Safety and Performance Criteria when deciding whether or not to go ahead with Implementation. Other factors can prevent a 'go' decision. For example –

- A change to the ATM system, needed to support the implementation, may prove impossible to realise despite careful identification of this enabler and a go-ahead being given by ATM systems engineers;

Or, For example -

- Dramatic political events which have nothing to do with the Terminal Airspace design and which could never have been foreseen when the Traffic Assumptions were chosen, could nullify the entire Terminal Airspace design project. This could occur, for example, if the entire design concept rested on the (traffic) assumption that 80% of the traffic would enter the Terminal Airspace from the west and unforeseen political events change the geographic distribution of traffic completely;
- Unforeseen change by lead operator concerning aircraft equipment upgrades causes collapse of the Business Case or, for example, Navigation assumptions.

It can therefore be said that it is the possibility of unexpected events that explain why it is necessary to fix a go/no-go date. (In 'purist' terms, the occurrence of a foreseeable event is not strictly an implementation issue but rather one of Project Planning which affects Implementation).

1.2.2 PRE-IMPLEMENTATION REVIEW

At this go/no go date, a **Pre-Implementation Review** is undertaken, the result of which decides the next project step. During the Pre-Implementation Review, the Terminal Airspace design project's progress is measured against the implementation criteria selected during the planning stage.

Examples of Criteria which a Terminal Airspace design team may have selected to determine whether to go ahead with implementation include:-

- Collapse of the main assumptions (see Part C, Chapter 4)
- Critical Enablers become void (see Part C, Chapter 4)
- Emergence of a project-critical constraint (see Part C, Chapter 4)
- Performance/Safety Criteria are not satisfied during or by the Validation or Safety Assessment process.
- No regulatory approival

1.2.2.1 'NO-GO' decision

Although it can be very discouraging to be confronted with a 'no-go' decision, it is essential that attempts should not be made to 'produce' a quick-fix' or work-around' so that implementation takes place at any cost. However difficult it might be *not* to proceed with implementation, a 'no-go' decision should be respected.

As shown in Figure 1 - 1, and as suggested by the Criteria listed in the preceding paragraph, the route to be followed after a 'no-go' decision depends upon the reason for which the no-go decision was reached. In extreme cases, it may be necessary to scrap an entire project and return to the planning stage. In others, it might be appropriate to return to the selection of Assumptions, Constraints and Enablers as per Part C, Chapter 4. And it is also possible, that a new Validation exercises will have to be developed, or a new Safety Assessment completed. What-ever the route, the work needs to be organised and planned in a manner such as suggested in Part B.

1.3 'GO' DECISION – PLAN IMPLEMENTATION

If, on the other hand, all the implementation criteria are satisfied the Terminal Airspace design team needs to plan for implementation – not only as regards their 'own' airspace and ANSP but in co-operation with any affected parties which may include ANSPs in an adjacent State. To this end, a Quick Reference List for Implementation Planning is provided at ***Attachment E. 1-1***. Whilst an attempt has been made to place the items in a logical sequence, it is recognised that the order of the items listed may vary, dependent on the nature of the Terminal Airspace design project, the extent/complexity of the changes and ANSP internal processes.

1.4 IMPLEMENTATION

With proper planning and organisation, the culmination of a Terminal Airspace design project is trouble-free Implementation. Nevertheless, the Terminal Airspace design team would be advised to –

[i] Make members of the Terminal Airspace design team available in the operations hall on a 24-hour basis for at least two days before implementation, during implementation and for at least one week following implementation. This makes it possible for the Terminal Airspace design team to -

- Monitor the implementation process;
- Support the Centre supervisor/Approach Chief or Operational Manager should it become necessary to use redundancy or contingency procedures;
- Provide support and information to operational controllers;

[ii] Enable a log-keeping system for a period similar to that in [i] above, so that implementation-related difficulties may be noted and used in future project planning;

1.5 POST-IMPLEMENTATION REVIEW

It is evident that the Implementation and Review phase provides for Review on two occasions: once before and once after Implementation. Post-Implementation Review is concerned with monitoring and checking the effects of the implementation so as to ensure that unforeseen consequences do not arise. If they do, the Terminal Airspace design team should put mitigation measures (or redundancy procedures) in place as soon as possible.

As can be appreciated, the proper planning of a Terminal Airspace design project and robust Implementation planning is unlikely to necessitate drastic/radical action during the Post-Implementation Review phase. Nevertheless, this Review phase is important: it allows the Terminal Airspace design team to critically review the Implementation Scenario in a manner that is similar to the way in which the Critical Review of the Reference Scenario is undertaken during the Conceptual design phase. As such, the Quick Reference list at the end of Part C may serve as a basis for the development of a Post-Implementation Review Quick list.

Attachment E. 1-1

Quick Reference List for Implementation Planning

IMPLEMENTATION QUICKLIST (ref. Part E)	
PROJECT NAME:	
TARGET IMPLEMENTATION DATE	
NO-GO DECISION – JUSTIFY	**'GO' DECISION - JUSTIFY** **CONDITIONS:**
SAFETY CRITERIA	
1.	Satisfied/Not-Satisfied
2.	Satisfied/Not-Satisfied
3.	Satisfied/Not-Satisfied
4.	Satisfied/Not-Satisfied
PERFORMANCE CRITERIA	
1.	Satisfied/Not-Satisfied
2.	Satisfied/Not-Satisfied
3.	Satisfied/Not-Satisfied
4.	Satisfied/Not-Satisfied
VALIDITY OF ASSUMPTIONS, CONSTRAINTS AND ENABLERS	
1. Assumptions … **a.**	**Valid/Invalid**
2. Enablers … **a.**	**Valid/Invalid**

3. Constraints **a.**	**Valid/Invalid**
A. PROJECT REPORTS	
➢ Validation Report ➢ Safety Assessment and other Safety Documentation as per Safety Policy ➢ Environmental Report in accordance with State Policy.	➢ Completed/Outstanding ➢ Completed/Outstanding ➢ Completed/Outstanding
B. PROCEDURES AND REGULATORY MATERIAL	
➢ Letters of Agreement ➢ National Regulations and Operating Procedures (including redundancy/contingency procedures) ➢ Local Regulations and Operating Procedures ➢ Register differences with ICAO in accordance with Article 38 of Chicago Convention, if applicable.	➢ Completed/Outstanding ➢ Completed/Outstanding ➢ Completed/Outstanding ➢ Completed/Outstanding
C. PUBLICATION	
➢ Design Terminal Routes in accordance with PANS-OPS criteria. ➢ Publish new SIDs/STARs in AIP in accordance with AIRAC system. ➢ Publish other relevant AIS material	➢ Completed/Outstanding ➢ Completed/Outstanding ➢ Completed/Outstanding
D. PILOT AND CONTROLLER TRAINING	
➢ Training exercises ➢ Training Briefings ➢ Feedback questionnaires ➢ Analysis of feedback ➢ Briefings to Air Traffic Controllers ➢ Briefings to Pilots ➢ Pilot and ATC Awareness material (CBT/Fly-leafs etc.)	➢ Completed/Outstanding ➢ Completed/Outstanding ➢ Completed/Outstanding ➢ Completed/Outstanding ➢ Completed/Outstanding ➢ Completed/Outstanding ➢ Completed/Outstanding

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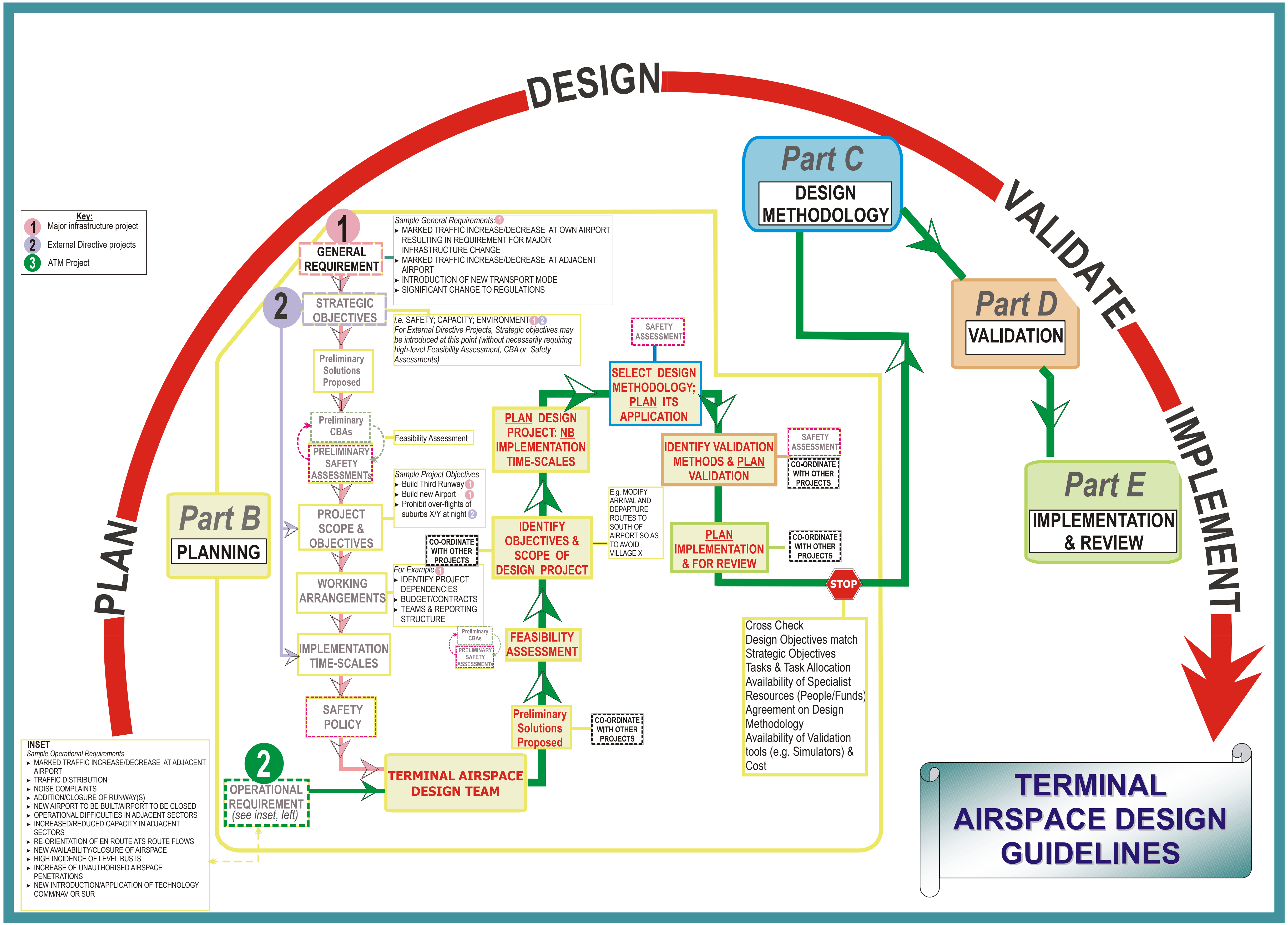
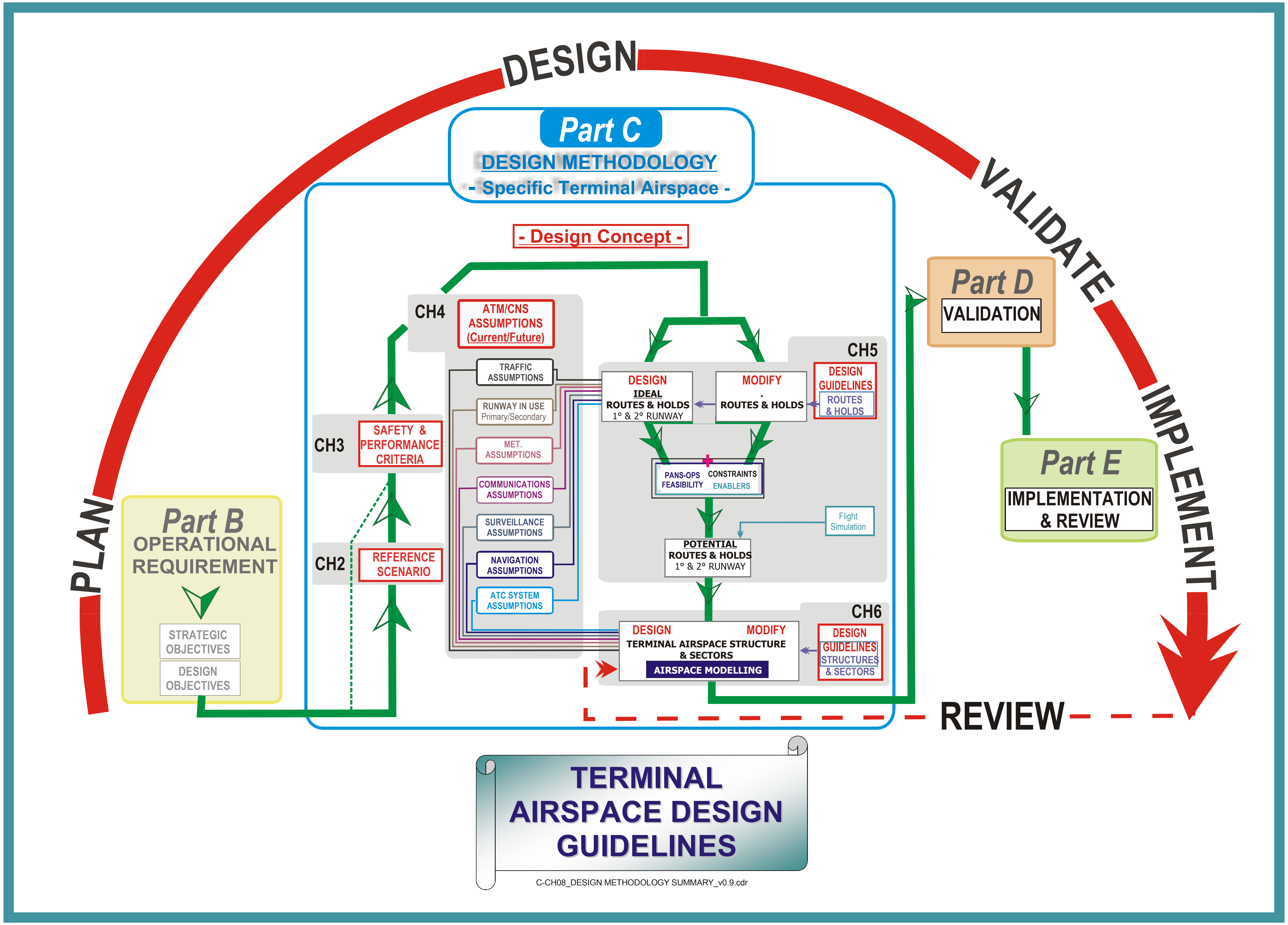
APPENDICES

TERMINAL AIRSPACE DESIGN GUIDELINES

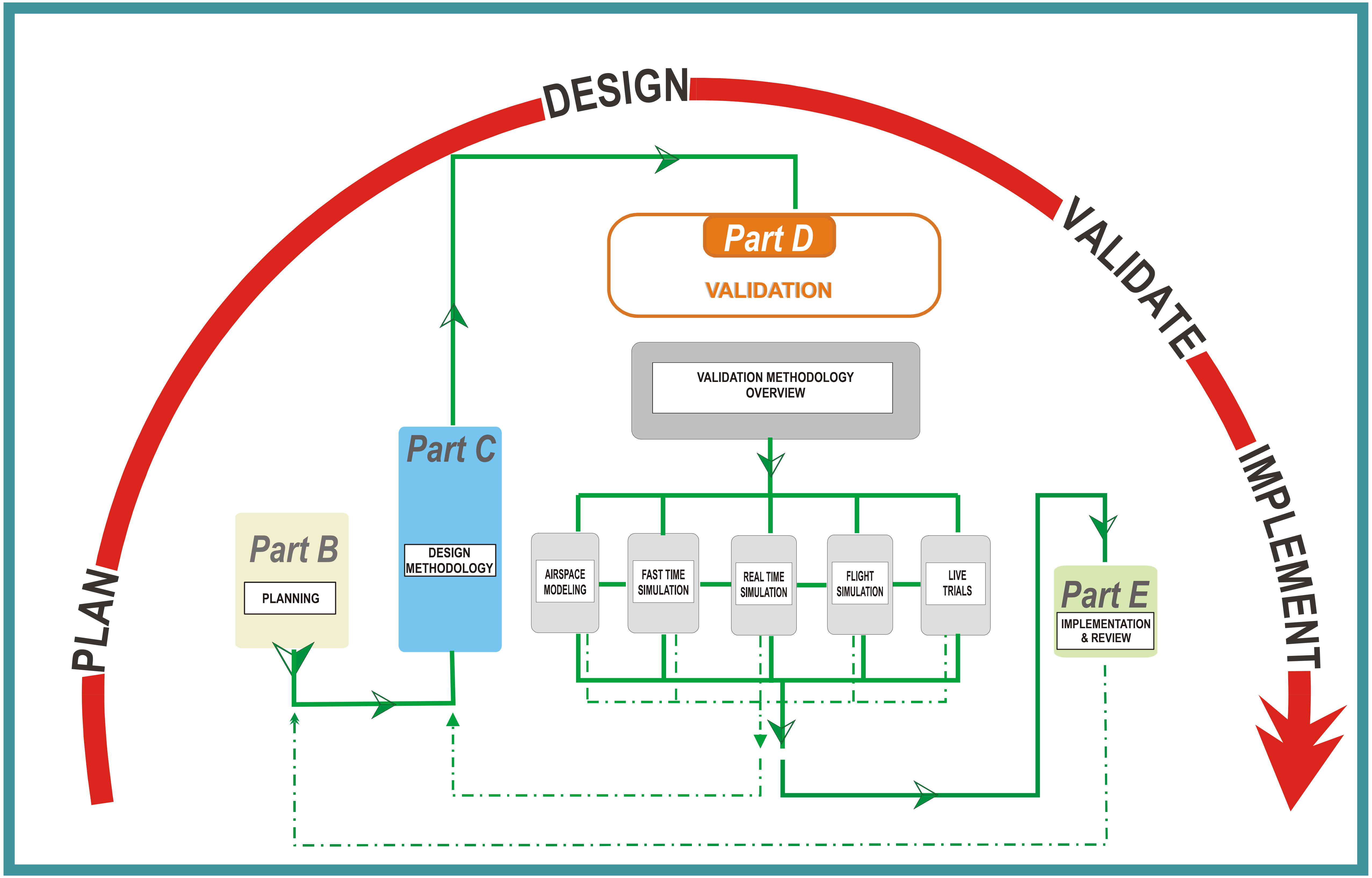
APPENDIX 1: PROJECT PLANNING OVERVEIW



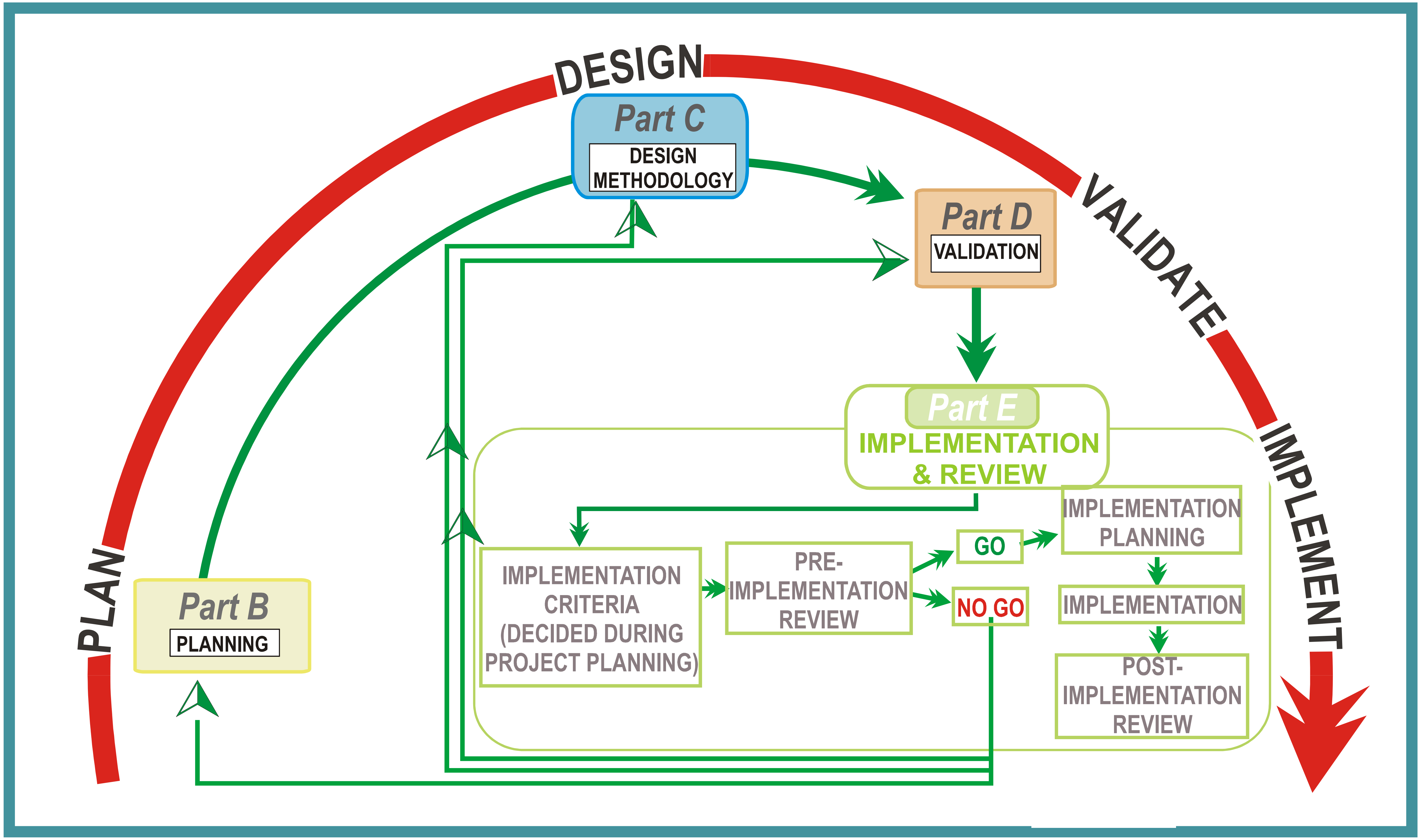
APPENDIX 2: DESIGN METHODOLOGY



APPENDIX 3: VALIDATION PROCESS



APPENDIX 4: IMPLEMENTATION AND REVIEW



SECTION 6

GUIDELINES FOR DELEGATION OF THE RESPONSIBILITY FOR THE PROVISION OF ATS

SECTION CHECKLIST

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SECTION 6

GUIDELINES FOR DELEGATION OF THE RESPONSIBILITY FOR THE PROVISION OF ATS

6.1 INTRODUCTION

6.1.1 Definition

6.1.1.1 As regards to the terminology describing the situation of one State delegating to another State the responsibility for the provision of ATS in a portion of the airspace above its territory, two different expressions seem to be currently used.

6.1.1.2 In several bilateral agreements and corresponding documents the notion “delegation of airspace” is used. This notion would seem to imply that a State would transfer all responsibilities associated to the provision of ATS, including the regulatory competence, to another State which is in effect not the case.

6.1.1.3 So, a clear distinction should be made between "Delegation of Airspace" and "Delegation of the responsibility for the provision of Air Traffic Services":

– "Delegation of Airspace" will refer to the delegation of jurisdiction in a portion of the airspace over a territory from one State to another State with the transfer of all responsibilities associated to the provision of ATS, including the regulatory competence which may necessitate changes to FIR boundaries and/or imply derogation of national sovereignty.

– "Delegation of the responsibility for the provision of Air Traffic Services" will refer only to the delegation of the responsibility for the provision of ATS in a portion of the airspace over a territory from one State to another State.

6.1.2 Scope

6.1.2.1 The Delegation of Airspace is a very rare event requiring the approval of Governments concerned and ICAO, as it may involve changes to FIR boundaries. As ECAC States do not anticipate any such delegation in the foreseeable future, the Guidance Material in this Section 6 refers only to the Delegation of the responsibility for the provision of Air Traffic Services.

6.1.3 Process

6.1.3.1 The present Guidance Material is recommended to be used in conjunction with the Common Format, Cross-Border, Inter-Centre Letter of Agreement, Edition 3.0, REF: ASM.ET1.ST015, EUROCONTROL (hereinafter referred to as the **Common Format LoA**) for the purpose of describing the basic principles and operational aspects regarding the situation where one State delegates to another State the responsibility for the provision of ATS in a portion of the airspace above the territory of the former State.

6.1.3.2 The Guidance Material takes into consideration the provisions of the Model Agreement on the Delegation of Air Traffic Services developed by the Delegation of ATS Task Force, and approved by the EUROCONTROL Provisional Council. This type of Agreement between States, once implemented, takes precedence over any other lower level agreement, such as the Common Format LoA.

6.2 SOVEREIGNTY

6.2.1 According to the Convention on International Civil Aviation (Chicago Convention) “the contracting States recognise that every State has complete and exclusive sovereignty over the airspace above its territory. For the purposes of this Convention the territory of a State shall be deemed to be the land areas and territorial waters adjacent thereto under the sovereignty, suzerainty, protection or mandate of such State”.

6.2.2 Based on the principle of the territorial sovereignty, it will fall under the jurisdiction of a State to prescribe the rules and regulations for the airspace above its territory. However, through signing the Chicago Convention, the States have undertaken to maintain, to the extent possible, their national rules and regulations in conformity with ICAO international standards and procedures.

6.2.3 In the Chicago Convention it is further prescribed that “any State which finds it impracticable to comply in all respects with any such international standard or procedure, or to bring its own regulations or practices into full accord with any international standard or procedure after amendment of the latter, or which deems it necessary to adopt regulations or practices differing in any particular respect from those established by an international standard, shall give immediate notification to the International Civil Aviation Organisation of the differences between its own practice and that established by the international standard”.

6.2.4 As a principle of sovereignty, the rules and procedures of the Delegating State apply in its territory. It is, however, actual practice to apply the rules and procedures pertaining to the provision of ATS of the Providing State. In the interest of safety and for the sake of efficiency, it is necessary that the air traffic controller is able to apply only one set of rules and procedures – those of the Providing State.

6.2.5 The rules and procedures pertaining to the provision of ATS in the Providing State shall apply when providing ATS in a portion of the airspace of the Delegating State.

6.2.6 The ATS Unit/Authority of the Contracting States may agree, however, that certain rules and procedures of the Delegating State pertaining to the provision of ATS will remain applicable in the airspace concerned.

6.3 TERMINOLOGY

6.3.1 In accordance with para. 2.1.1 of Annex 11 to the Chicago Convention the full term prescribed is delegation of “the responsibility for establishing and providing air traffic services”. As this term indicates, the objective of the delegation is purely functional and will not imply any derogation of national sovereignty.

6.3.2 Thus, in the event of a State delegating to another State the responsibility for the provision of ATS in a portion of the airspace above its territory, the term delegation of the responsibility for the provision of ATS, as provided for in the Note under para. 2.1.1 of Annex 11 to the Chicago Convention, should be used by the States (instead of delegation of airspace) when drafting their delegation agreements.

6.4 AIR TRAFFIC SERVICES

6.4.1 General

6.4.1.1 In Annex 11 to the Chicago Convention it is expressed as a Recommendation that “the delineation of airspace wherein air traffic services are to be provided, should be related to the nature of the route structure and the need for efficient service rather than to national boundaries”.

6.4.1.2 According to Note 1. under the Recommendation above it is further expressed that, “conclusions of agreements to permit the delineation of airspace lying across national boundaries is advisable when such action will facilitate the provision of air traffic services”.

6.4.2 Delegation of the responsibility for the provision of ATS

6.4.2.1 Annex 11 to the Chicago Convention (para. 2.1.1) prescribes that “contracting States shall determine, in accordance with the provisions of this Annex, and for the territories over which they have jurisdiction, those portions of the airspace and those aerodromes where air traffic services will be provided. They shall thereafter arrange for such services to be established and provided in accordance with the provisions of this Annex, except that, by mutual agreement, a State may delegate to another State the responsibility for establishing and providing air traffic services in flight information regions, control areas or control zones extending over the territories of the former”.

6.4.2.2 In the Note. under para. 2.1.1 of Annex 11 to the Chicago Convention it is expressed that, “if one State delegates to another State the responsibility for the provision of air traffic services over its territory, it does so without derogation of its national sovereignty. Similarly, the providing State’s responsibility is limited to technical and operational considerations and does not extend beyond those pertaining to the safety and expedition of aircraft using the concerned airspace”.

6.4.2.3 “Furthermore, the providing State in providing air traffic services within the territory of the delegating State will do so in accordance with the requirements of the latter which is expected to establish such facilities and services for the use of the providing State as are jointly agreed to be necessary. It is further expected that the delegating State would not withdraw or modify such facilities or services without prior consultation with the providing State. Both the delegating and providing States may terminate the agreement between them at any time”.

6.4.2.4 The States shall describe the lateral and vertical limits of the portion of airspace within which the responsibility for the provision of ATS is delegated from one State to another State.

6.4.2.4.1 In the cases where a delegation of the responsibility for the provision of ATS is based on a technically required adjustment of the AoR boundaries caused by the inability of video displays to depict the exact FIR boundaries, it may be sufficient to identify the new AoR boundary(ies) through use of significant points and agree to a broad statement that the responsibility for the provision of ATS is delegated in all airspace north, east, south or west of the AoR boundary(ies).

6.4.2.5 Both the Delegating and Providing State shall keep each other advised of any changes in the operational status of their communication and/or navigational facilities which may have an influence on the provision of ATS in the portion of airspace within which the responsibility for the provision of ATS is delegated.

6.4.2.6 Moreover, the Common Format LoA provides that both Centres shall keep each other advised of any changes in the operational status of their facilities and navigational aids which may affect the procedures specified in the Letter of Agreement (LoA).

6.4.2.7 The States shall have established procedures pertaining to revisions and cancellation of the delegation agreement. According to the **Common Format LoA**, cancellation of the LoA by either State requires that the cancelling party declares its intention to cancel the LoA with a minimum pre-notification time as agreed and prescribed in the LoA. Should the Agreement on the Delegation of Air Traffic Services between the Contracting States be terminated, the LoA under it will, as a consequence, be cancelled with effect from the same date as that Agreement.

6.4.3 Authority responsible for the provision of ATS

6.4.3.1 In Annex 11 to the Chicago Convention (para. 2.1.3) it is prescribed that “when it has been determined that air traffic services will be provided, the States concerned shall designate the authority responsible for providing such services”.

6.4.3.2 According to Note 1. under the paragraph mentioned above, “the authority for establishing and providing the services may be a State or a suitable Agency”.

6.4.3.3 Furthermore, in the situation where a State delegates to another State the responsibility for the provision of ATS in a portion of the airspace above its territory, “the State which designates the authority responsible for establishing and providing the air traffic services is: the State to whom responsibility for the establishment and provision of air traffic services has been delegated”.

6.4.4 Scope of the delegation of the responsibility for the provision of ATS

6.4.4.1 The delegation of the responsibility for the provision of ATS should encompass air traffic control service, flight information service and alerting service.

6.4.4.2 Moreover, the delegation of the responsibility for the provision of ATS normally encompasses GAT traffic operating under IFR, unless otherwise specified.

6.4.4.3 Considering the fact that the Common Format LoA provides for, on an optional basis, the inclusion of co-ordination procedures for Operational Air Traffic and/or VFR traffic, the delegation may also include the responsibility for the provision of ATS to such Operational Air Traffic (OAT) and/or VFR traffic. Thus, in the event the Letter of Agreement encompasses co-ordination procedures for OAT and/or VFR traffic, and if the responsibility for the provision of ATS to OAT/VFR traffic is delegated, this shall be clearly specified also in the relevant paragraphs of the Letter of Agreement pertaining to delegation of the responsibility for the provision of ATS.

6.4.4.4 With respect to alerting service this is, according to ICAO definitions, “a service provided to notify appropriate organisations regarding aircraft in need of search and rescue aid, and assist such organisations as required”. The responsibility for the provision of alerting service will normally fall on the ATS unit responsible for the provision of ATS in the airspace concerned.

6.4.4.5 In the event of a State delegating to another State the responsibility for the provision of ATS in a portion of the airspace above its territory, the States should establish co-ordination procedures regarding the provision of search and rescue services for the territory connected with the airspace concerned.

6.4.4.6 According to the Common Format LoA, the Centre responsible for the provision of ATS, by virtue of delegation, shall provide alerting service and shall co-ordinate with the appropriate Rescue Co-ordination Centre as required.

6.4.5 Radar separation minima

6.4.5.1 In Annex 11 to the Chicago Convention it is prescribed that “the selection of separation minima for application within a given portion of airspace shall be as follows:

a) the separation minima shall be selected from those prescribed by the provisions of the PANS-ATM and the Regional Supplementary Procedures as applicable under the prevailing circumstances except that, where types of aids are used or circumstances prevail which are not covered by current ICAO provisions, other separation minima shall be established as necessary by:
b) the appropriate ATS authority, following consultation with operators, for routes and portions of routes contained within the sovereign airspace of a State”.

6.4.5.2 As regards to the radar separation minima it is prescribed in ICAO PANS-ATM (Doc 4444) Chapter 8 that “the radar separation minimum or minima to be applied shall be prescribed by the appropriate ATS authority according to the capability of the particular radar system or sensor to accurately identify the aircraft position in relation to the centre of an RPS, PSR blip or SSR response......”.

6.4.5.3 The appropriate ATS authority is, according to Annex 11 to the Chicago Convention, defined as “the relevant authority designated by the State responsible for providing air traffic services in the airspace concerned”.

6.4.5.4 As a consequence, in the situation where a State delegates to another State the responsibility for the provision of ATS in a portion of the airspace above its territory, the appropriate ATS authority designated by the Providing State should be responsible for the selection of the separation minima to be applied in the portion of airspace concerned.

6.4.6 Special activities which will have an influence on the provision of ATS

6.4.6.1 In the situation where a State delegates to another State the responsibility for the provision of ATS in a portion of the airspace above its territory, the Providing State should be kept informed of all pertinent conditions regarding airspace restrictions (Prohibited, Restricted and Danger Areas) and airspace reservations located in the portion of airspace concerned.

6.4.6.2 Moreover, the Delegating State should keep the Providing State informed of all relevant aspects relating to the application of the EATCHIP Concept of the Flexible Use of Airspace (FUA), which will have an impact on the portion of airspace within which the responsibility for the provision of ATS has been delegated (ref. EUROCONTROL Handbook for Airspace Management, ASM-ET1-ST08.5000-HBK-02-00).

6.4.7 SSR code assignment

6.4.7.1 In the event of a State delegating to another State the responsibility for the provision of ATS in a portion of the airspace above its territory, the States should have established procedures for the allocation of SSR codes to the ATS units concerned.

6.4.8 Language

6.4.8.1 Regarding the language to be used it is in Volume II of Annex 10 to the Chicago Convention (para. 5.2.1.1.1) expressed as a Recommendation that “in general, the air-ground radiotelephony communications should be conducted in the language normally used by the station on the ground”. Furthermore, in accordance with the Note. under the same paragraph “the language normally used by the station on the ground may not necessarily be the language of the State in which it is located”.

6.4.8.2 In Volume II of Annex 10 to the Chicago Convention (para. 5.2.1.1.2) it is further expressed as a Recommendation that "pending the development and adoption of a more suitable form of speech for universal use in aeronautical radiotelephony communications, the English language should be used as such and should be available , on request from any aircraft station unable to comply with 5.2.1.1.1, at all stations on the ground serving designated airports and routes used by international air services".

6.4.8.3 The language(s) to be used in the portion of airspace within which the responsibility for the provision of ATS is delegated from one State to another State should be specified.

6.4.9 Promulgation

6.4.9.1 In Annex 15 to the Chicago Convention it is prescribed that "an aeronautical information service shall collect, collate, edit and publish aeronautical information concerning the entire territory of the State as well as areas in which the State is responsible for air traffic services outside its territory".

6.4.9.2 As a consequence, in the situation where a State delegates to another State the responsibility for the provision of ATS in a portion of the airspace above its territory, both the Delegating and Providing State shall agree upon the content of, and publish all relevant information regarding the portion of airspace concerned, in their Aeronautical Information Package as defined in ICAO Annex 15.

6.4.10 Air Traffic Controller Licence

6.4.10.1 With regard to air traffic controller licence, Annex 1 to the Chicago Convention prescribes that "before issuing an air traffic controller licence, a Contracting State shall require the applicant to meet the requirements of 4.4.1 (see ICAO Annex 1) and the requirements of at least one of the ratings set out in 4.5 (see ICAO Annex 1). Unlicensed State employees may operate as air traffic controllers on condition that they meet the same requirements".

6.4.10.2 In Annex 1 to the Chicago Convention it is also prescribed that "a Contracting State having issued an air traffic controller licence shall not permit the holder thereof to carry out instruction in an operational environment unless such holder has received proper authorisation from such Contracting State". Furthermore, "a Contracting State, having issued a licence, shall ensure that other Contracting States are enabled to be satisfied as to the validity of the licence".

6.4.10.3 In the situation where a State delegates to another State the responsibility for the provision of ATS in the airspace above its territory, the validity of the air traffic controller licences relevant to the provision of ATS in the portion of airspace concerned, should have been ensured. The training of ATS personnel of one Contracting State, providing ATS in the portion of airspace of the other Contracting State, shall include the requirements pertaining to the airspace concerned.

6.4.10.4 Furthermore, in Annex 1 to the Chicago Convention it is stated that "before exercising the privileges indicated in 4.5.3.1 (see ICAO Annex 1), the licence holder shall be familiar with all pertinent and current information".

6.4.10.5 Therefore, in the event of a State delegating to another State the responsibility for the provision of ATS in a portion of the airspace above its territory, the Providing State should be kept advised of all pertinent and current information regarding the portion of airspace concerned, in order to accomplish properly the requirements above.

6.4.11 Forwarding of meteorological information

6.4.11.1 According to ICAO PANS-ATM (Doc 4444) Chapter 4 “air traffic services units shall forward without delay to their associated meteorological offices, in accordance with local arrangements, meteorological information received from aircraft in flight”.

6.4.11.2 In the situation where a State delegates to another State the responsibility for the provision of ATS in a portion of the airspace above its territory, the States should establish procedures regarding the forwarding of meteorological information.

6.4.12 Contingency procedures

6.4.12.1 In the event the ATS unit of the Providing State is unable to continue the provision of ATS in the portion of airspace of the Delegating State, the appropriate procedures to be applied should be specified.

6.5 APPLICATION OF THE RULES OF THE AIR

6.5.1 In Annex 2 to the Chicago Convention it is prescribed that “*the rules of the air shall apply to aircraft bearing the nationality and registration marks of a Contracting State, wherever they may be, to the extent that they do not conflict with the rules published by the State having jurisdiction over the territory overflown”.*

6.5.2 As a consequence, in the portion of the airspace above the territory of a State where the responsibility for the provision of ATS is delegated to another State, the rules of the air published by the Delegating State shall apply. However, Article 12 of the Chicago Convention prescribes that “*each contracting State undertakes to keep its own regulations in these respects uniform, to the greatest possible extent, with those established from time to time under this Convention”.*

6.6 TERRITORIAL MATTERS

6.6.1 (1) State Aircraft, other than those of the Delegating State, may not enter that portion of the airspace where the responsibility for the provision of ATS has been delegated without prior Diplomatic Clearance or special permission from the Delegating State.

(2) For State Aircraft operating as GAT the same rules and procedures are to be applied as for Civil Air Traffic, but where necessary, special procedures should be established to permit access to the airspace. OAT shall be subject to prior co-ordination between the military unit and the ATS Unit/Authority concerned.

6.6.2 If deemed necessary, the States should have established procedures authorising the Delegating State to temporarily suspend or limit the delegation of the responsibility for the provision of ATS (see the Common Format LoA, para. 2.2.5).

6.7 ATS AIRSPACE CLASSIFICATION

6.7.1 In accordance with Annex 11 to the Chicago Convention "States shall select those airspace classes appropriate to their needs".

6.7.2 However, in the situation where a State delegates to another State the responsibility for the provision of ATS in a portion of the airspace above its territory, the ATS airspace classifications as determined by the Delegating State apply in the airspace concerned.

6.7.3 Since the airspace classification is directly related to the level of ATS provided, States might, in the situation where a State delegates to another State the responsibility for the provision of ATS in a portion of the airspace above its territory, undertake to negotiate the ATS airspace classifications to be applied in the portion of airspace concerned, in order to better accomplish the level of air traffic services requested.

6.8 AIR TRAFFIC INCIDENT INVESTIGATION

6.8.1 Regarding the applicability of Annex 13 to the Chicago Convention it is prescribed that "unless otherwise stated, the specifications in this Annex apply to activities following accidents and incidents wherever they occurred".

6.8.2 In Annex 13 to the Chicago Convention it is prescribed that "the State of Occurrence shall institute an investigation into the circumstances of the accident". Furthermore, in Annex 13 to the Chicago Convention it is expressed as a Recommendation that "the State of Occurrence should institute an investigation into the circumstances of a serious incident".

6.8.3 In Annex 13 to the Chicago Convention the terms accident, serious incident and incident are defined. In the definition of a serious incident it is noted, that the difference between an accident and a serious incident lies only in the result. A list, however not exhaustive, of serious incidents is attached to Annex 13.

6.8.4 Annex 13 to the Chicago Convention further prescribes that "any State, the facilities or services of which have been, or would normally have been, used by an aircraft prior to an accident or an incident wherever it occurred, and which has information pertinent to the investigation, shall provide such information to the State conducting the investigation".

6.8.5 Chapter 3 (Part II) of the ICAO Air Traffic Services Planning Manual (Doc 9426) is concerned with incidents specifically related to the provision of ATS and known as Air Traffic Incidents.

6.8.6 The term Air Traffic Incident is not defined, however described, according to ICAO PANS-ATM (Doc 4444), as incidents specifically related to the provision of air traffic services involving such occurrences as aircraft proximity (AIRPROX) or other serious difficulty resulting in a hazard to aircraft, caused by e.g. faulty procedures, non-compliance with procedures (PROCEDURE), or failure of ground facilities (FACILITY).

6.8.7 Air Traffic Incident Reports, intended for use by pilots and air traffic controllers and any associated information should be recorded by the ATS unit concerned and forwarded to the appropriate investigation authority. All material relevant for the investigation should be secured.

6.8.8 The initial ATS investigation is normally carried out by the ATS unit to which the Air Traffic Incident has been reported or which noted it and should contain the following information:

statements by personnel involved;
tape transcripts of relevant radio and telephone communications;
copies of flight progress strips and other relevant data, including recorded radar data, if available;
copies of the meteorological reports and forecasts relevant to the time of the incident;
technical statements concerning the operating status of equipment, if applicable;
unit findings and recommendations for corrective actions, if appropriate.

6.8.9 In the situation where a State delegates to another State the responsibility for the provision of ATS in a portion of the airspace above its territory, it normally falls within the responsibility of the ATS unit of the Providing State to accomplish the activities described in paras. 8.7 and 8.8. The further investigation is normally carried out by the relevant investigation authorities of the Delegating State.

6.8.10 In the situation where a State delegates to another State the responsibility for the provision of ATS in a portion of the airspace above its territory the following shall apply:

1. A Contracting State will institute an inquiry into the circumstances of accidents or serious incidents occurring in its territory.

2. At its request, the Delegating State shall be provided with the necessary materials from the ATS Unit/Authority of the Providing State (e.g. radar data recordings, tape transcriptions, etc.) in order to enable it to conduct an enquiry into an accident or serious incident occurring in the Delegating State's territory.

3. The Providing State shall be given the opportunity to appoint observers to be present at the inquiry and the Delegating State shall communicate the report and findings of the inquiry to that State.

6.9 CRITERIA FOR THE IDENTIFICATION OF AREAS WHERE DELEGATION OF ATS WOULD BE BENEFICIAL:

1) Geographical position of airports close to FIR boundaries;
2) Geographical position of major crossing points close to FIR boundaries;
3) Lateral protection of airways and/or predetermined routes close to FIR boundaries;
4) Optimising the use of available radar coverage;
5) Optimising the use of available radiotelephony coverage;
6) Optimising the use of available air traffic control capacity;
7) Rationalisation of airspace sectorisation, avoiding short sector crossing times;
8) Straightening of boundaries between ACCs to permit the transfer of control at clear operational boundaries;
9) Early transfer of control on unidirectional traffic flows;
10) On major traffic flows transfer of control where traffic is predominantly in level flight;
11) Avoiding multiple co-ordination between ACCs, where traffic penetrates one or several ACCs for short periods of time;
12) Ensuring operational continuity during climb and descent phases to avoid multiple co-ordination between ACCs;
13) Specific operations;
14) Optimising the ATS provided to reduce aircrew workload.

(Ref: Final Report of the EATCHIP Task Force on Airspace Structure and Management)

[Editorial Note: The numbering above does not indicate a ranking of priorities]

Annex 6A

MODEL AGREEMENT ON THE DELEGATION OF AIR TRAFFIC SERVICES

EUROCONTROL

The Model Agreement on the Delegation of Air Traffic Services aims at facilitating and harmonising the delegation of Air Traffic Services (ATS), and hence to contributing to the optimisation of airspace utilisation. The Model Agreement has been endorsed by the EUROCONTROL ATM/CNS Consultancy Group (ACG) and approved by the EUROCONTROL Provisional Council. Further to a decision of the ICAO European Air Navigation Planning Group (EANPG), the Model Agreement will also have been disseminated to interested parties in the whole ICAO EUR Region.

The Model Agreement addresses the legal and regulatory aspects of delegation of ATS, and allows the appropriate ATS Units/Authorities to negotiate and conclude Letters of Agreement containing the operational and technical aspects of delegation of ATS. It recognises the need for States to follow the EUROCONTROL Common Format, Cross-Border, Inter-Centre Letter of Agreement when concluding their operational Letters of Agreement (LoA).

Although this Model Agreement will have been distributed to States under separate cover, the Model Agreement is included here as background, informative material.

<table>
<tr><th>Text</th><th>Explanatory Notes</th></tr>
<tr><td> <u>Preamble</u> A g r e e m e n t between the Government of ......(State)
and the Government of ......…....(State) on the Delegation of Air Traffic Services </td><td></td></tr>
<tr><td>The Government of ....(State) and the Government of..........(State)
(hereinafter: “the Contracting States”)

Desiring to facilitate the safe conduct of international flight operations across their common State boundaries in the interests of the airspace users and their passengers;

For the purpose of promoting air traffic services relations between the Contracting States for their mutual benefit;

Being Parties to the Convention on International Civil Aviation, opened for signature at Chicago on December 7, 1944 and desiring to conclude an agreement for the purpose of providing Air Traffic Services according to the international Standards and Recommended Practices set out in Annex 11 to the Chicago Convention, across and beyond their respective territories;

Referring to the ECAC Institutional Strategy for ATM in Europe and the Protocol consolidating the EUROCONTROL International Convention relating to Co-operation for the Safety of Air Navigation, which was opened for signature on 27 June 1997 (the revised Convention);

Recognising that the conclusion of an agreement between States regarding the delegation of ATS shall not prejudice the principle that every State has complete and exclusive sovereignty over the airspace above its territory or the capacity of every State to exercise its prerogatives with regard to security and defence in its national airspace;

Recognising, that the aim of this agreement is to address legal and institutional aspects of the delegation of ATS and to allow lower level authorities involved to negotiate and conclude Letters of Agreement containing the specific operational and technical aspects related to these matters.

Have agreed as follows:</td><td></td></tr>
</table>

Article 1 Definitions For the purpose of this Agreement, unless otherwise stated, the term:	
1. *"Agreement*" means this Agreement, its Appendices and any amendments thereto.	*In conformity with Annex 11 of the Chicago Convention.*
2. *"Air Traffic Service*" as a generic term includes flight information service, alerting service, air traffic advisory service, air traffic control service provided by the Contracting States.	
3. *"Appropriate ATS authority"* means the relevant authority designated by the Contracting State responsible for providing air traffic services in the airspace concerned.	
4. *"Chicago Convention"* means the Convention on International Civil Aviation, opened for signature at Chicago on December 7, 1944 and includes: a) any amendment thereof that has been ratified by both Contracting States and has entered into force under Article 94a of the Convention, and b) any Annex or any amendment thereto adopted under Article 90 of the Convention, insofar as the international Standards referred to in Article 37 of the Convention in such Annex or amendment are at any given time effective for both Contracting States.	
5. *"Delegation of ATS"* means the delegation from one State (the Delegating State) to another State (the Providing State) of the responsibility for providing air traffic services in a portion of airspace extending over the territories of the former.	
6. *"GAT" or General Air Traffic* means flights conducted in accordance with the rules and provisions of ICAO. 7. *"OAT" or Operational Air Traffic* means flights which do not comply with the provisions stated for GAT and for which rules and procedures have been specified by the appropriate authorities. 8. *"Territory" in* relation to a State, has the meaning specified in Article 2 of the Chicago Convention.	*Article 2 of the Chicago Convention:* "Territory: For the purposes of this Convention the territory of a State shall be deemed to be the land areas and the territorial waters adjacent thereto under the sovereignty, suzerainty, protection or mandate of such State."

<u>Article 2</u> Authorisation to Lower Level Authorities (ATS Unit /ATS Authority) (1) The Contracting States agree that the responsibility for control of air traffic shall be transferred from an ATS unit of one State to another ATS unit in a neighbouring State, according to the provisions set forth in Annex 11 and under the terms of this Agreement. (2) The control information pertinent to the transfer shall be exchanged between the ATS units concerned having due regard to the national regulations in force and to the local circumstances. (3) The Contracting States agree that the appropriate ATS Unit/Authority of one State may provide air traffic services in a portion of the airspace of the other State, in accordance with the terms of this Agreement. (4) To that effect the Contracting States authorise their appropriate ATS Units/Authorities to conclude Letters of Agreement (LoA). (5) These Letters of Agreement (LoA) shall define the portion of airspace concerned and specify the rules and procedures to be applied in accordance with the provisions of this Agreement and shall follow the structure of the EUROCONTROL Common Format, Cross-Border, Inter-Centre Letter of Agreement (Hereinafter the *Common Format LoA*).	*Based on the provisions of Annex 11 of the Chicago Convention and the conclusions of MATSE/5.* *Paragraph 4 refers solely to paragraph 3 of Article 2. Hence the words "To that effect".* *The present Common Format LoA of EUROCONTROL will serve as a guideline for States.*
<u>Article 3</u> Application of Rules and Procedures (1) The rules and procedures pertaining to the provision of ATS in the Providing State shall apply when providing ATS in a portion of the airspace of the Delegating State. (2) The ATS Unit/Authority of the Contracting States may agree, however, that certain rules and procedures of the Delegating State pertaining to the provision of ATS will remain applicable in the airspace concerned.	***As a principle of sovereignty, the rules and procedures of the Delegating State apply in its territory. It is, however, actual practice to apply the rules and procedures pertaining to the provision of ATS of the Providing State. In the interest of safety and for the sake of efficiency, it is necessary that the air traffic controller is able to apply only one set of rules and procedures – those of the Providing State.***

Article 4 Financial Arrangements (1) Each Contracting State shall bear the costs of any activity performed by it under this Agreement, unless otherwise agreed by the Contracting States. (2) The introduction of financial arrangements requires prior written agreement between the appropriate representatives of the Contracting States.	*Generally, the delegation of ATS is in the interest of the service provider. The reason for delegation of ATS is in many cases lack of airspace to provide a proper service to the users.* *Activities involving inter alia cost-sharing or revenue sharing are subject to bilateral negotiations. Reasons for doing it could be manifold.*
Article 5 Civil Liability (1) The Providing State shall be liable for the damage caused by its negligence, or that of its agents or of any other person acting on its behalf, under the provisions of this Agreement. (2) Claims against the Providing State, its agents or any other person acting on its behalf shall be made in the courts, and subject to the law of the Providing State. (3) The Delegating State may bring an action against the Providing State to recover any compensation or costs paid or incurred as a result of loss or damage caused by the negligence of the Providing State, its agents or any other person acting on its behalf, while applying the provisions of this Agreement. The action shall be brought in the courts, and subject to the law of the Providing State.	*Provisions of this article are only applicable in the relationship between the Contracting States and do not constitute rights or obligations for third parties.*

<u>Article 6</u> Licensing and Training (1) The Contracting States agree that: (a) an air traffic controller licence issued by one Contracting State, or (b) an authorisation by a service provider, or (c) an authorisation to a unlicensed State employee to operate as an air traffic controller, is valid for the provision of air traffic services in the portion of the airspace of the other Contracting State within which the responsibility for the provision of ATS is delegated. (2) Training of ATS personnel of one Contracting State, providing ATS in the portion of airspace of the other Contracting State, shall include the requirements pertaining to the airspace concerned.	*This is actual practice which is applied by several ATS Units/Authorities in the world.* *Different airspace classifications, restricted and reserved areas and/or special regulations in the neighbouring State including military procedures should be taken into account.*
<u>Article 7</u> State Aircraft (1) State Aircraft other than those of the Delegating State may not enter that portion of airspace where the responsibility for the provision of ATS has been delegated without prior Diplomatic Clearance or special permission from the Delegating State. (2) For State aircraft operating as **GAT** the same rules and procedures are to be applied as for Civil Air Traffic, but where necessary, special procedures should be established to permit their access to the airspace. **OAT** shall be subject to prior co-ordination between the military unit and the ATS Unit/Authority concerned.	*Generally a distinction between GAT and OAT is made to reflect their different objectives. For GAT, the relevant ICAO regulations (transferred into national law) would be applicable.*

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<u>Article 8</u>

Co-ordination and Contingency Procedures
for Military and Other Reasons

(1) Letters of Agreement (LoA) shall be supplemented by co-ordination and contingency procedures established by the Units/Authorities concerned.

(2) The ATS Unit/Authority of the Providing State shall provide the appropriate military Authorities/Units of the Delegating State with pertinent flight plans and other data concerning the flights in the airspace where the responsibility for the provision of ATS has been delegated.

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The co-ordination and contingency procedures could include the following item, in accordance with Annex 11 and 2 of the Chicago Convention:
service the aircraft in the event of an emergency
steps to be taken in-flight contingencies
steps to be taken to assist the strayed aircraft
steps to be taken concerning the interception of (civil) aircraft / unlawful use of the airspace
co-ordination between military authorities and air traffic services
co-ordination of activities potentially hazardous to civil aircraft
information exchange between the appropriate civil and military authorities / units
requirements relating to the diplomatic clearances or for special permissions for State Aircraft of the other State

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<u>Article 9</u>

Publication

Contracting States shall agree upon the content of, and publish all relevant information regarding the portion of airspace, where the responsibility for the provision of ATS has been delegated, in their Aeronautical Information Package as defined in Annex 15 to the Chicago Convention.

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Article 10 Investigation of Accidents or Serious Incidents (1) A Contracting State will institute an inquiry into the circumstances of accidents or serious incidents occurring in its territory. (2) At its request, the Delegating State shall be provided with the necessary materials from the ATS Unit/Authority of the Providing State (e.g. radar data recordings, tape transcriptions, etc.) in order to enable it to conduct an inquiry into an accident or serious incident occurring in the Delegating State's territory. (3) The Providing State shall be given the opportunity to appoint observers to be present at the inquiry and the Delegating State shall communicate the report and findings of the inquiry to that State.	*In conformity with Article 26 and Annex 13 of the Chicago Convention.* *In conformity with Directive 94/56 of the European Council.* *Co-ordination between the two States concerned is in most cases necessary.*
Article 11 Dispute Resolution (1) If any dispute arises between the Contracting States regarding the interpretation or application of any provision of this Agreement, the Contracting States shall in the first place endeavour to settle it by negotiation. (2) If the Contracting States are unable to resolve any disagreement by negotiation, the dispute shall be submitted for final decision to a third party (arbitrator) designated by both Contracting States. (3) The costs of arbitration, including its fees and expenses, shall be shared equally by the Contracting States.	*The possibility that the Contracting States could elect EUROCONTROL as their arbitrator was suggested by the members involved in the drafting of this Agreement.*

Article 12 Termination/Suspension (1) This Agreement may be terminated by either Contracting State at any time by written notice to the other Contracting State. The termination shall become effective {12} months after the date of receipt of such notice by the other Contracting State.	*See Article 9 of the Chicago Convention.*
(2) In the event of war, during a period of emergency or in the interest of public safety, or in other exceptional circumstances, each Contracting State has the right to suspend or terminate the Agreement with immediate effect, and shall notify the other Contracting State accordingly. (3) The Letters of Agreement referred to in Article 2 (5) shall contain provisions regarding their suspension and termination.	*This is to meet defence requirements. If this agreement (State level) is terminated, the LoA under it will, as a consequence, be cancelled with effect from the same date of termination.*
Article 13 Entry into Force (1) This Agreement shall enter into force as soon as the Contracting States have notified each other in writing of the completion of their respective constitutional requirements. (2) This Agreement may be provisionally applied from the date of its signature.	
Article 14 Amendments (1) If a Contracting State considers it desirable to amend any provisions of this Agreement, it may request consultations with the other Contracting State. Any amendments agreed by the Contracting States shall come into force when they have been confirmed by an exchange of diplomatic notes. (2) Amendments to the Attached *Common Format LoA* may be jointly determined by direct Agreement between the appropriate ATS Units/Authorities of the Contracting States.	

Article 15 Transitional Measures for Agreements Already in Operation Agreements which are in operation on the date of entry into force of this Agreement shall be assessed for possible revision in accordance with the provisions set out in this Agreement.	*"Agreements already in operation" refers to agreements on co-ordination procedures as well as agreements at the State level.*
Article 16 ICAO Registration This Agreement shall be registered with the ICAO Council, in accordance with the provisions of Article 83 of the Chicago Convention.	
In witness whereof, the undersigned, being duly authorised by their respective Governments, have signed this Agreement. Done in duplicate at.............................. this..........day of 2000 in the English ( ) languages. In case of any divergence of interpretation of the text, the English one shall prevail. For the Government of For the Government of	

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SECTION 6

GUIDELINES FOR DELEGATION OF THE RESPONSIBILITY FOR THE PROVISION OF ATS

FINAL PAGE

SUGGESTION - COMMENTS

To propose modifications, if so required, to the present Section 6 "Guidelines for Delegation of Air Traffic Services", please contact:

Mr Anders Hallgren
EUROCONTROL
Airspace / Flow Management and Navigation Business Division (AFN BD)
Rue de la Fusée, 96
B-1130 BRUSSELS
(E-mail: anders.hallgren@eurocontrol.int)

SECTION 6 - SPONSOR: ATM PROCEDURES DEVELOPMENT SUB-GROUP

Whenever material received, in accordance with the above procedure, makes it apparent that an amendment of the present Section 6 is required, such amendment will be first discussed within the ATM Procedures Development Sub-Group (APDSG) before its adoption by the Airspace & Navigation Team (ANT).

PUBLICATION OF AMENDMENT

The agreed amendment will then be issued by EUROCONTROL in the form most convenient for its insertion in the Planning Manual.

SECTION 7

GUIDELINES FOR FREE ROUTE AIRSPACE DESIGN

SECTION CHECKLIST

Page	Edition Amendment	Date
Section 7		
7-0	Amendment 1	17/01/05
7-1	Edition 2.0	22/10/03
7-2	Edition 2.0	22/10/03

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SECTION 7

GUIDELINES FOR FREE ROUTE AIRSPACE DESIGN

7.1 INTRODUCTION

7.1.1 TBD

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SECTION 8

TERMS AND REFERENCES

SECTION CHECKLIST

Page	Edition Amendment	Date
Section 8		
8-0	Amendment 1	17/01/05
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8-2	Edition 2.0	22/10/03
8-3	Edition 2.0	22/10/03
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SECTION 8

TERMS AND REFERENCES

8.1 ACRONYMS AND ABBREVIATIONS

ACA	AUP/UUP Composition Application
ACAS	Airborne Collision Avoidance System
ACC	Area Control Centre
ACFT	Aircraft
AD	Air Defence
AFN	EUROCONTROL Airspace/Flow Management & Navigation Business Division
AGL	Above Ground Level
AIP	Aeronautical Information Publication
AIS	Aeronautical Information Service
AMC	Airspace Management Cell
AME	ATM Message Exchange
AMSL	Above Mean Sea Level
ANT	EATM Airspace & Navigation Team
AO	Aircraft Operator
AOM	Airspace Organisation & Management (one of EATM Programmes)
AOWIR	Aircraft Operator What-if Re-routing (CFMU Function)
APATSI	Airports/Air Traffic Services Interface
APD-SG	ATM Procedures Development Sub-Group of ANT
APP	Approach (Control)
APW	Airspace Penetration Warning
ARN	ATS Route Network
ARO	ATS Reporting Office
ASAS	Airborne Separation Assurance System
ASM	Airspace Management
ASM-SG	Airspace Management Sub-Group of ANT
ATC	Air Traffic Control
ATCC	Air Traffic Control Centre
ATCO	Air Traffic Control Officer
ATCU	Air Traffic Control Unit
ATFM	Air Traffic Flow Management
ATFCM	Air Traffic Flow & Capacity Management
ATM	Air Traffic Management (ATS+ASM+ATFM)
ATN	Aeronautical Telecommunications Network
ATS	Air Traffic Services
ATSU	Air Traffic Service Unit
ATZ	Aerodrome Traffic Zone
AUP	Airspace Use Plan
AW	Aerial Work
B-RNAV	Basic Area Navigation
CAA	Civil Aviation Authority
CADF	ECAC Centralised Airspace Data Function
CBA	Cross-Border Area
CDR	Conditional Route

CDM	Collaborative Decision-Making
CFMU	EUROCONTROL Central Flow Management Unit
CIP	Convergence and Implementation Plan
CNS	Communication, Navigation and Surveillance
CODA	Central Office for Delay Analysis (EUROCONTROL)
COM	Communication
CPL	Current Flight Plan
CRAM	Conditional Route Availability Message
CRCO	Central Route Charges Office (EUROCONTROL)
CTA	Control Area
CTR	Control Zone
CVFR	Controlled VFR
D	Danger Area
DAA	Dynamic Airspace Allocation
DME	Distance Measuring System
EAD	European AIS Database
EANPG	ICAO Regional European Air Navigation Planning Group
EATCHIP	European ATC Harmonisation and Integration Programme
EATM	European Air Traffic Management
EATMS	European Air Traffic Management System
EC	European Commission
ECAC	European Civil Aviation Conference
ECIP	European Convergence and Implementation Plan
eFDP	European Flight Data Processing (Programme)
ETFMS	Enhanced Tactical Flow Management System
EUR ANP	ICAO European Air Navigation Plan
EUROCAE	European Organisation for Civil Aviation Electronics
EUROCONTROL	European Organisation for the Safety of Air Navigation
FDPS	Flight Data Processing System
FIR	Flight Information Region
FIS	Flight Information Service
FFA	Free Flight Airspace
FFAS	Free Flight Airspace Regime
FL	Flight Level
FLIPCY	Flight Plan Consistency
FMP	Flow Management Position
FMS	Flight Management System
FPL	Filed Flight Plan
FRA	Free Route Airspace
FRAP	Free Route Airspace Project
FUA	Flexible Use of Airspace
GA	General Aviation
GAT	General Air Traffic
GND	Ground (Level)
GPS	Global Positioning System

IATA	International Air Transport Association
IACA	International Air Carriers Association
IAOPA	International Council of Aircraft Owner and Pilot Associations
ICAO	International Civil Aviation Organisation
IFATCA	International Federation of Air Traffic Controllers' Associations
IFPS	Integrated Initial Flight Plan Processing System
IFR	Instrument Flight Rules
IM	Information Management
IMC	Instrument Meteorological Conditions
JAA	Joint Aviation Authorities
K	Know Traffic Environment
(k)m	(kilo)metres
LCIP	Local Convergence and Implementation Plan
LoA	Letter of Agreement
MASPS	Minimum Aircraft System Performance Specification (ICAO)
MOD	Ministry of Defence
Mode S	Selective Co-operation Secondary Surveillance System
MOPS	Minimum Operational Performance Standards (Specifications) / FAA
MOT	Ministry of Transport
MSAW	Minimum Safe Altitude Warning
MSSR	Mono pulse Secondary Surveillance Radar
MTCD	Medium Term Conflict Detection
N	Intended Traffic Environment
NATO	North Atlantic Treaty Organisation
NAV	Navigation
NBD	Non-Directional Beacon
NM	Nautical Miles
NOTAM	Notice to Airmen
NSG	Navigation Sub-Group of ANT
OAT	Operational Air Traffic
OCD	Operational Concept Document
OLDI	On-Line Data Interchange
P	Prohibited Area
PANS	Procedures for Air Navigation Services (ICAO)
PCA	Prior Co-ordination Airspace
PIB	Pre-flight Information Bulletin
PMP	Programme/Project Management Plan
PPD	Pilot Preferences Downlink (data link)
P-RNAV	Precision Area Navigation
PSR	Primary Surveillance Radar
R	Restricted Area
RAP	Recognised Air Picture
RCA	Reduced Co-ordination Airspace

RDPS	Radar Data Processing System
RIA	Regulatory Impact Assessment
RNAV	Area Navigation
RND-SG	Route Network Development Sub-Group of ANT
RNP	Required Navigation Performance
RPV	Remotely Piloted Vehicle
RTF	Radio Telephony Frequency
RVSM	Reduced Vertical Separation Minimum
RWY	Runway
R&D	Research and Development
SA	Separation Assurance
SARPS	Standards and Recommended Practices (ICAO)
SID	Standard Instrument Departure (Route)
SLoA	Stakeholder Line of Action (ECIP, LCIP)
SRA	Special Rules Area
SRS	Standard Routeing Scheme
SRZ	Special Rules Zone
SSR	Secondary Surveillance Radar
STAR	Standard (Instrument) Arrival Route
STCA	Short Term Conflict Area
SUR	Surveillance
SWIM	System-Wide Information Management
TAA	Temporary Airspace Allocation
TACT	CFMU Tactical System
TIA	Traffic Information Area
TIZ	Traffic Information Zone
TMA	Terminal Control Area
TPIAS	Transition Plan for the Implementation of the Airspace Strategy
TRA	Temporary Reserved Airspace
TSA	Temporary Segregated Area
TWR	Tower
U	Unknown Traffic Environment
UAC	Upper Area Control Centre
UAV	Uninhabited Aerial Vehicle
UCAS	Uncontrolled Airspace
UHF	Ultra High Frequency (300 to 3000Mhz)
UIFR	Uncontrolled IFR
UIR	Upper Information Region
UMAS	Unmanaged Airspace
UN	United Nations
UTA	Upper Control Area
UTC	Co-ordinated Universal Time
UUP	Updated Airspace Use Plan
VFR	Visual Flight Rules
VHF	Very High Frequency (30 to 300Mhz)
VMC	Visual Meteorological Conditions
VOR	VHF (Very High Frequency) Omni-Range
WEU	Western European Union
WGS	World Geodetic Survey

8.2 EXPLANATION OF TERMS

The terms used in the EUROCONTROL Manual for Airspace Planning have the following meanings.
The ICAO definitions are identified with an **(I)** at the end of the text.

Some terms have an explanatory note in italics.

A

Aerial Work is an aircraft operation in which an aircraft is used for specialised services such as agriculture, construction, photography, surveying, observation and patrol, search and rescue, aerial advertisement, etc. **(I)**

Aeronautical Information Publication (AIP) is a publication issued by or with the authority of a State containing aeronautical information of a lasting character essential to air navigation. **(I)**

Aeronautical Information Service (AIS) A service established within the defined area of coverage responsible for the provision of aeronautical information/data necessary for the safety, regularity and efficiency of air navigation.

Such information includes the availability of air navigation facilities and services and the procedures associated with them, and must be provided to flight operations personnel and services responsible for flight information service.

Aircraft Operating Agencies (AOs) are the person, organisation or enterprise engaged in, or offering to engage in, an aircraft operation. **(I)**

In the context of the FUA Concept, "AOs" encompass all aircraft operations other than aerial work operations, that is to say commercial air transport operations and general aviation operations.

Airspace Management (ASM) is a planning function with the primary objective of maximising the utilisation of available airspace by dynamic time-sharing and, at times, the segregation of airspace among various categories of users based on short-term needs. In future systems, airspace management will also have a strategic function associated with infrastructure planning. **(I)**

In the context of the FUA Concept, airspace management is a generic term covering any management activity at the three Strategic, Pre-tactical and Tactical Levels, provided for the purpose of achieving the most efficient use of airspace based on actual needs and, where possible, avoiding permanent airspace segregation.

Airspace Management Cell (AMC) is a joint civil/military cell responsible for the day-to-day management and temporary allocation of national or sub-regional airspace under the jurisdiction of one or more ECAC state(s).

Airspace Reservation is a defined volume of airspace normally under the jurisdiction of one aviation authority and temporarily reserved, by common agreement, for exclusive use by another aviation authority. **(I)**

In the context of the FUA Concept, airspace reservation include “Temporary Reserved Area” (TRA) and “Temporary Segregated Area” (TSA).

Airspace Structures are specific portions of airspace designed to accommodate the safe operation of aircraft.

In the context of the present document, "Airspace Structures" include Controlled Airspace, ATS Route, ATC Sectors, Danger Area (D), Restricted Area (R), Prohibited Area (P), Temporary Segregated Area (TSA), Temporary Reserved Area (TRA), Cross-Border Area (CBA),.....

Airspace Use Plan (AUP) is an ASM message of NOTAM status notifying the daily decision of an Airspace Management Cell on the temporary allocation of the airspace within its jurisdiction for a specific time period, by means of a standard message format.

Air Traffic encompasses all aircraft in flight or operating on the manoeuvring area of an aerodrome. **(I)**

Air Traffic Control Clearance is an authorisation for an aircraft to proceed under conditions specified by an Air Traffic Control unit. **(I)**

For convenience, the term "Air Traffic Control Clearance" is frequently abbreviated to "ATC Clearance" or "Clearance" when used in appropriate contexts.

The abbreviated term "Clearance" may be prefixed by the words "taxi", "take-off", "departure", "en-route", "approach" or "landing" to indicate the particular portion of flight to which the Air Traffic Control Clearance relates. **(I)**

Air Traffic Control Service (ATC) is a service provided for the purpose of:

a) preventing collisions:

1) between aircraft, and

2) on the manoeuvring area between aircraft and obstructions, and

b) expediting and maintaining an orderly flow of air traffic. **(I)**

Air Traffic Flow Management (ATFM) is a service established with the objective of contributing to a safe, orderly and expeditious flow of air traffic by ensuring that ATC capacity is utilised to the maximum extent possible, and that the traffic volume is compatible with the capacities declared by the appropriate ATS authority. **(I)**

Air Traffic Flow Management Notification Message (ANM) is the official medium for the notification of ATFM measures. It is produced by the CFMU the day before the day of operation to provide a summary of planned ATFM measures and to promulgate any specific instructions or communications requirements associated with those measures.

Air Traffic Management (ATM) is the aggregation of the airborne functions and ground-based functions (air traffic services, airspace management and air traffic flow management) required to ensure the safe and efficient movement of aircraft during all phases of operations. **(I)**

The general objective of ATM is to enable aircraft operators to meet their planned departure and arrival times and to adhere to their preferred flight profiles with the minimum constraints, without compromising agreed levels of safety.

Air Traffic Services (ATS) is a generic term meaning variously, Flight Information Service (FIS), Alerting Service, Air Traffic Advisory Service, Air Traffic Control (ATC) Service (Area Control Service, Approach Control Service or Aerodrome Control Service). **(I)**

Air Traffic Services Unit (ATSU) is a generic term meaning variously, air traffic control unit, flight information centre or air traffic services reporting office. **(I)**

Airway (AWY) is a control area or portion thereof established in the form of a corridor. **(I)**

AMC-Manageable Area is an area subject to management and allocation by an AMC at Level 2.

Under the Temporary Airspace Allocation Process, these manageable areas are either formal structures entitled “TSAs or TRAs” or R and D Areas that are manageable at Level 2 in the same way as TSA/TRAs.

Approved Agencies (AAs) are units, which are authorised by a State to deal with an Airspace Management Cell for airspace allocation and utilisation matters.

Area Control Centre (ACC) is a unit established to provide air traffic control service to controlled flights in control areas under its jurisdiction. **(I)**

Area Navigation (RNAV) is a method of navigation which permits aircraft operation on any desired flight path within the coverage of station-referenced navigation aids or within the limits of the capability of self-contained aids, or a combination of these. **(I)**

ATC Clearance (see Air Traffic Control Clearance)

ATC Co-ordination is the process of communication between ATC units, or controllers within such units, of the necessary flight plan data, radar data and control information with a view to reaching an agreed course of action as the controlled flight(s) progress(es).

ATC Instructions are directives issued by air traffic control for the purpose of requiring a pilot to take a specific action. **(I)**

ATC Unit is a generic term meaning variously, area control centre (ACC), approach control office or aerodrome control tower. **(I)**

ATS Airspace (Class A to G) are airspaces of defined dimensions, alphabetically designated, within which specific types of flights may operate and for which air traffic services and rules of operation are specified. **(I)**

ATS airspaces are classified as Class A to G **(I)**.

ATS Environment Data Base is a specific part of the CFMU Data Base containing all environment data concerning airspace organisation and structure, ACC operational organisation and ATC capacities. The ATS Environment Data Base is used by the CFMU systems for the calculation of flight profiles taking account of all the airspace constraints.

ATS Reporting Office (ARO) is a unit established for the purpose of receiving reports concerning air traffic services and flight plans submitted before departure. **(I)**

ATS Route is a specified part of the airspace structure designed for channelling the flow of traffic as necessary for the provision of air traffic services. **(I)**

In the context of the FUA Concept, the term "ATS route" is used to mean variously Upper Air Route, Airway, Advisory Route, Standard Instrument Departure or Standard Arrival Route, RNAV Route, Permanent Route and Conditional Route.

C

Central Flow Management Unit (CFMU) is an EUROCONTROL Directorate established in accordance with the ICAO Centralised ATFM Organisation to provide the ATFM Service, on behalf of the participant States, in a specified part of the EUR Region.

The CFMU comprises the Flow Management Division (FMD) and the Flight Data Operations Division with the Integrated Initial Flight Plan Processing System (IFPS). For ASM purposes, the CFMU is also entrusted with the Centralised Airspace Data Function (CADF).

Centralised Airspace Data Function (CADF) is an ASM function entrusted to the CFMU by the ECAC States for extracting Conditional Route (CDR) information contained in the various national AUPs. The CADF compiles it into a single coherent list, the Conditional Route Availability Message (CRAM).

Civil/Military Co-ordination is the communication between civil and military elements (human and/or technical) necessary to ensure safe, efficient and harmonious use of the airspace.

Clearance (see Air Traffic Control Clearance) **(I)**

Cleared Flight Level (CFL) is the flight level at or to which an aircraft is authorised to proceed under conditions specified by an ATC unit.

Conditional Route (CDR) is an ATS route or a portion thereof which can be planned and used under certain specified conditions.

CDRs can be divided into different categories according to their flight-planning possibilities and the expected level of activity of the possible associated TSAs/TRAs. A CDR can be established in one or more of the three following categories:

a) *Category One - Permanently Plannable CDR,*

b) *Category Two - Non-Permanently Plannable CDR, and*

c) *Category Three - Not Plannable CDR.*

Conditional Route Availability Message (CRAM) is a special consolidated ASM message issued daily by the CADF to promulgate in one message, on behalf of ECAC States, the AMC decisions on Conditional Routes (CDRs) availability notified by the AUPs for all the ECAC area. The CRAM is used by Aircraft Operators for flight planning purposes.

Control Area (CTA) is a controlled airspace extending upwards from a specified limit above the earth. **(I)**

Control Zone (CTR) is a controlled airspace extending upwards from the surface of the earth to a specified upper limit. **(I)**

Controlled Airspace is an airspace of defined dimensions within which air traffic control services are provided to IFR flights and to VFR flights in accordance with the airspace classification. **(I)**

Controlled Airspace is a generic term, which covers ATS airspace classes A, B, C, D & E

Controlled Airspace includes Control Area (CTA), Terminal Control Area (TMA), Airway (AWY) and Control Zone (CTR). **(I)**

Controlled Flight is any flight, which is subject to an ATC clearance. **(I)**

Controller's Intentions are updated flight data, which shall be exchanged, as laid down in LoAs, either simultaneously with or before, the corresponding ATC clearance is issued.

Cross-Border Area (CBA) is a Temporary Segregated Area established over international boundaries for specific operational requirements.

Current Flight Plan (CPL) is the flight plan, including changes, if any, brought about by subsequent clearances. **(I)**

When the word "message" is used as a suffix to this term, it denotes the content and format of the current flight plan data sent from one unit to another. **(I)**

D

Danger Area (D) is an airspace of defined dimensions within which activities dangerous to the flight of aircraft may exist at specified times. **(I)**

In the context of the FUA Concept, some Danger Areas subject to management and allocation at Level 2 are established at Level 1 as "AMC-manageable areas" and identified as such in AIP.

E

En-Route Phase is that part of the flight from the end of the take-off and initial climb phase to the commencement of the approach and landing phase or more generally the portion of a flight excluding the airport phases. **(I)**

F

Filed Flight Plan (FPL) is the flight plan as filed with an ATS unit by the pilot or a designated representative, without any subsequent changes. **(I)**

When the word "message" is used as a suffix to this term, it denotes the content and format of the filed flight plan data as transmitted. **(I)**

Flexible Use of Airspace (FUA) Concept is based on the fundamental principle that airspace should not be designated as either pure civil or military airspace, but rather be considered as one continuum in which all user requirements have to be accommodated to the extent possible.

Flight Information Region (FIR) is an airspace of defined dimensions within which flight information service and alerting service are provided. **(I)**

Flight Management System (FMS) is an integrated system, consisting of airborne sensor, receiver and computer with both navigation and aircraft performance data bases, which provides performance and RNAV guidance to a display and automatic flight control system.

Flight Plan contains specified information provided to air traffic services units, relative to an intended flight or portion of a flight of an aircraft. **(I)**

Flow Management Division (FMD) is the CFMU unit responsible for the planning, co-ordination and execution of the Strategic, Pre-Tactical and Tactical Air Traffic Flow Management.

Flow Management Position (FMP) is a working position established within an ACC to ensure the necessary interface with the CEU on matters concerning the provision of the ATFM Service and the interface with national AMCs on matters concerning the ASM Service.

G

General Air Traffic (GAT) encompasses all flights conducted in accordance with the rules and procedures of ICAO and/or the national civil aviation regulations and legislation.

GAT can include military flights for which ICAO rules and procedures satisfy entirely their operational requirements.

General Aviation encompasses all civil aviation operations other than scheduled air services and non-scheduled air transport operations for remuneration or hire. ***(I)***

I

Integrated Initial Flight Plan Processing System (IFPS) is the CFMU system in charge of receiving and processing the GAT IFR flight plan data and associated update messages for the area covered by the participating States. It subsequently distributes these messages in a format, which can be received and processed automatically by ATC Flight Plan Processing Systems (FPPS) and the CEU (West) without further intervention. The IFPS is installed in two geographical sites.

K

Known Traffic Environment (KTE) is the environment within which all traffic is known to ATS.

L

Level 1 - Strategic ASM is the act of defining and reviewing, as required, the national airspace policy taking into account national and international airspace requirements.

Level 2 - Pre-Tactical ASM is the act of conducting operational management within the framework of pre-determined existing ATM structure and procedures defined in Level 1 and of reaching specific agreement between civil and military authorities involved.

Level 3 - Tactical ASM is the act, on the day of operation, of activating, de-activating or real-time reallocating of airspace allocated in Level 2 and of solving specific airspace problems and/or of individual OAT/GAT traffic situations in real-time between civil and military ATS units and/or controllers, as appropriate. This co-ordination can take place either in active or passive mode with or without action by the controller.

M

Manoeuvring Area is that part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, excluding aprons. **(I)**

N

Notice to Airmen (NOTAM) is a notice distributed by means of telecommunication containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations. **(I)**

O

Off-Route Traffic encompasses all GAT flying outside the published ATS Routes Network.

On-Route Traffic encompasses all GAT flying along the published ATS Routes Network.

Operational Air Traffic (OAT) encompasses all flights which do not comply with the provisions stated for GAT and for which rules and procedures have been specified by appropriate national authorities.

OAT can include civil flights such as test-flights, which require some deviation from ICAO rules to satisfy their operational requirements.

P

Permanent ATS Route is a permanently designated ATS route which is not subject to daily management at Level 2 by AMCs.

Pre-Tactical Civil/Military Co-ordination (see definition of Level 2 - Pre-Tactical ASM).

Prior Co-ordination Airspace (PCA) is a portion of airspace of defined dimensions within which individual GAT is permitted to fly "off-route" only after prior co-ordination initiated by GAT controllers with OAT controllers.

Prohibited Area (P) is an airspace of defined dimensions, above the land area or territorial waters of a State, within which the flight of aircraft is prohibited. **(I)**

R

Real-Time Civil/Military Co-ordination (see definition of Level 3 - Tactical ASM).

Reduced Co-ordination Airspace (RCA) is a portion of airspace of defined dimensions within which GAT is permitted to fly "off-route" without requiring GAT controllers to initiate co-ordination with OAT controllers.

Restricted Area (R) is an airspace of defined dimensions, above the land areas or territorial waters of a State, within which the flight of aircraft is restricted in accordance with specific conditions. **(I)**

In the context of the FUA Concept, some Restricted Areas are subject to management and allocation at Level 2 are established at Level 1 as “AMC-manageable areas” and identified as such in AIP.

Route Availability Document (RAD) is a strategically planned routing system for the CFMU area agreed at the annual ICAO Stratplan meeting. The RAD is designed as a part of the CFMU ATFM operation to make the most effective use of ATC capacity while allowing aircraft operators flight planning flexibility. The RAD enables ATC to maximise capacity by defining routings that provide an organised system of major traffic flows through congested areas and reduce the crossing of major flows at critical points.

S

Standard Arrival Route (STAR) is a standard ATS route identified in an approach procedure by which aircraft should proceed from the en-route phase to an initial approach fix**.**

Standard Instrument Departure Route (SID) is a standard ATS route identified in an instrument departure procedure by which aircraft should proceed from take-off phase to the en-route phase**.**

Strategic Civil/Military Co-ordination (see definition of Level 1 - Strategic ASM).

T

Tactical Civil/Military Co-ordination (see definition of Level 3 - Tactical ASM).

Temporary Airspace Allocation Process consists in the allocation process of an airspace of defined dimensions assigned for the temporary reservation (TRA/TSA) or restriction (D/R) and identified more generally as an "AMC-manageable" area. (See Section 3).

Temporary Reserved Area (TRA) is a defined volume of airspace normally under the jurisdiction of one aviation authority and **temporarily reserved**, by common agreement, for the specific use by another aviation authority and through which other traffic may be allowed to transit, under ATC clearance.

Temporary Segregated Area (TSA) is a defined volume of airspace normally under the jurisdiction of one aviation authority and **temporarily segregated**, by common agreement, for the exclusive use by another aviation authority and through which other traffic will not be allowed to transit.

In the context of the FUA Concept, all TRAs and TSAs are airspace reservations subject to management and allocation at Level 2.

Note: Pending results from consultation with ICAO on above definitions, the current TSA definition is maintained i.e. :

"***Temporary Segregated Area (TSA)*** *is an airspace of defined dimensions within which activities require the reservation of airspace for the exclusive use of specific users during a determined period of time".*

Terminal Airspace is a generic term encompassing Terminal Control Area (TMA), Control Area (CTA), Control Zone (CTR), Special Rules Zone (SRZ), Aerodrome Traffic Zone (ATZ), or any other nomenclature, such as Traffic Information Area (TIA) or Traffic Information Zone (TIZ) and Airspace Classification, used to describe the airspace around an airport.

Terminal Control Area (TMA) is a control area normally established at the confluence of ATS routes in the vicinity of one or more major aerodromes. **(I)**

U

Unknown Traffic Environment (UTE) is the environment within which not all traffic is known to ATS.

Updated Airspace Use Plan (UUP) is an ASM message of NOTAM status issued by an AMC on the day of operation to update AUP information.

8.3 REFERENCES AND SOURCE DOCUMENTS

EUROCONTROL Documentation

Final Report of the Task Force on Airspace Structure and Management.
(EUROCONTROL Doc 92.10.13 - July 1992)

Report on the Organisational Structures and Procedures Required for the Application of the Concept of the Flexible Use of Airspace.
(EUROCONTROL Doc 94.70.08 - March 1994)

Report on Route Network Development and Associated Sectorisation Improvements in the ECAC Area.

(EUROCONTROL Doc 95.70.05 - January 1995)

Functional Specifications for System Support for Airspace Management and Civil/Military Co-ordination.
(EUROCONTROL Document DPS.ET1.ST10.2000-FS-01-00 - 15 May 1996)

Guidance Document for the Implementation of the Flexible Use of Airspace Concept.
(EUROCONTROL Document ASM.ET1.ST08.5000-GUI-02-00 – 18 August 2003)

ATS Data Exchange Presentation (ADEXP)
(EUROCONTROL Standard Document DPS-ET1-ST09-STD-01-00)

EUROCONTROL Airspace Strategy for the ECAC States
(EUROCONTROL Document ASM.ET1.ST03.4000-EAS-01-00 – 18 January 2001) .

Transition Plan for the Implementation of the EUROCONTROL Airspace Strategy for the ECAC States (EUROCONTROL Document ASM.ET1.ST03.4000-TPIAS-01-01 – 19 April 2002)

EUROCONTROL Handbook for Airspace Management
(EUROCONTROL Document ASM.ET1.ST08.5000.HBK-02-00 – 22 October 2003)

ICAO Documentation

Annex 2	Rules of the Air
Annex 11	Air Traffic Services
Annex 15	Aeronautical Information Services
Doc. 4444	PANS – ATM/501
Doc. 7754	EUR Air Navigation Plan
Doc. 8126	Aeronautical Information Services Manual
Doc. 8168	PANS – OPS/611
Doc. 9426	Air Traffic Services Planning Manual
Doc. 9554	Manual Concerning Safety Measures Relating to Military Activities Potentially Hazardous to Civil Aircraft Operations
EUR Doc 001	Guidance Material Relating to the Implementation of Area Navigation (RNAV) in the EUR Region

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