

# **Infraestructures del Transport Aeri**

## **Airspace Management (ASM)**

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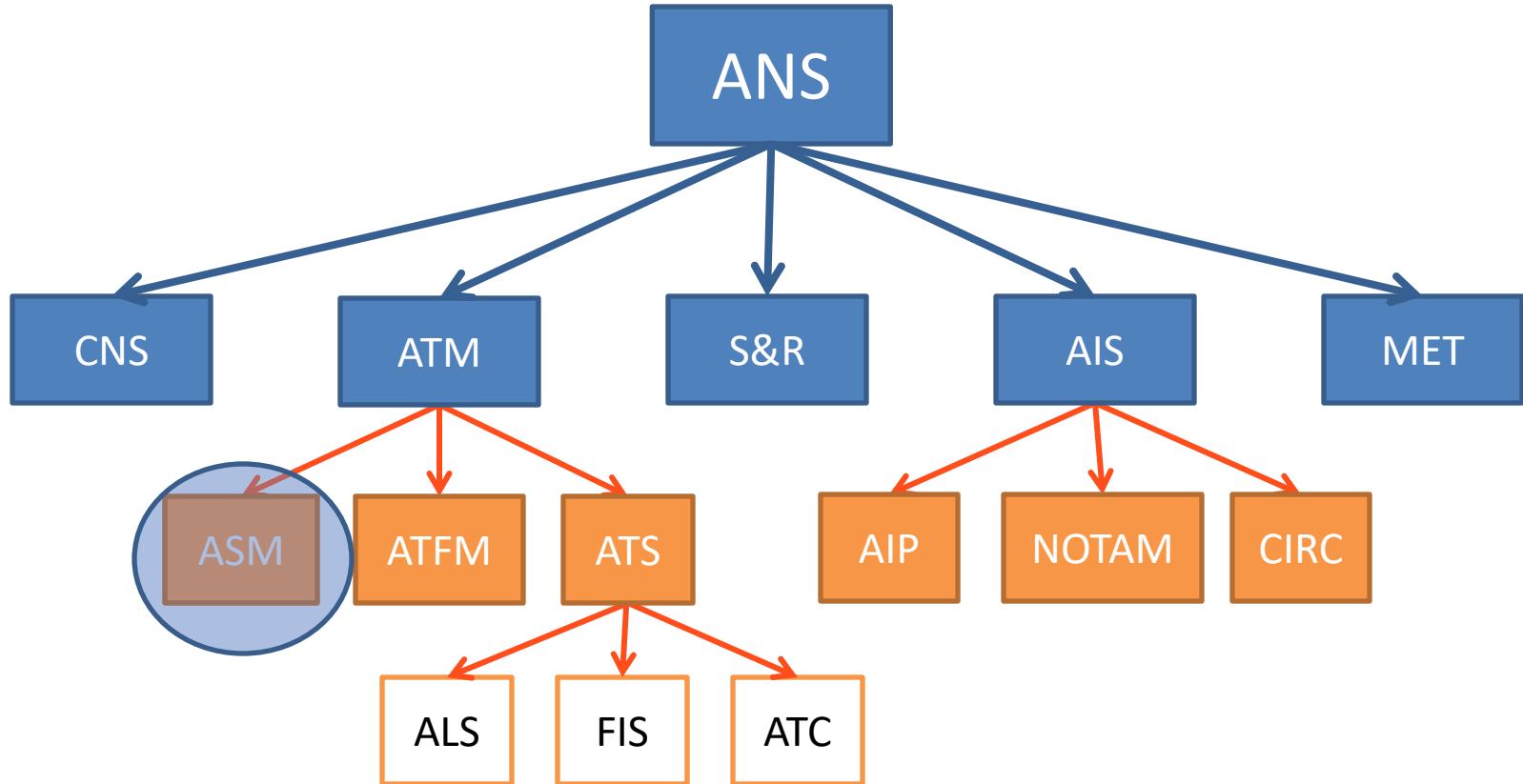
**September 2019 – Version 4.0**



Escola d'Enginyeria de Telecomunicació  
i Aeroespacial de Castelldefels

UNIVERSITAT POLITÈCNICA DE CATALUNYA

# Introduction



ANS: Air Navigation Services

CNS: Communications, Navigation and Surveillance

ATM: Air Traffic Management

S&R: Search and Rescue

AIS: Air Information Services

MET: Meteorological Services

ASM: AirSpace Management

ATFM: Air Traffic Flow Management

ATS: Air Traffic Services

AIP: Aeronautical Information Publications

NOTAM: Notices to Airmen

CIRC: Circulars

ALS: Alert Services

FIS: Flight Information Services

ATC: Air Traffic Control

# Airspace Management (ASM)

- Development of ATS Routes and TMA procedures
- Designation of airspace types and classes
- Design of ATS sectorisations
- Airspace design and modelling
- Analysis, estimation and allocation of ATS (sector) capacities
- Civil/military coordination

Depends on CNS  
infrastructure!



Just few examples:

- Radar control vs. procedure control
- Radionavigation aids infrastructure?
- RNAV coverage?
- ASAS applications?
- VHF availability and coverage?
- CPDL implemented?
- ...

# Airspace Management (ASM)

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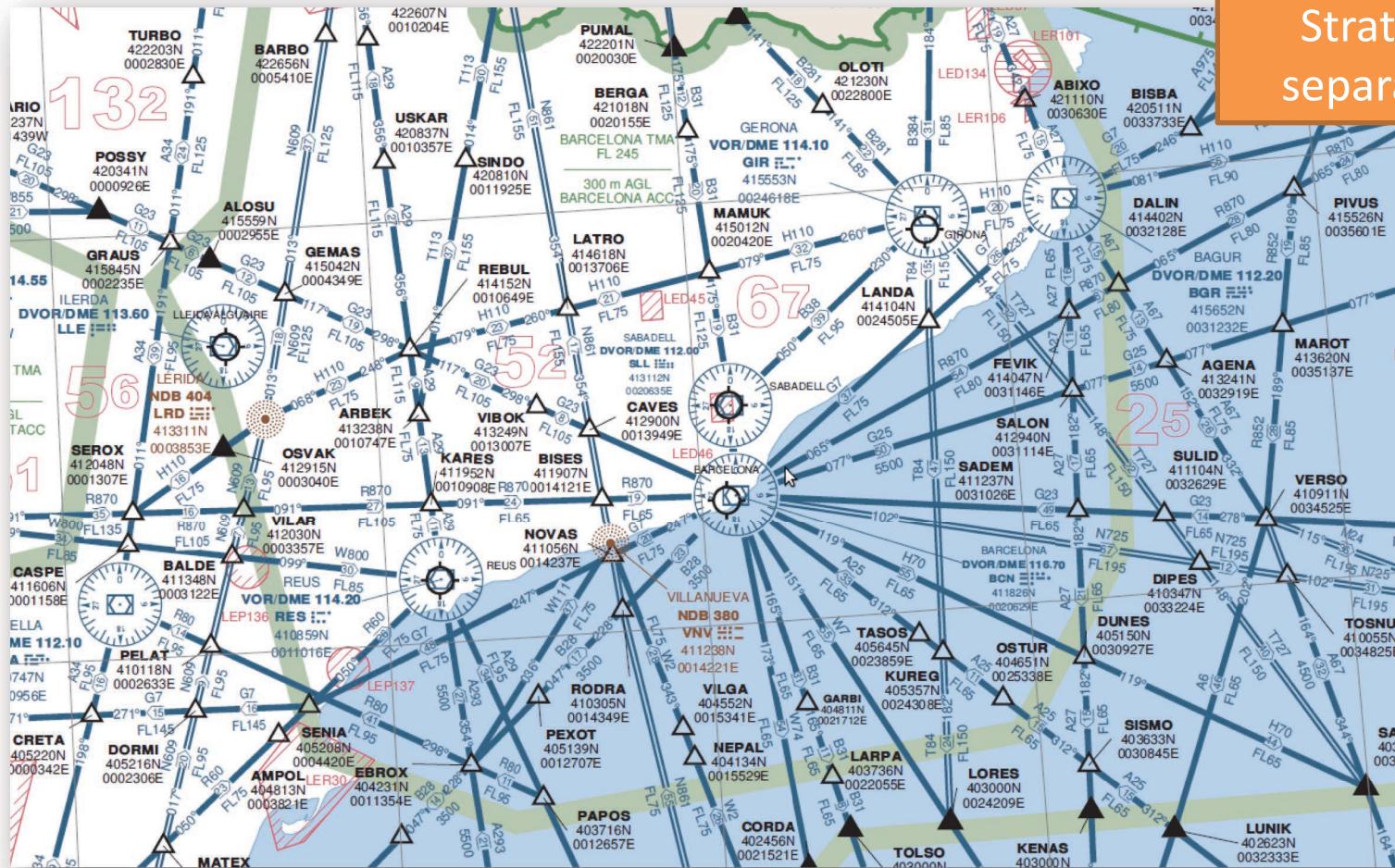
**ASM can improve air transportation efficiency by:**

- Creating more direct routings
- Supporting an interoperable infrastructure to facilitate re-routings
- Managing modular ATC sector schemes
- Enhancing civil-military concepts of operations
- (In Europe) facilitating the creation of Function Airspace Blocks
- ...



# Development of ATS routes

Example: High-altitude IFR ATS routes above Catalonia



Strategic separation

ATS: Air Traffic Services

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# Development of ATS routes

Example: **High-altitude IFR ATS routes in the continental USA**



ATS: Air Traffic Services

# Development of ATS routes

## Cruising Altitudes

Strategic separation

### VFR Cruising Altitudes

Example

4,500  
6,500  
8,500

VFR  
Even  
1000's  
+500'

359° 0°  
180° 179°

Example

3,500  
5,500  
7,500

VFR  
Odd  
1000's  
+500'

Magnetic Track  
Above 3000' AGL

### IFR Cruising Altitudes

Example

4,000  
6,000  
8,000

IFR  
Even  
1000's

359° 0°  
180° 179°

Example

5,000  
7,000  
9,000

IFR  
Odd  
1000's

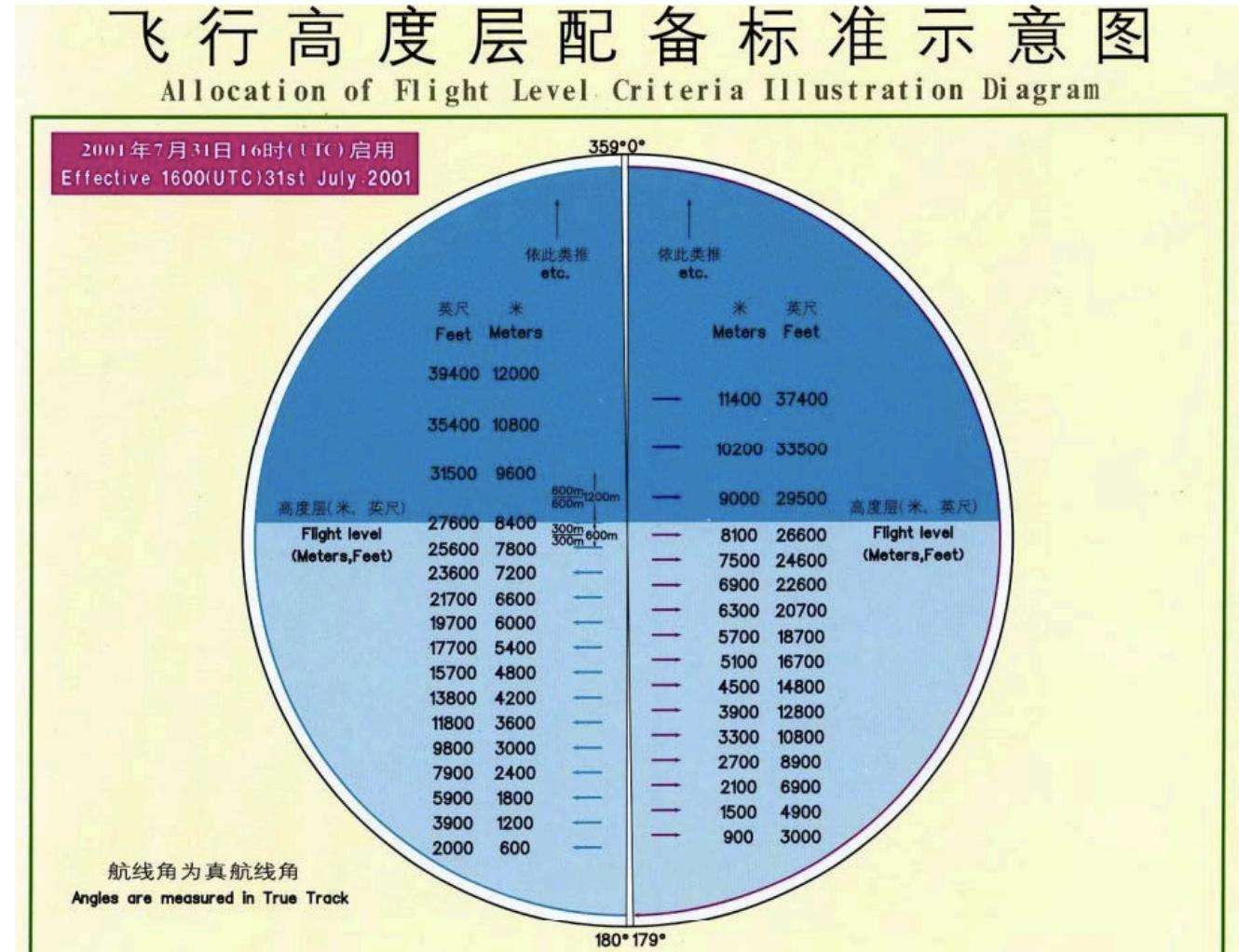
Magnetic Track  
Above 3000' AGL

ICAO Annex 2: Rules of the Air – Appendix 3

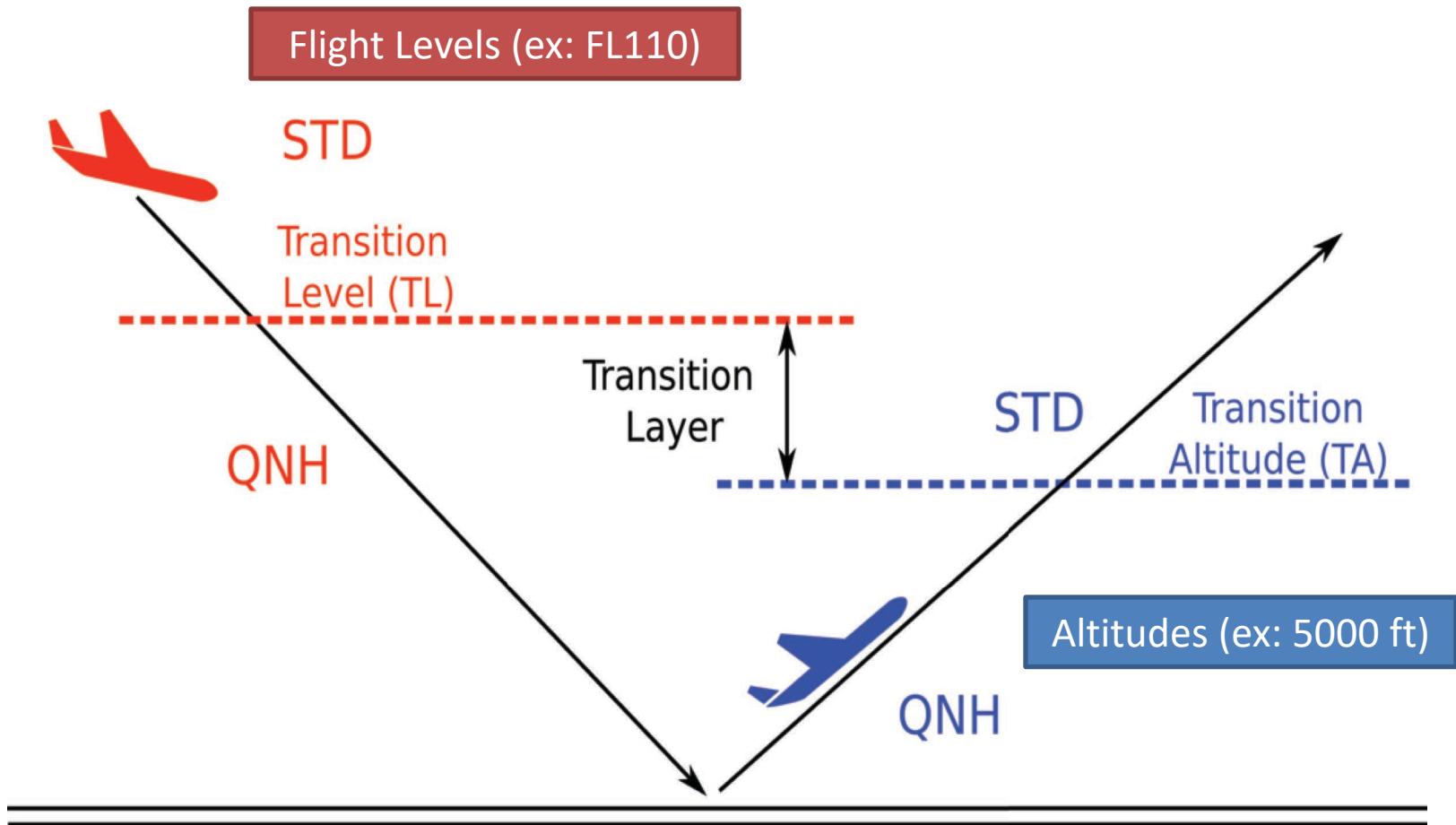
Note: National regulations may differ from ICAO standards!

# Development of ATS routes

## Cruising Altitudes

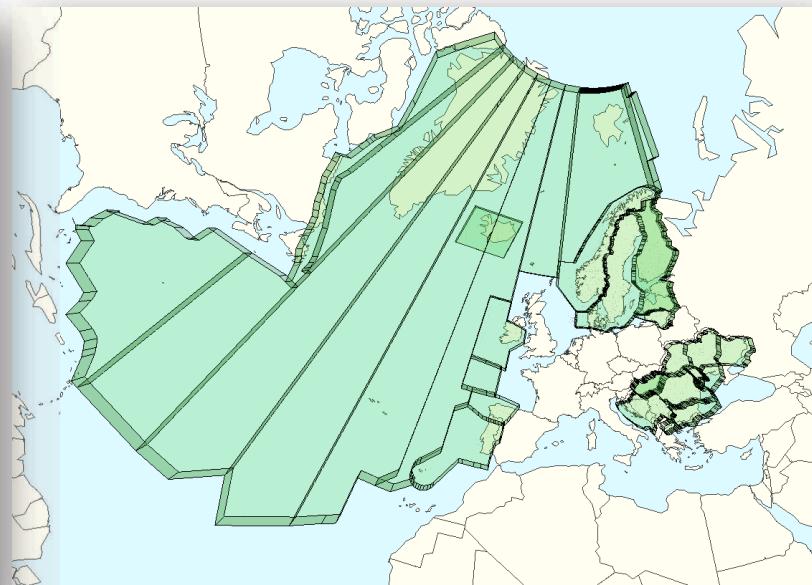
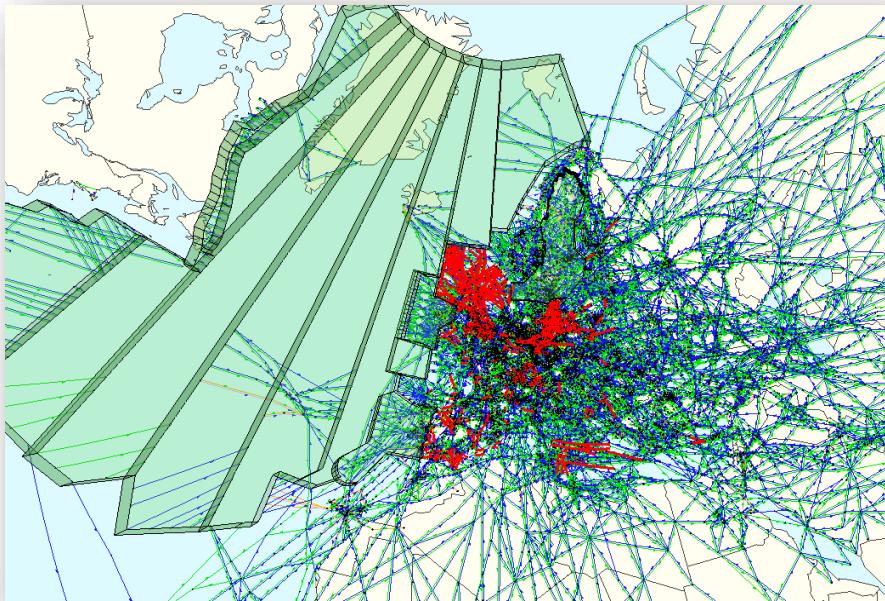


# Remember the basics of altimetry?



# Development of ATS routes

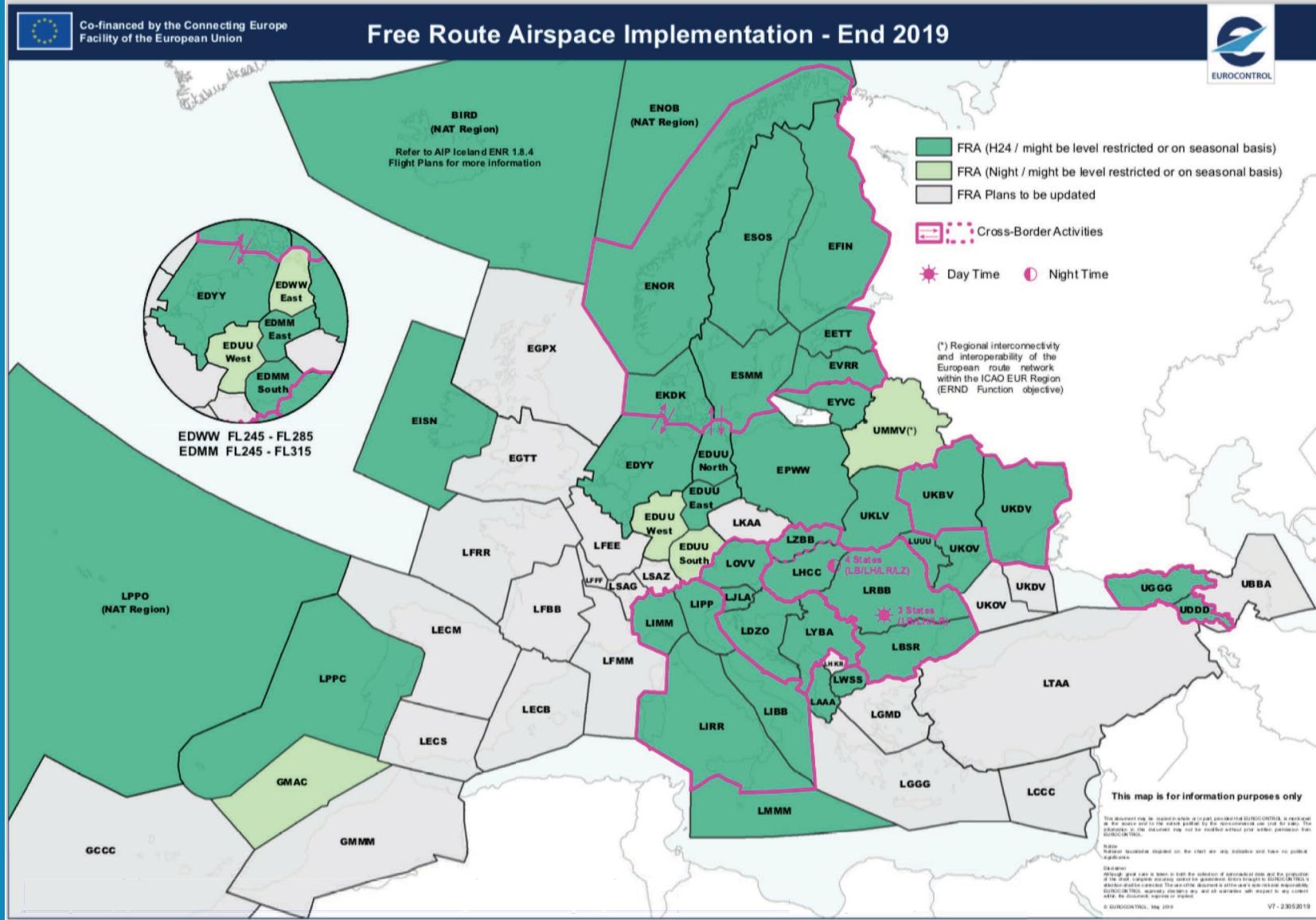
Example: Free-route areas in Europe



The operator can freely plan routes between entry and exit points without reference to ATS route network.

Note: some free-route areas are only active in night periods and/or during weekends

# Development of ATS routes



# Development of ATS routes

## Example: North Atlantic Operations

- Two major alternating flows exist (due to passenger demand, time zone differences and airport noise constraints):
  - Westbound flow departing Europe in the morning
  - Eastbound flow departing North America in the evening
- North Atlantic airspace is “in principle” a *free-route* area, but...
- Due to large horizontal separation and limited height band: North Atlantic airspace is congested at peak hours!

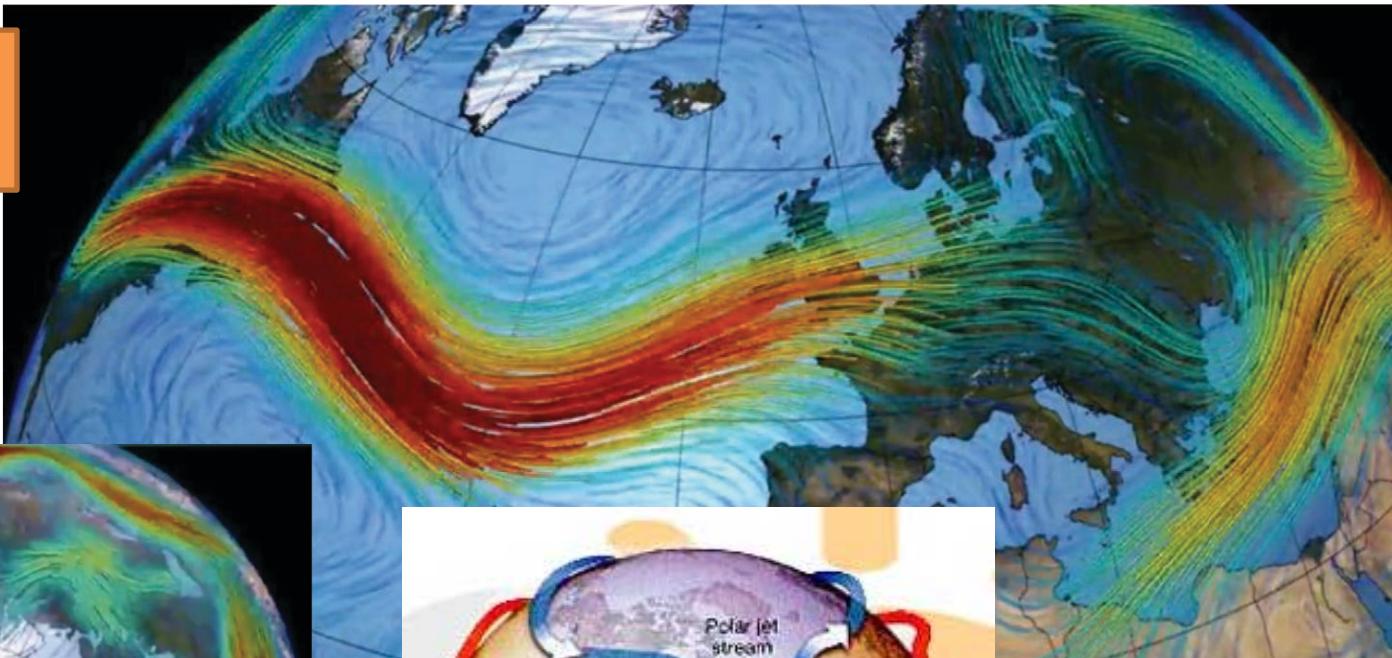
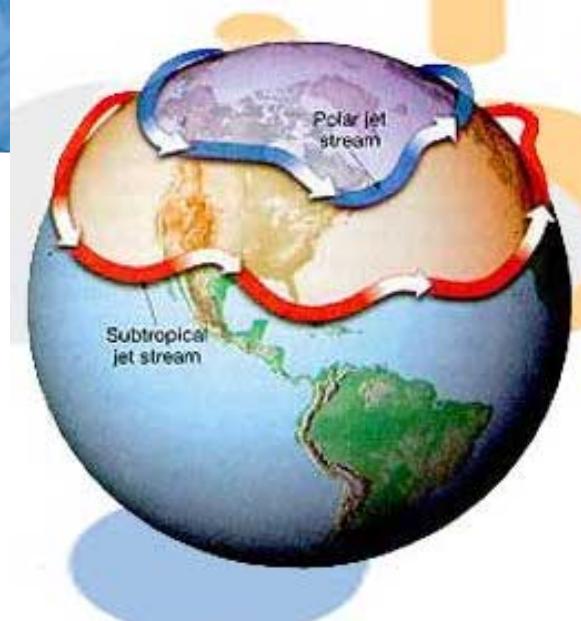
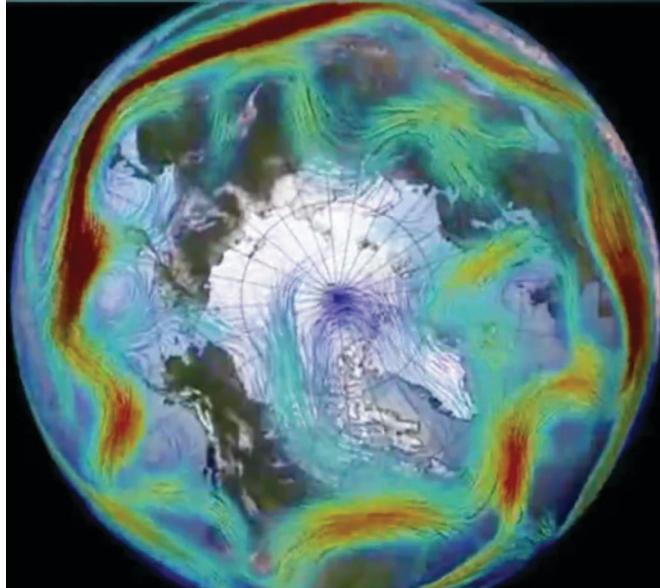
Definition of an Organised Tracks System (OTS) or  
North Atlantic Track System (NAT)



# Development of ATS routes

## Example: North Atlantic Operations

Jet Stream

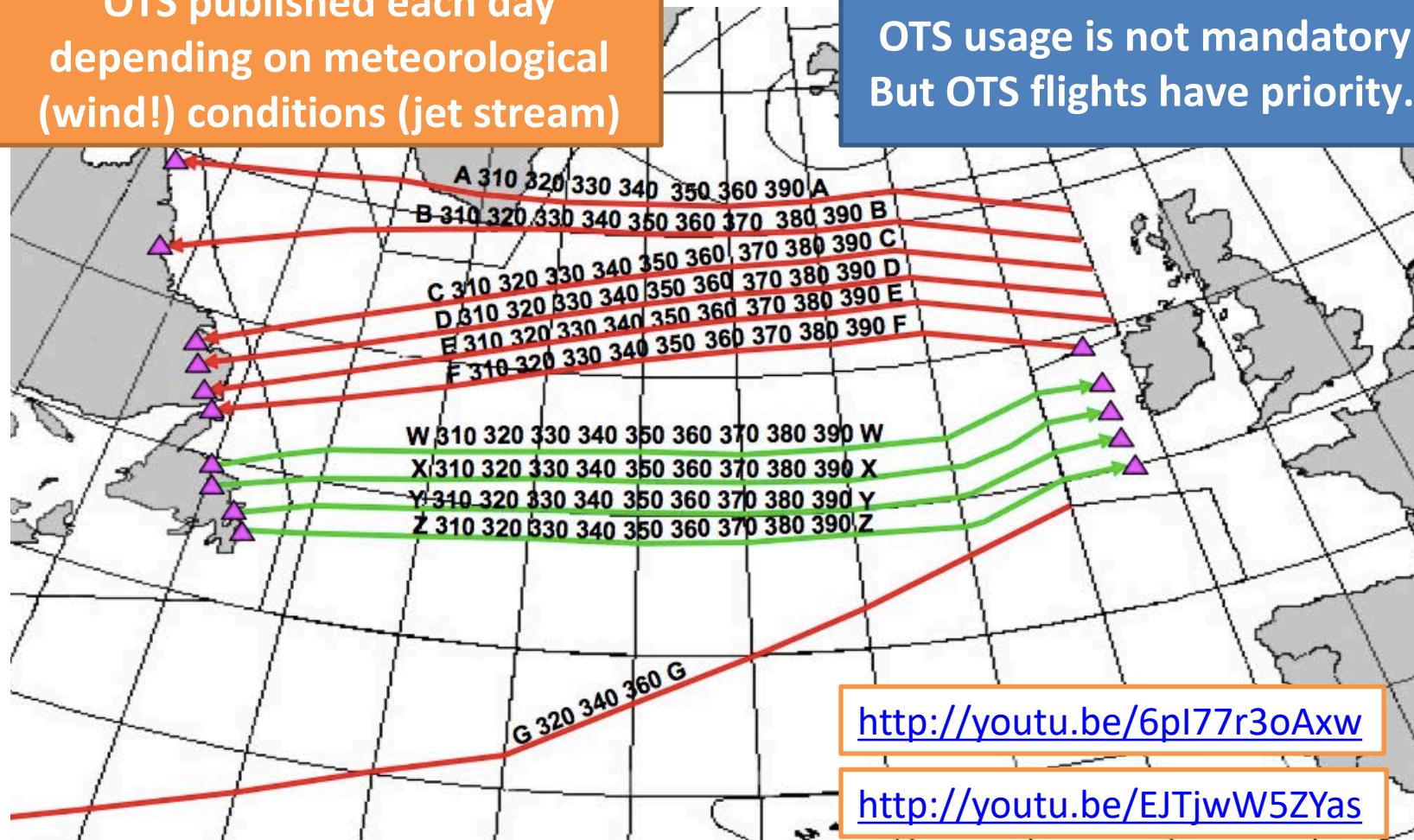


# Development of ATS routes

## Example: North Atlantic Operations

OTS published each day  
depending on meteorological  
(wind!) conditions (jet stream)

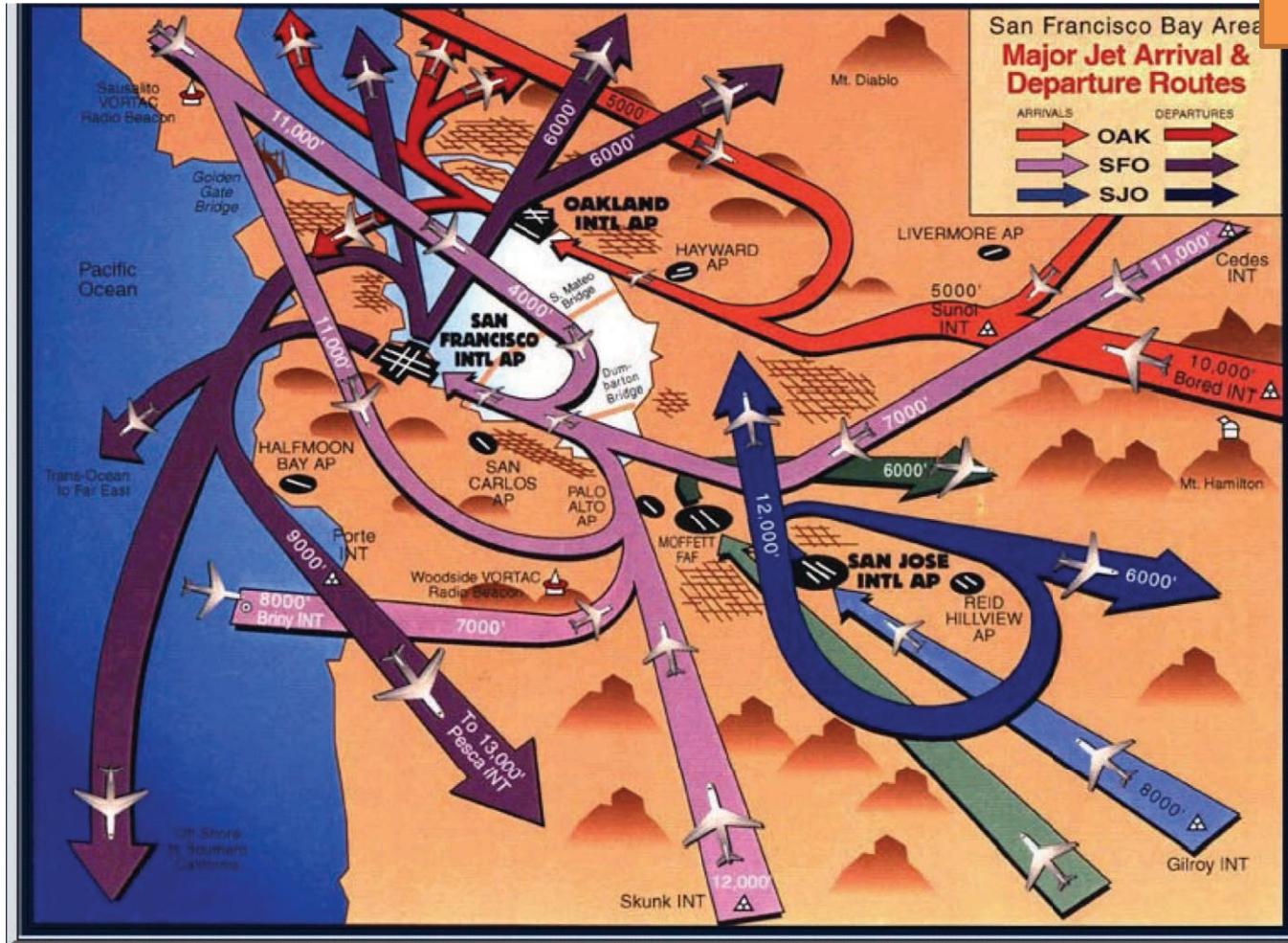
OTS usage is not mandatory!  
But OTS flights have priority...



# Development of TMA procedures

Example:  
**BAY TRACON West Plan Traffic Flow**

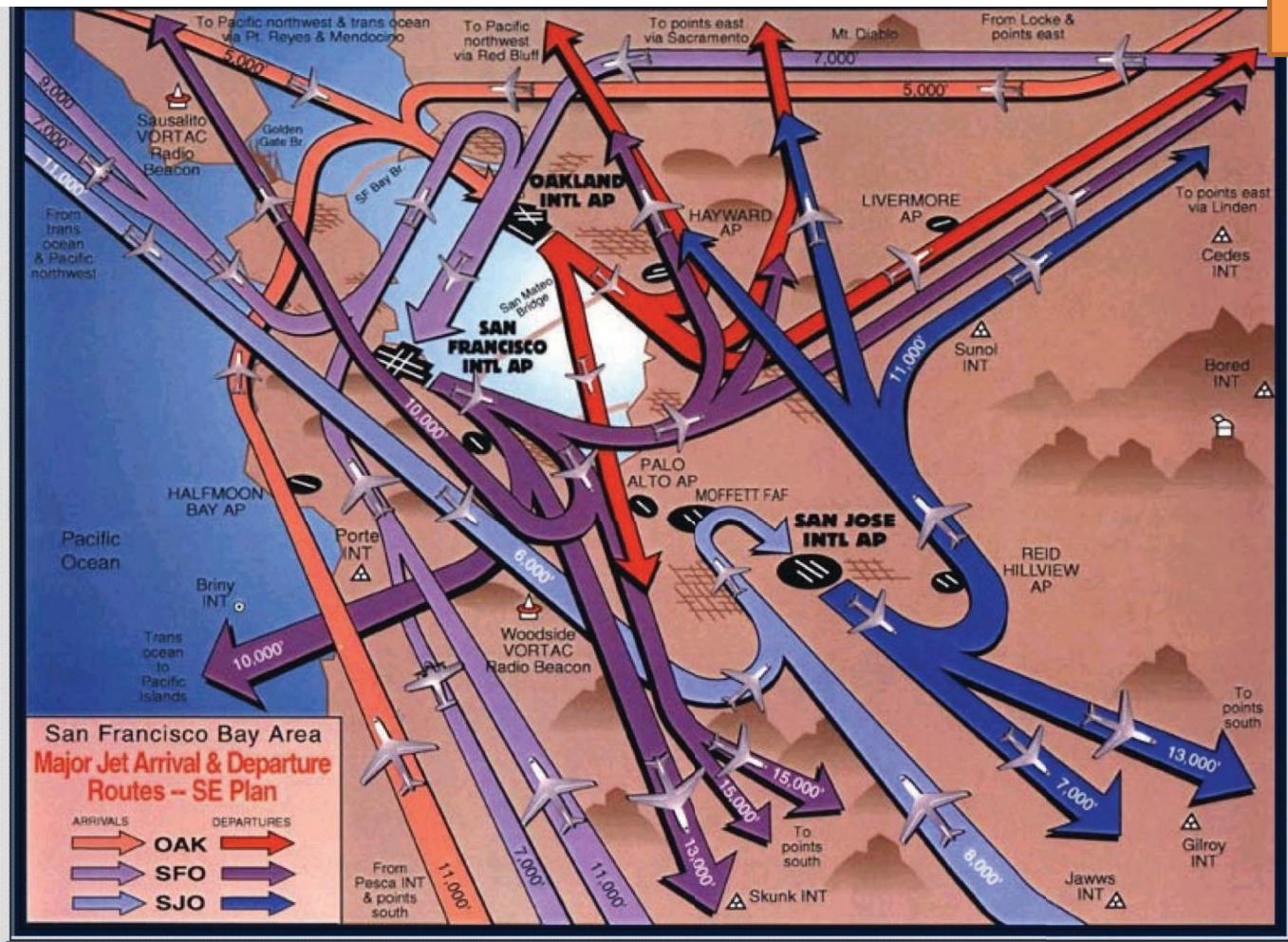
Strategic separation



# Development of TMA procedures

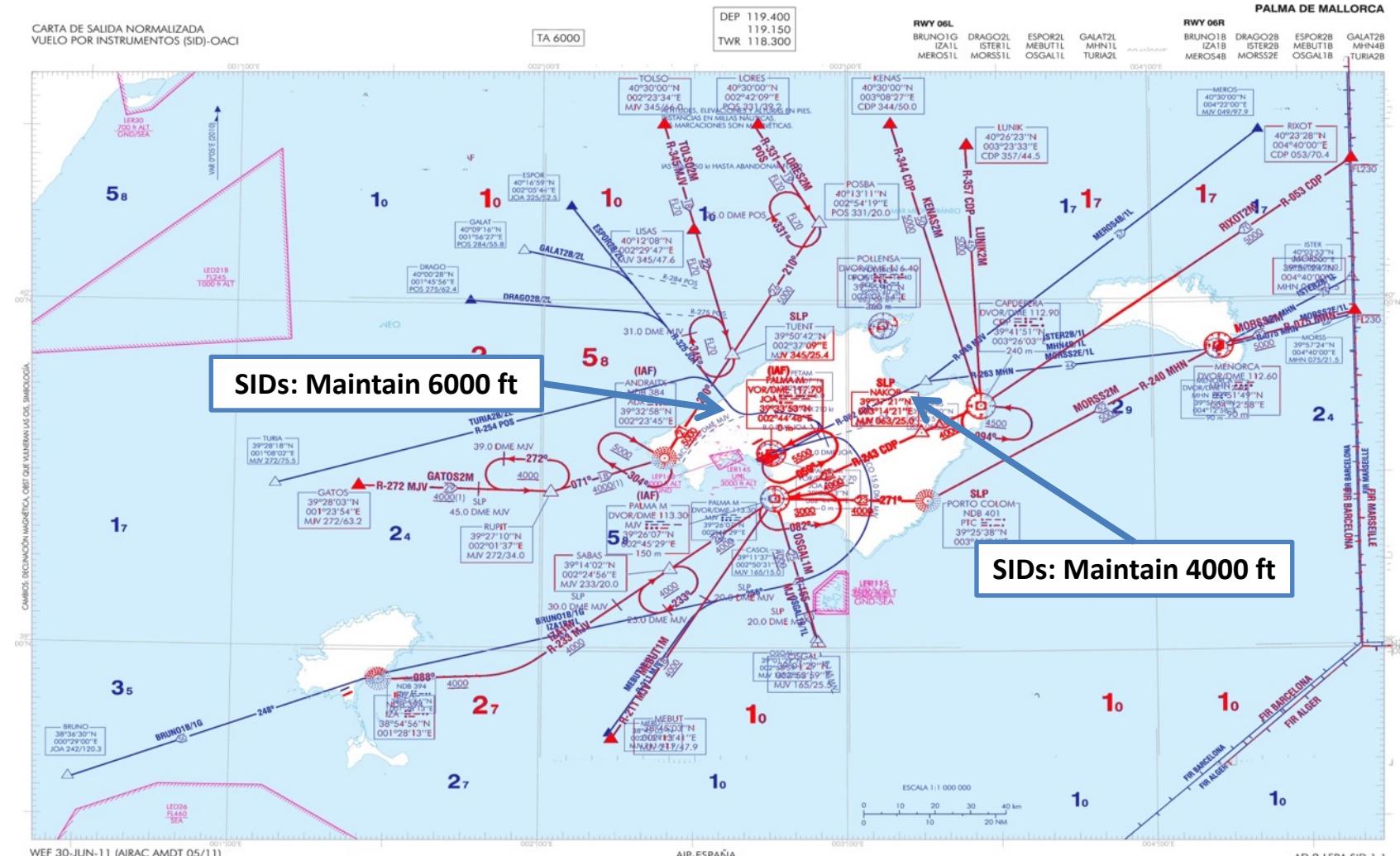
# **Example: BAY TRACON East Plan Traffic Flow**

# Strategic separation



# Development of TMA procedures

## **Example1: Palma de Mallorca IFR SIDs and STARs strategic separation**



SID: Standard Instrumental Departure - STAR: Standard Terminal Arrival Route

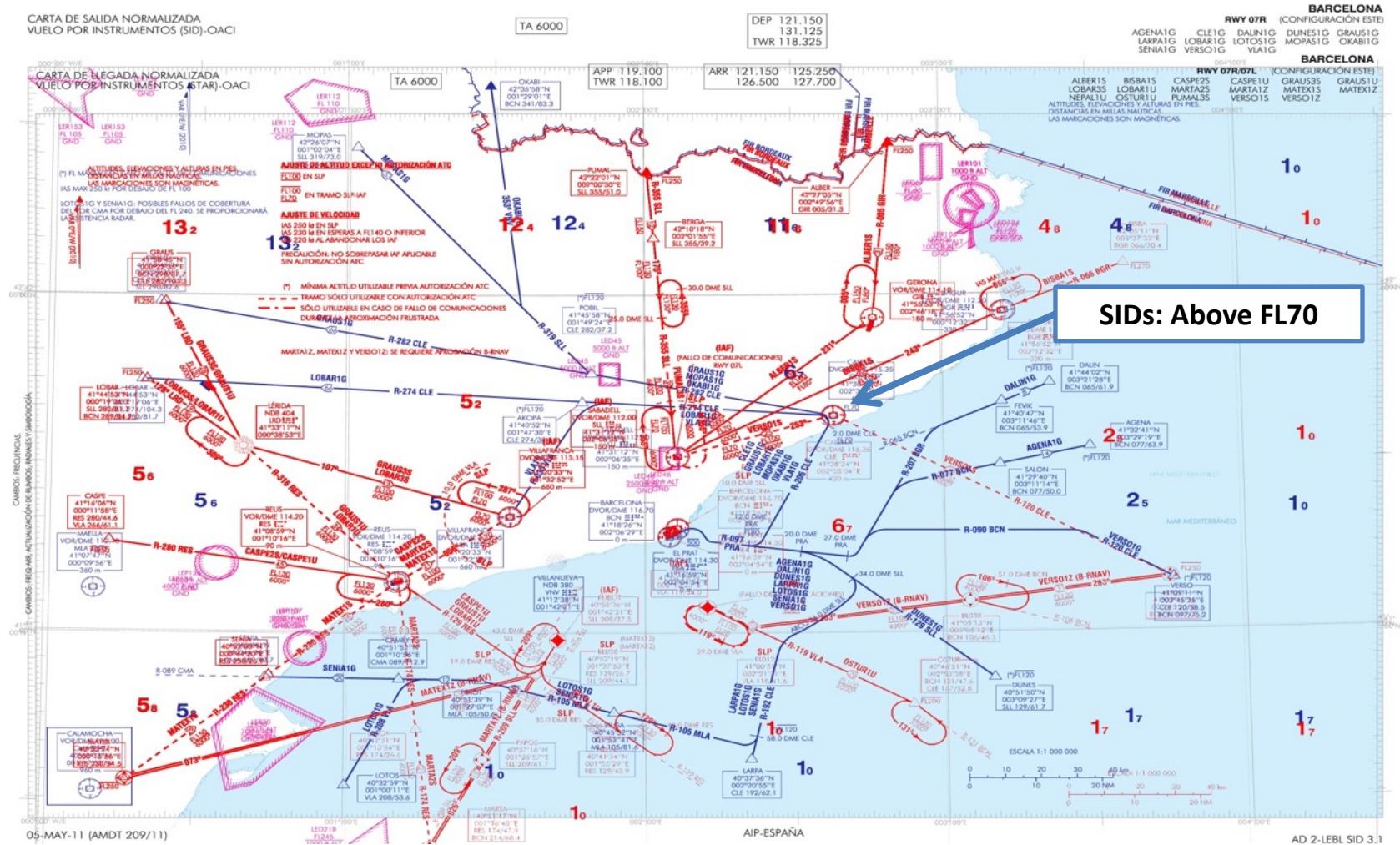
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# Development of TMA procedures

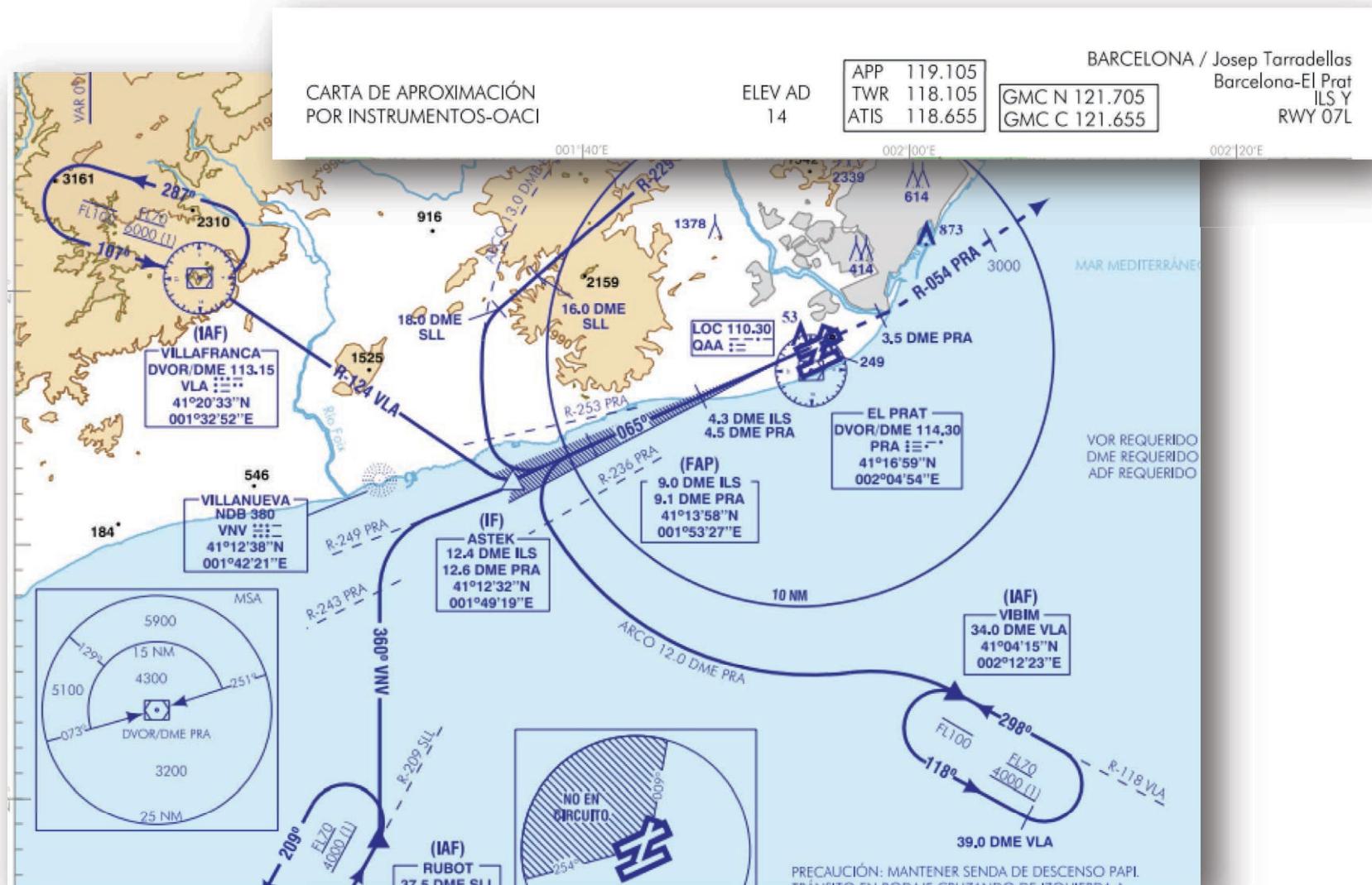
## **Example2: Barcelona IFR SIDs and STARs strategic separation**



SID: Standard Instrumental Departure - STAR: Standard Terminal Arrival Route

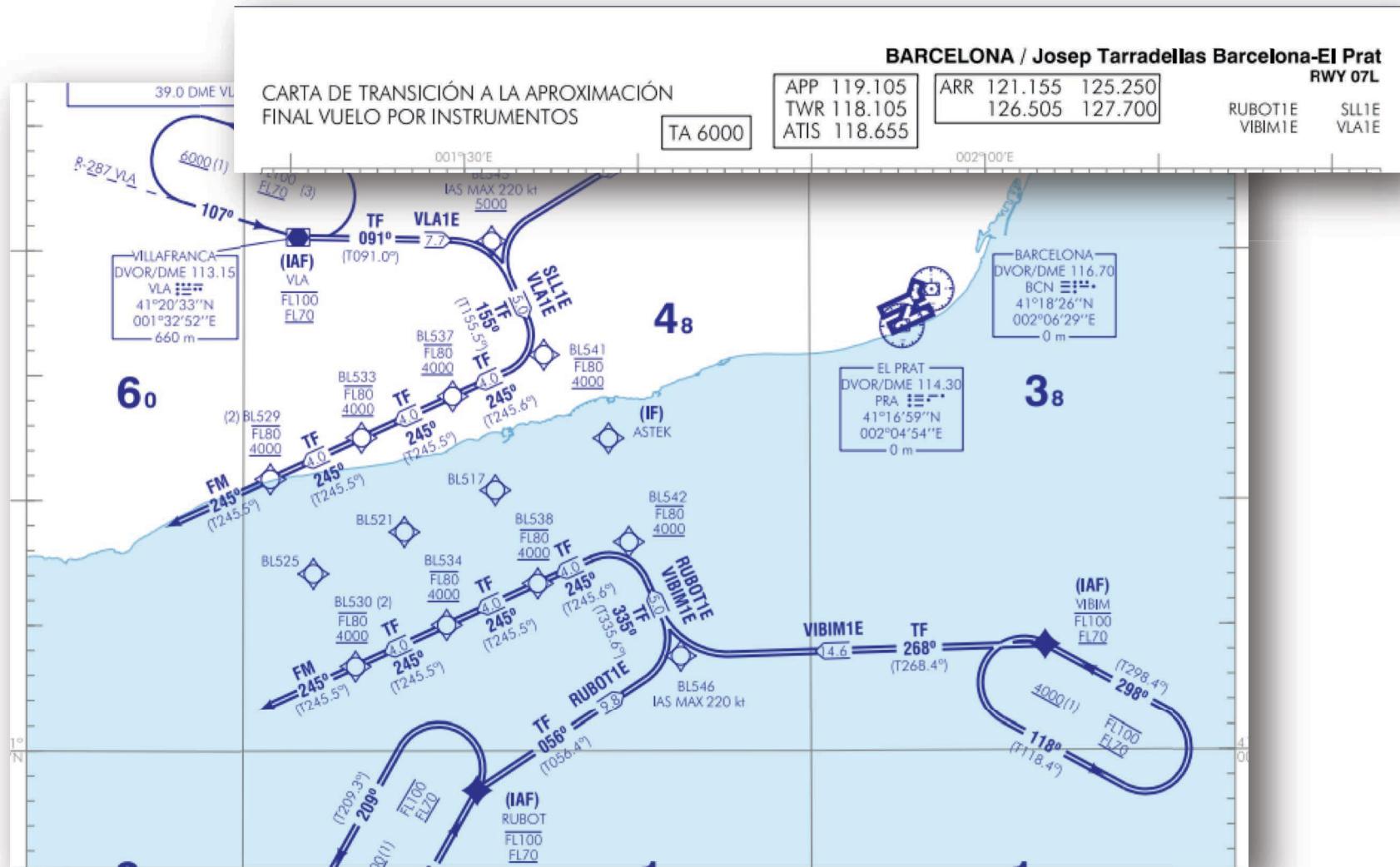
# Development of TMA procedures

## Example 3: (Old) Barcelona approaches to RWY 07L



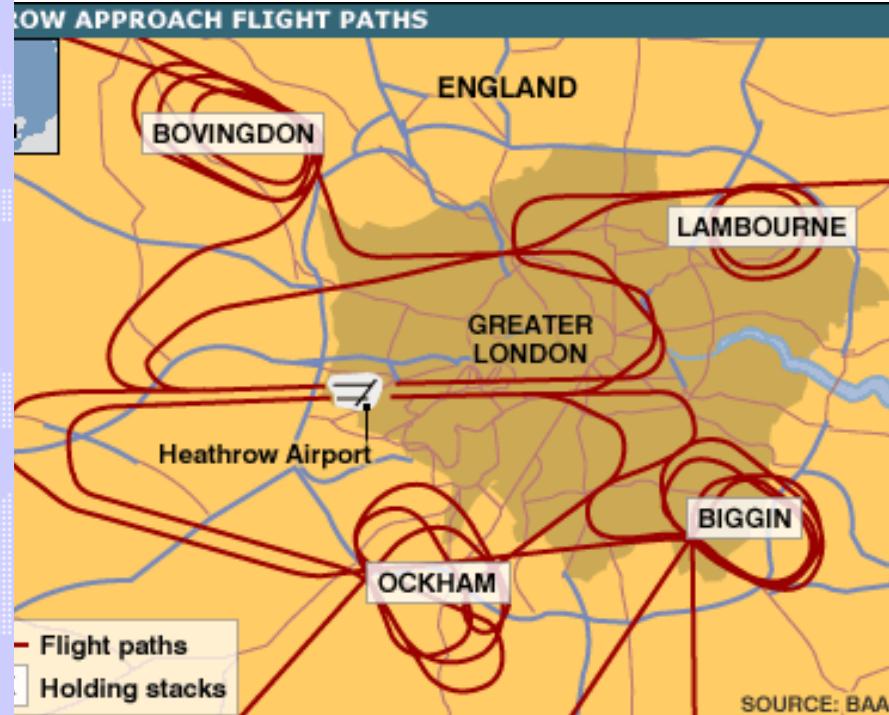
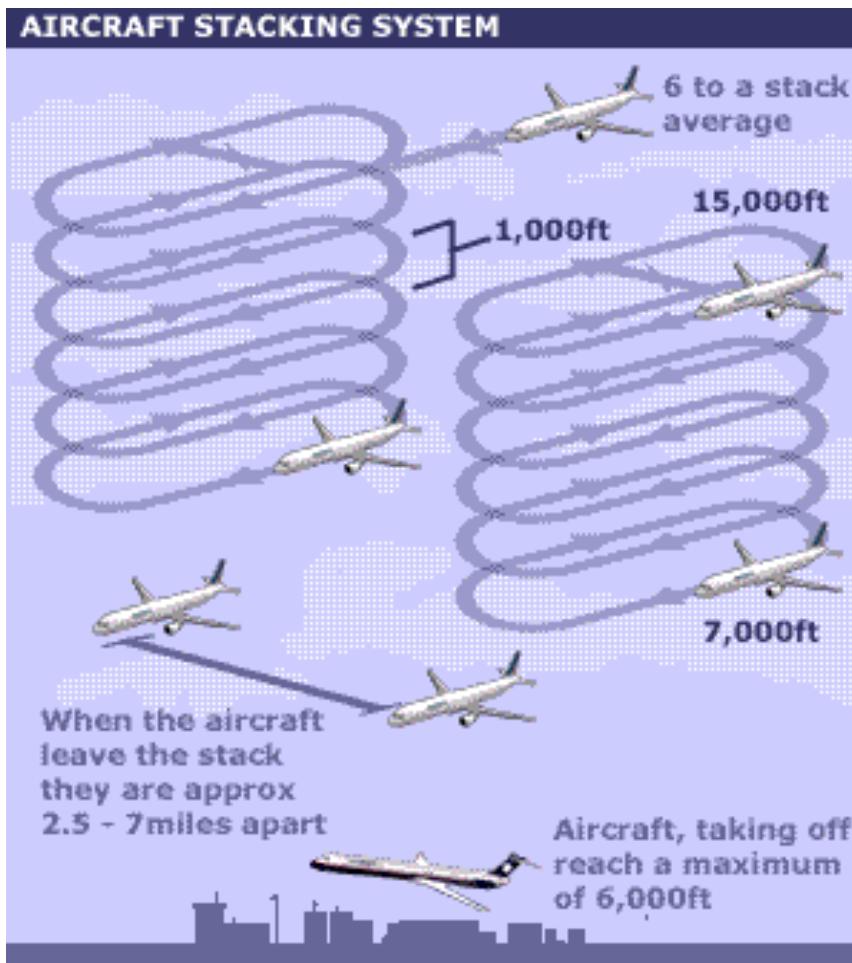
# Development of TMA procedures

Example 3: New Barcelona IFR transitions to RWY07L final using tromboning



# Development of TMA procedures

Example 3: Heathrow IFR arrival/departures strategic separation



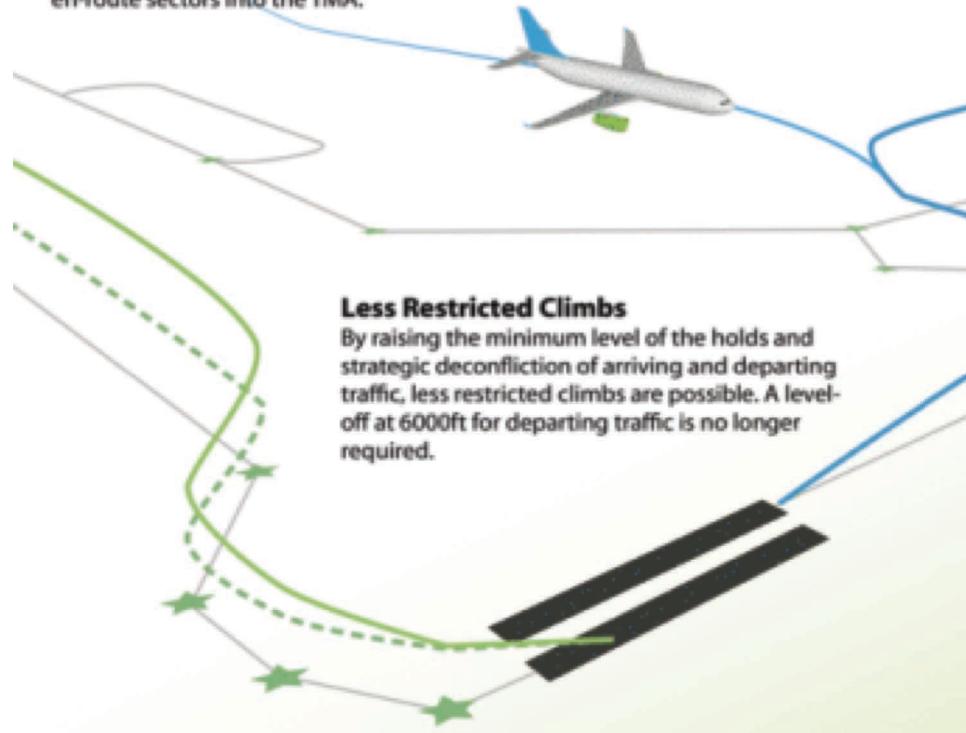
**Heathrow separation minimas:**  
<http://youtu.be/1SrqFtrARuc>  
(video In spanish)

# Terminal Procedures

## Example 4: Heathrow new ERAT project ([www.erat.aero](http://www.erat.aero))

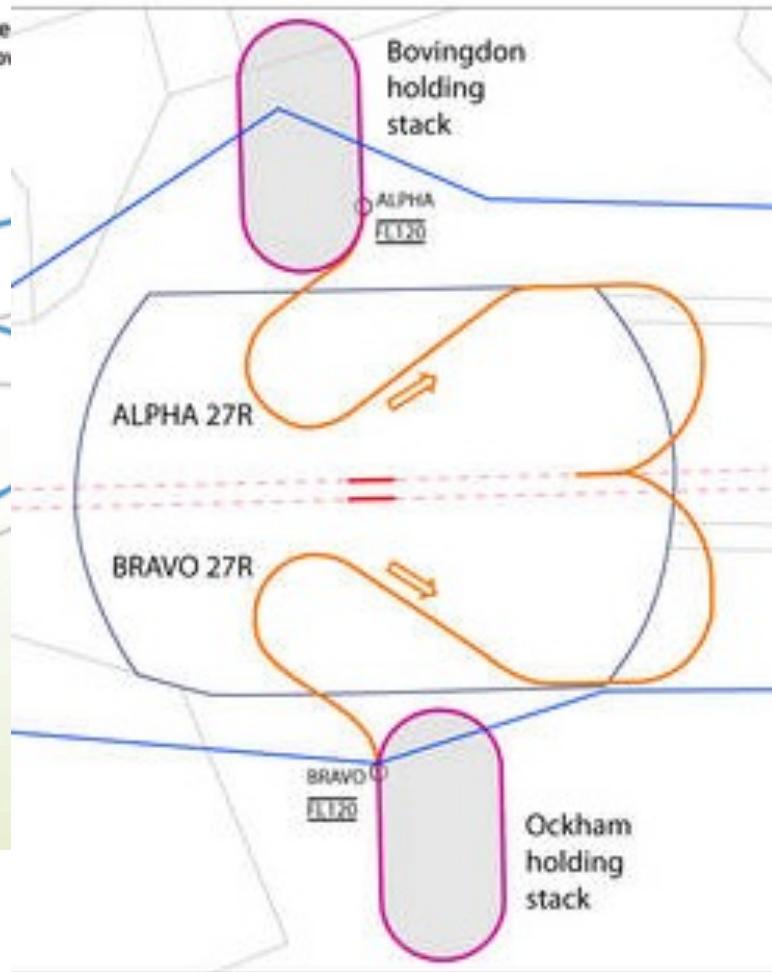
### Arrival Manager

The arrival manager (AMAN) is a key enabler for the ERAT concept at London Heathrow and delivers a smoothed and metered flow of traffic from en-route sectors into the TMA.



### High-level Stack Holding

The AMAN reduces the use of the levels are required, which are more levels to save fuel.



### ERAT Heart 1a concept

<http://youtu.be/e0C7SR1gSs0>

# Airspace types and classes

## Controlled Airspace

- ATS clearance required to enter/exit the airspace
- *Separation or traffic information* provided by Air Traffic Controllers

## Non-controlled airspace

- **No** ATS clearance required to enter/exit the airspace
- *Separation or traffic information* in general **not** provided

ATS: Air Traffic Services

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# Airspace types and classes

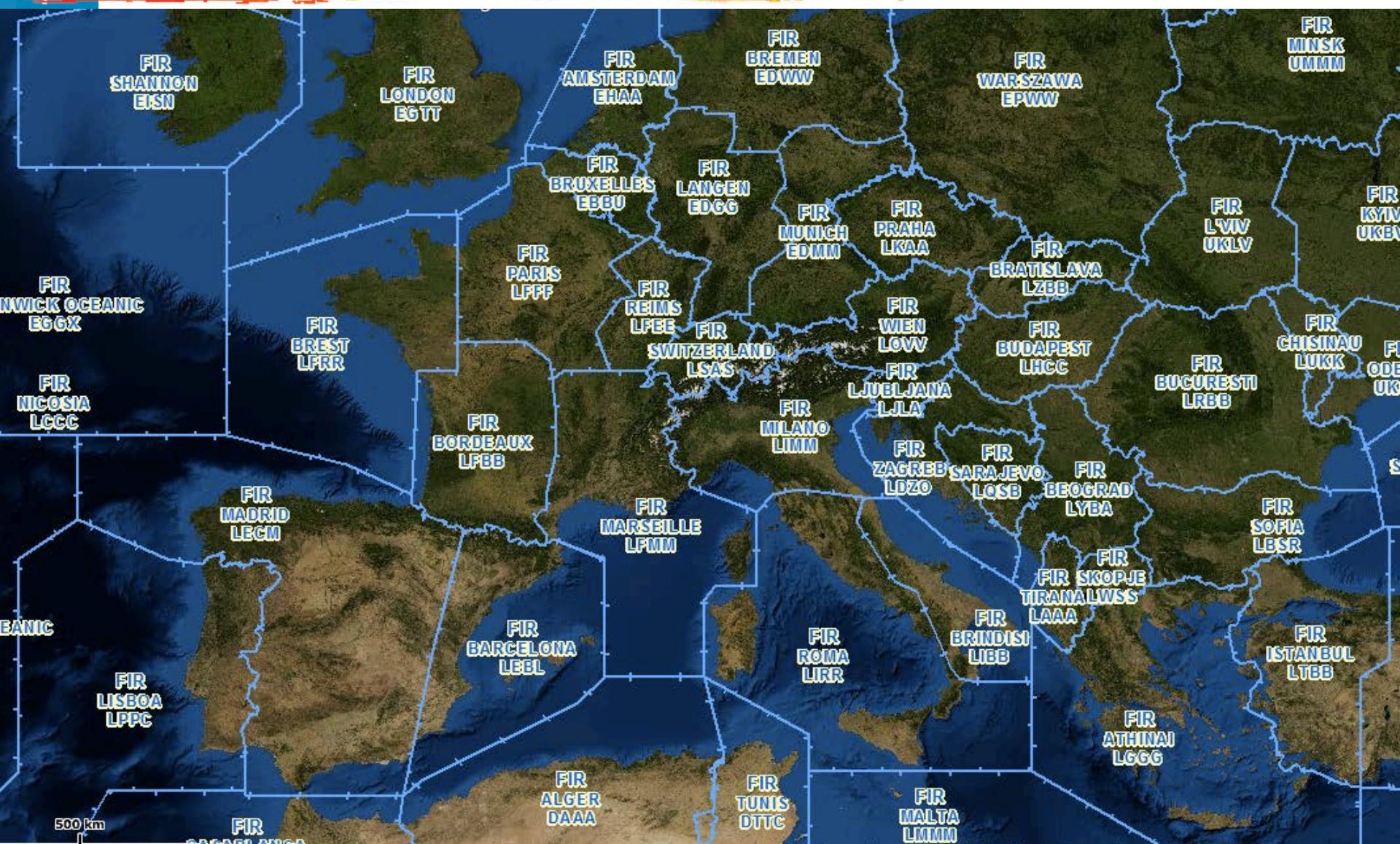
## ICAO Airspace Classes

Airspace Class	Controlled					Non-Controlled	
	A	B	C	D	E	F	G
IFR allowed	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SVFR Allowed	Yes	Yes	Yes	Yes	Yes	No	No
VFR Allowed	No	Yes	Yes	Yes	Yes	Yes	Yes
Separation	IFR / IFR	IFR / IFR				IFR / IFR if possible	NONE
		IFR / (S)VFR		IFR / SVFR			
		(S)VFR / (S)VFR	SVFR/SVFR				
Traffic information	N/A		VFR / VFR	IFR / VFR	if possible	if possible	NONE
				VFR / VFR			
Clearance Required	Yes	Yes	Yes	Yes	Only for IFR	No	No

National regulations may differ from ICAO standards!



# Airspace: Information Regions

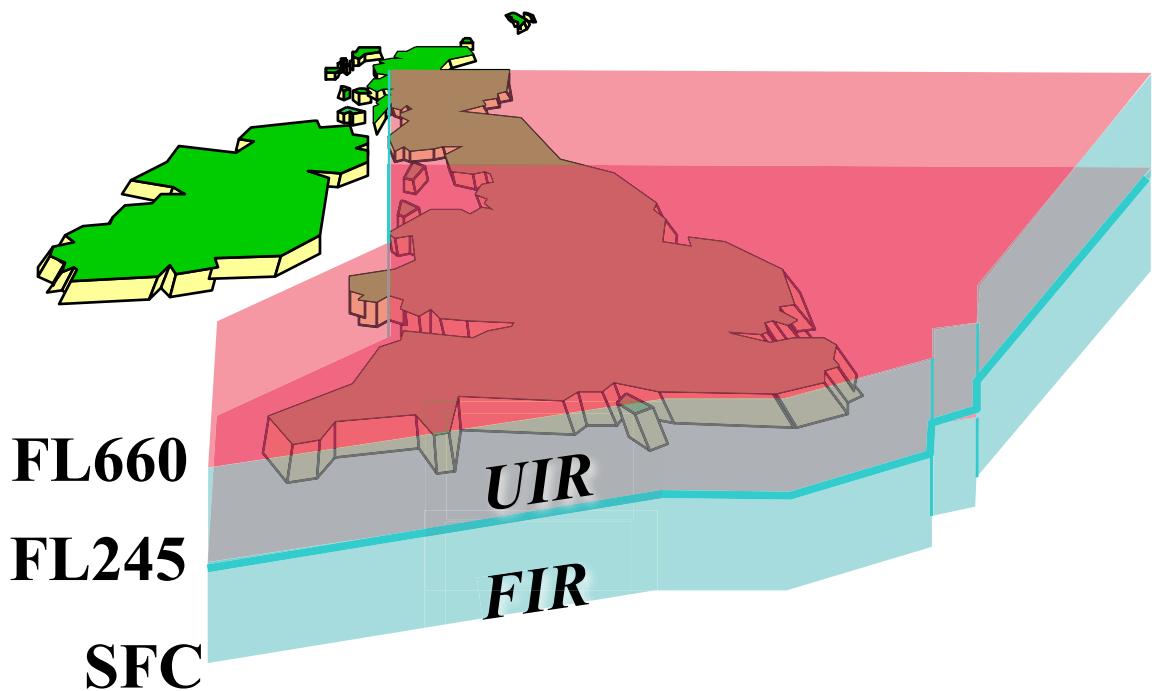


# Airspace: Information Regions

FIR: Flight Information Region

UIR: Upper Information Region

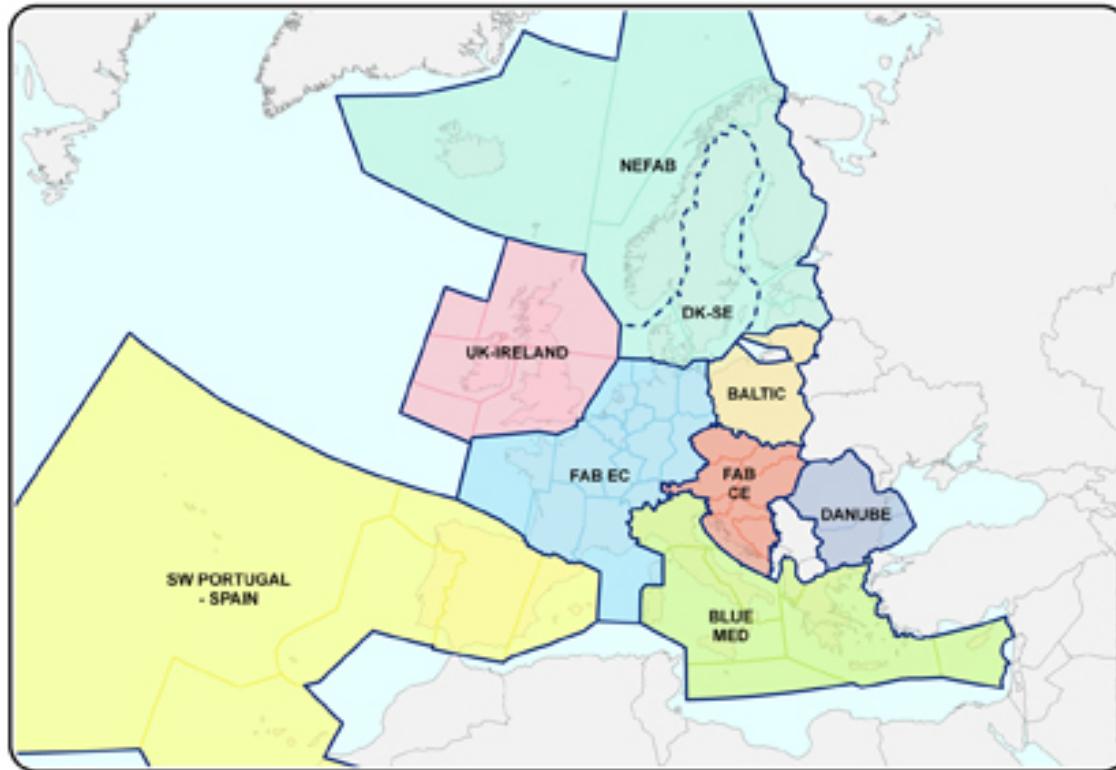
Example: UK



Note: FIR/UIR separation comes from historical reasons. Nowadays, not all states differentiate them

# Single European Sky

## FAB: Functional Airspace Blocs



Example:  
MUAC traffic fast-time animation  
<http://youtu.be/QK-Y1ZyrWHs>

[http://ec.europa.eu/transport/air/single\\_european\\_sky/functional\\_airspace\\_blocks\\_en.htm](http://ec.europa.eu/transport/air/single_european_sky/functional_airspace_blocks_en.htm)  
<http://www.eurocontrol.int/functional-airspace-block-fabs-defragmenting-european-airspace>

# Airspace types and classes

## Types of controlled Airspace

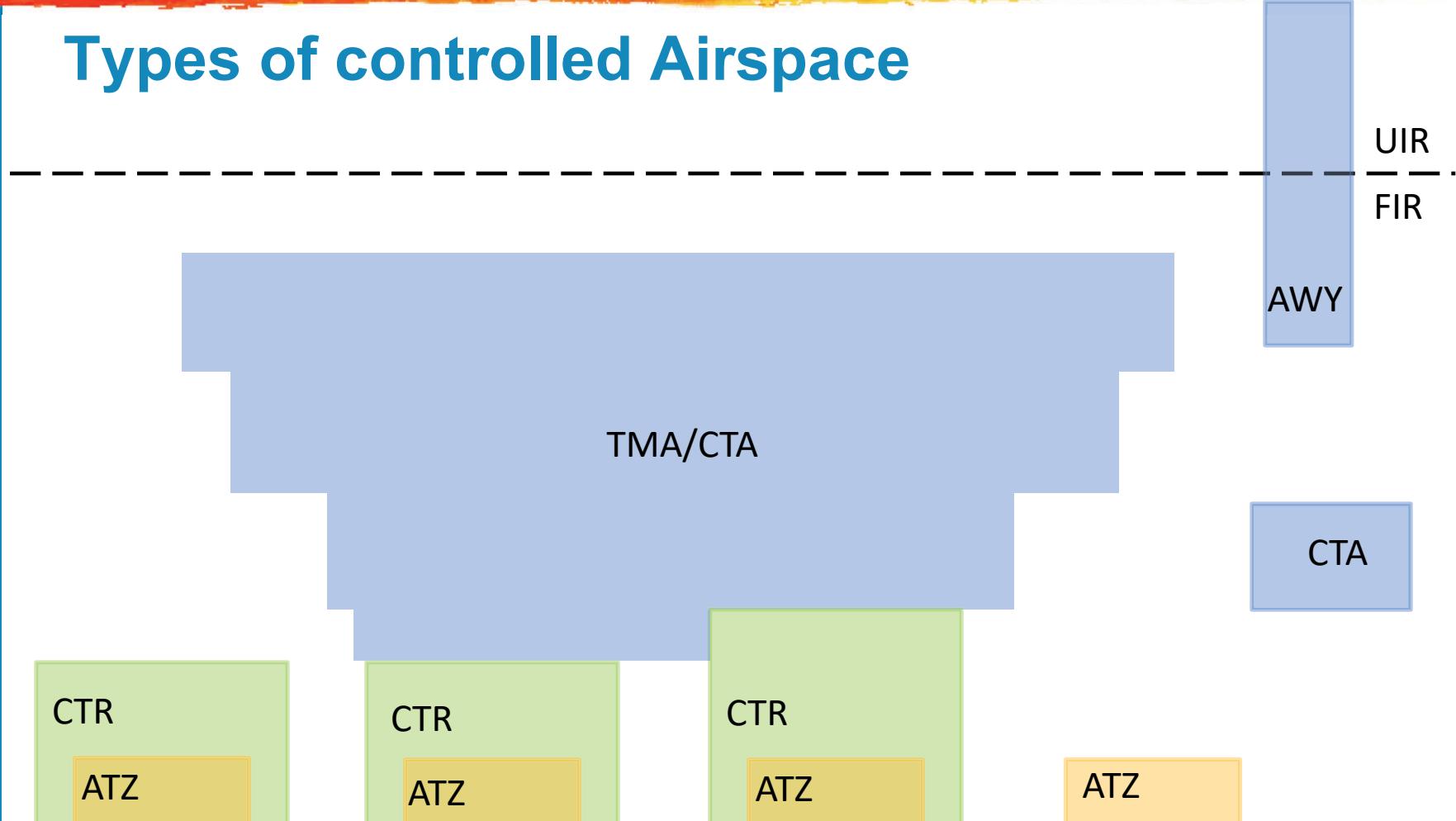
- AWY: Airway
- CTA: Control Area (generic controlled airspace)
- TMA: Terminal Maneuvering Area (like CTA, but specific to control arrival/departure procedures) [typically accommodating IFR SIDs and STARs]
- CTR: Control Zone (from SFC) [typically accommodating IFR approaches]
- ATZ\*: Aerodrome Traffic Zone (usually 1500' and 5NM) [typically accommodating IFR final approach and VFR airfield traffic patterns]

\* The ATZ can be non-controlled (only traffic information and/or alert services)



# Airspace types and classes

## Types of controlled Airspace



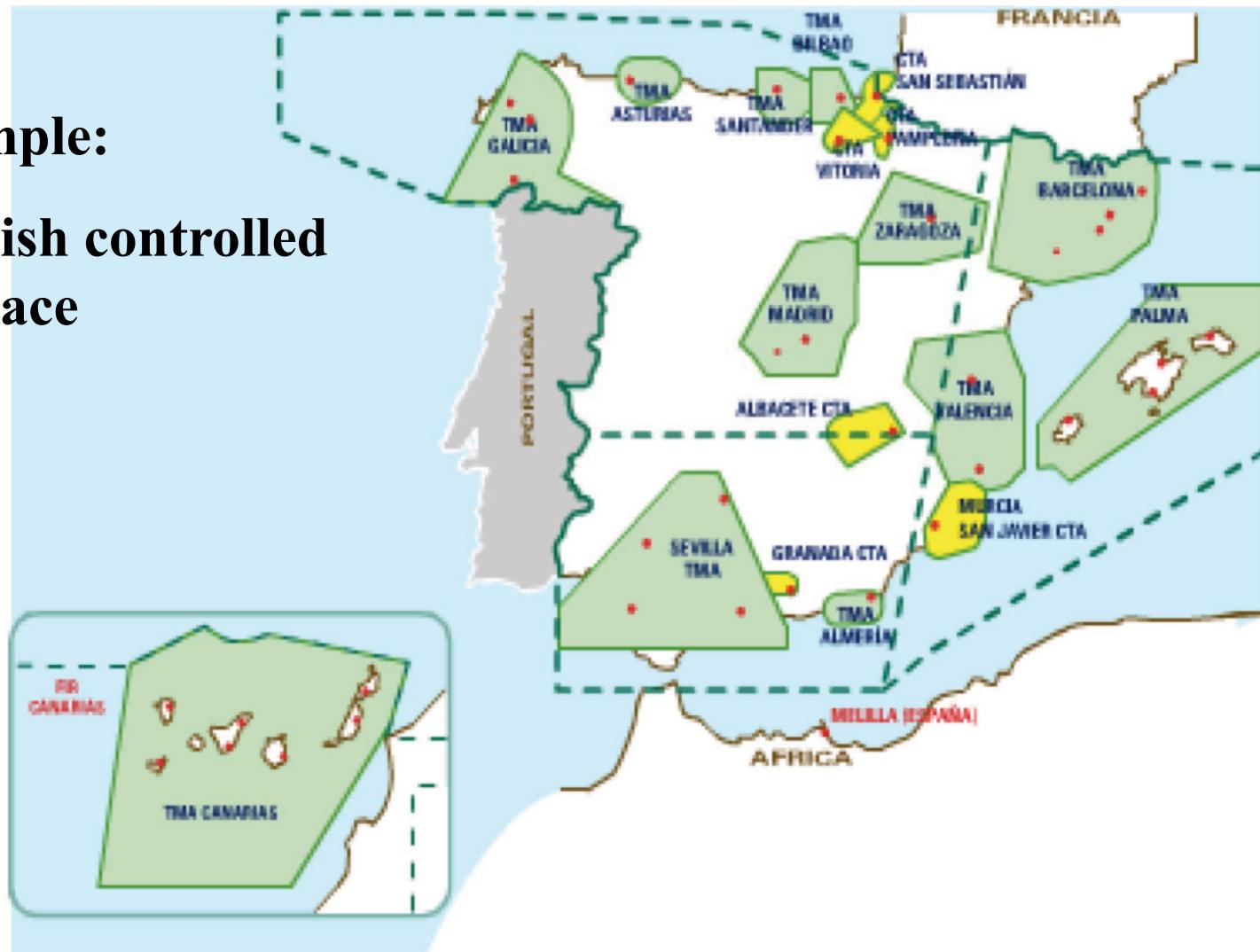
Example: ATC centers (1'14'')

<http://youtu.be/8X2KkNQWobw>

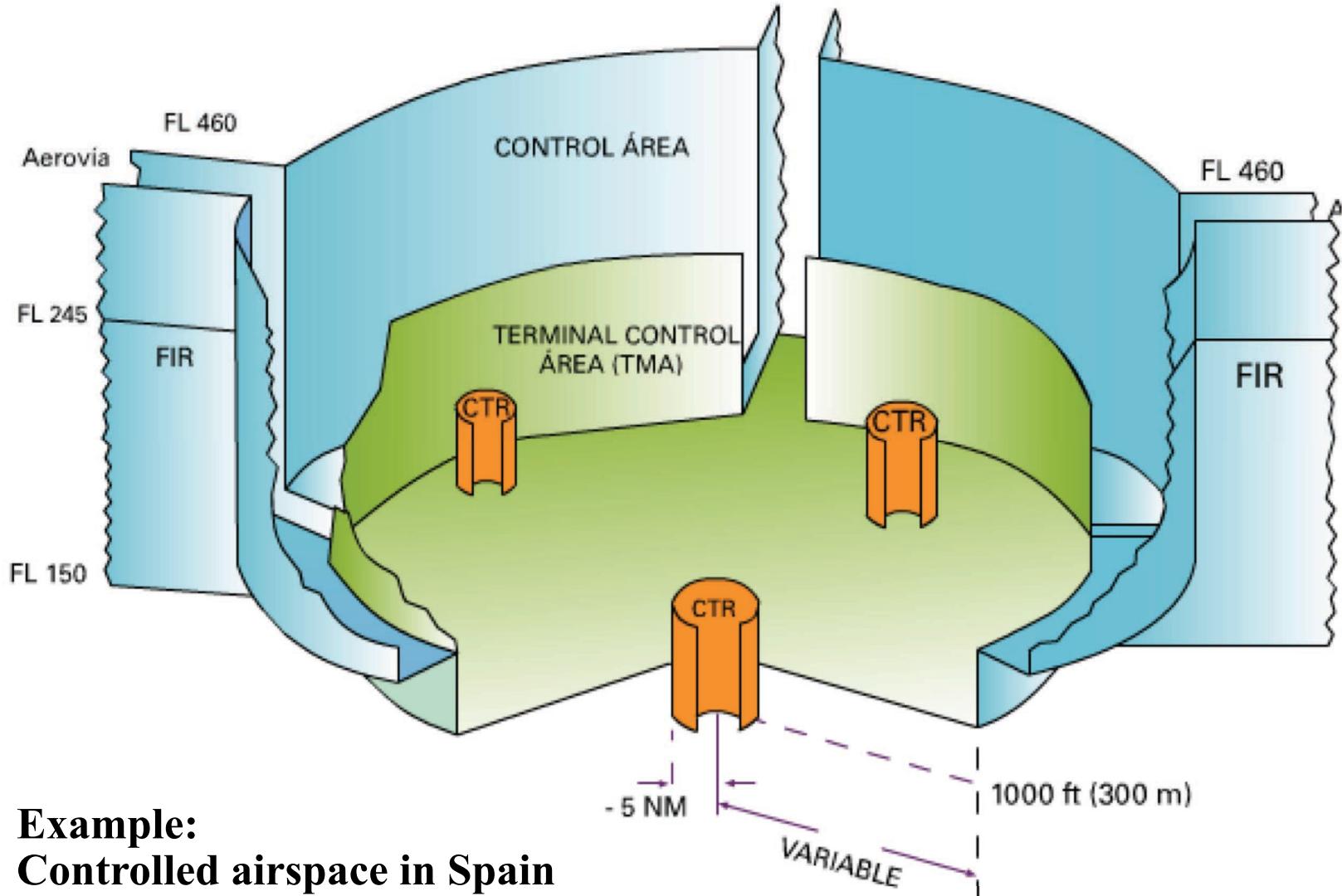
# Airspace types and classes

Example:

Spanish controlled  
airspace



# Airspace types and classes

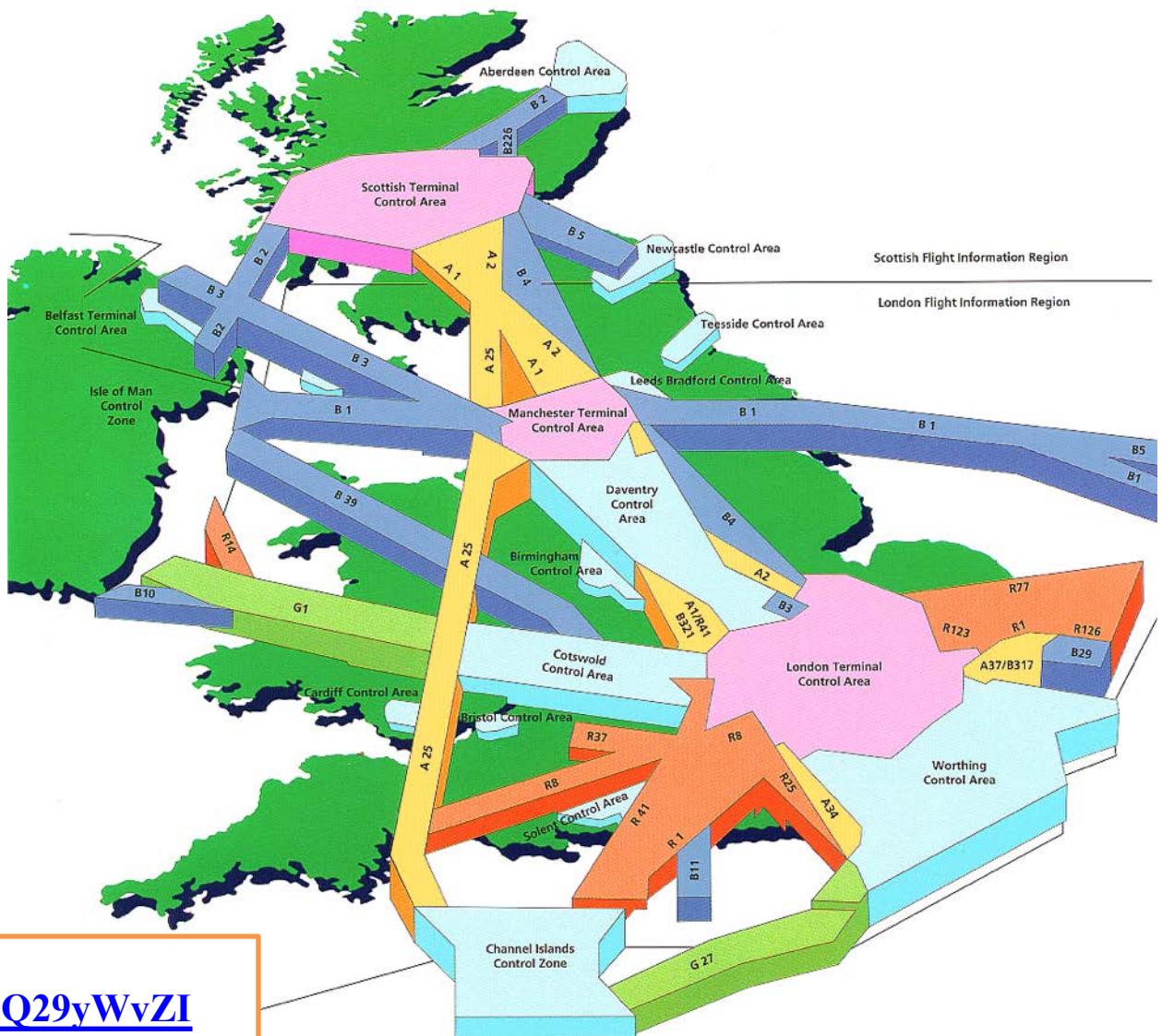


**Example:**  
Controlled airspace in Spain

# Airspace types and classes

## Example:

# UK controlled airspace



# UK traffic

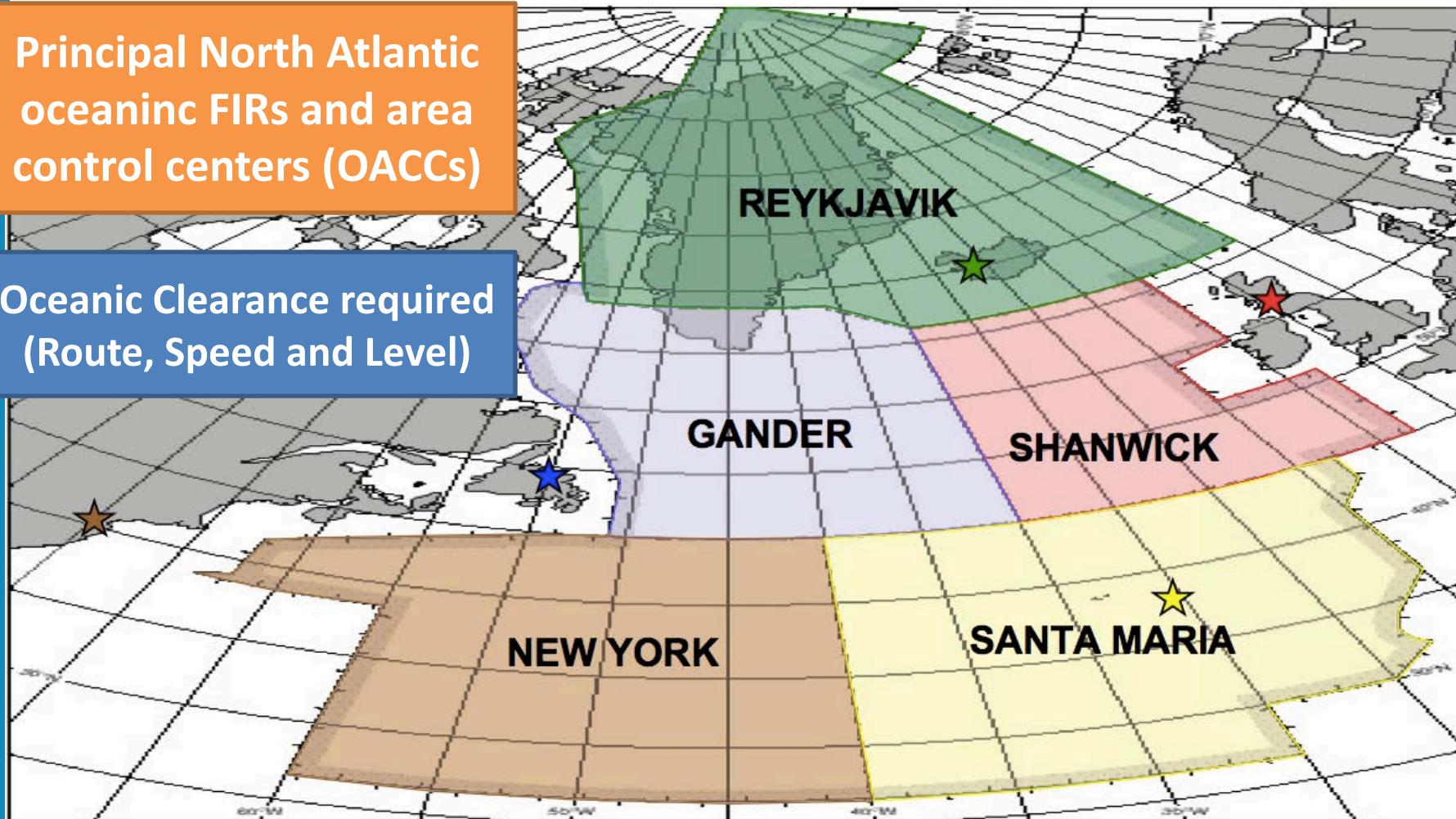
**24h:**<http://youtu.be/a8CQ29yWvZI>

# Airspace types and classes

## Area Control: Oceanic control

Principal North Atlantic oceanic FIRs and area control centers (OACCs)

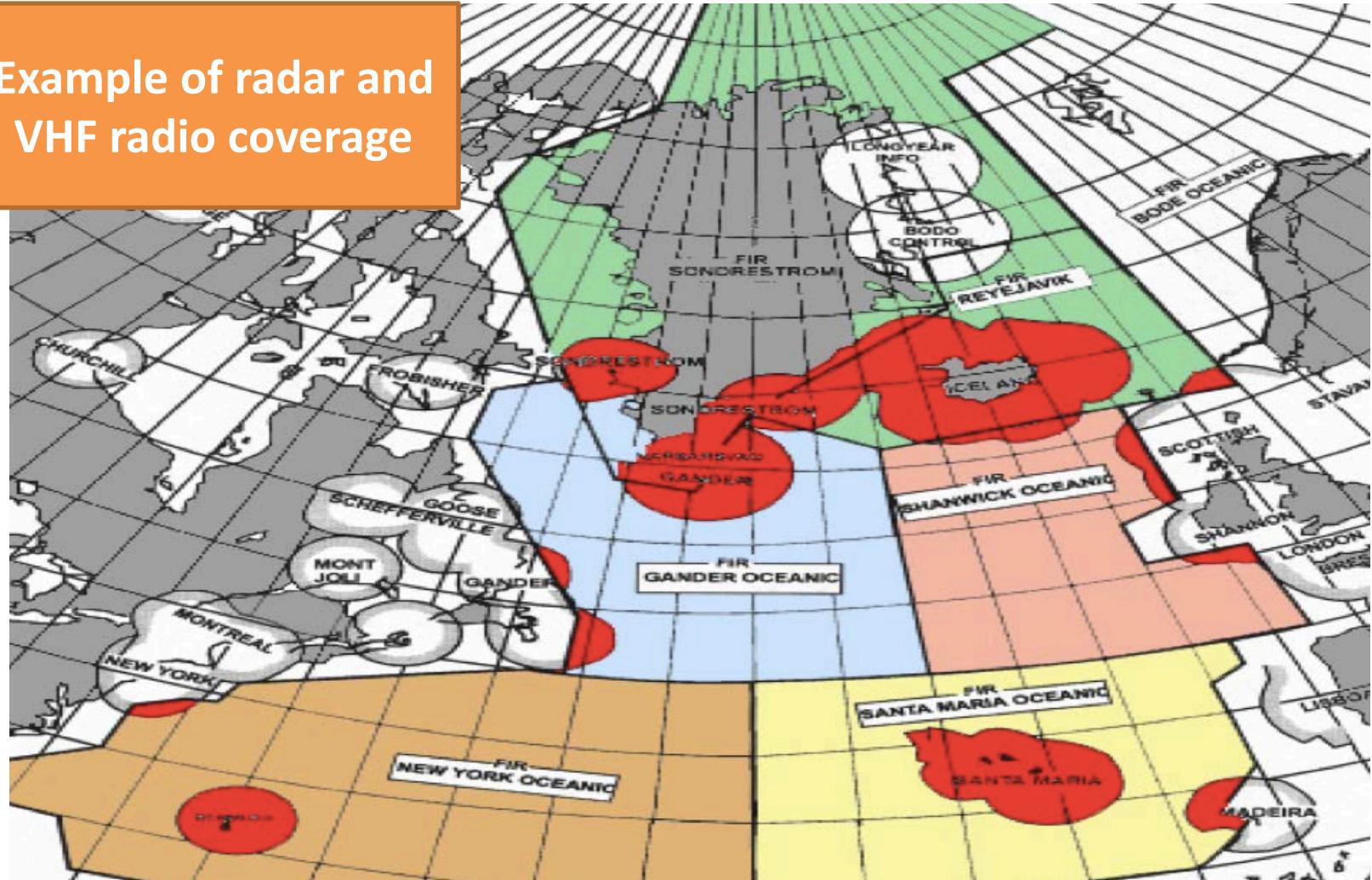
Oceanic Clearance required  
(Route, Speed and Level)



# Airspace types and classes

## Area Control: Oceanic control

Example of radar and VHF radio coverage



# Airspace type and classes

## Example: North Atlantic Operations

- [FL285-FL420]: Minimum Navigation Performance Specifications (MNPS)

- Std. Deviation of lateral track error: < 6.3 NM
- Proportion of flight time with error >30NM off-track: <  $5.3 \cdot 10^{-4}$
- Proportion of flight time with error >50NM (and <70NM) off-track: <  $13 \cdot 10^{-5}$

Aircraft equipped with at least two fully serviceable Long Range Navigation Systems (LRNS). A LRNS may be one of the following:

- 1 Global Navigation Satellite System (GNSS)
- 1 Inertial Navigation System (INS)
- 1 or more Inertial Reference System (IRS)
- 1 system using sensor(s) complying with the MNPS requirement

- [FL290-FL410]: Reduced Vertical Separation Minima (RVSM)
- Specific aircraft crew training

**More information:** European and North Atlantic Office of ICAO (2012) "North Atlantic Operations and Airspace Manual", NAT Doc 007.

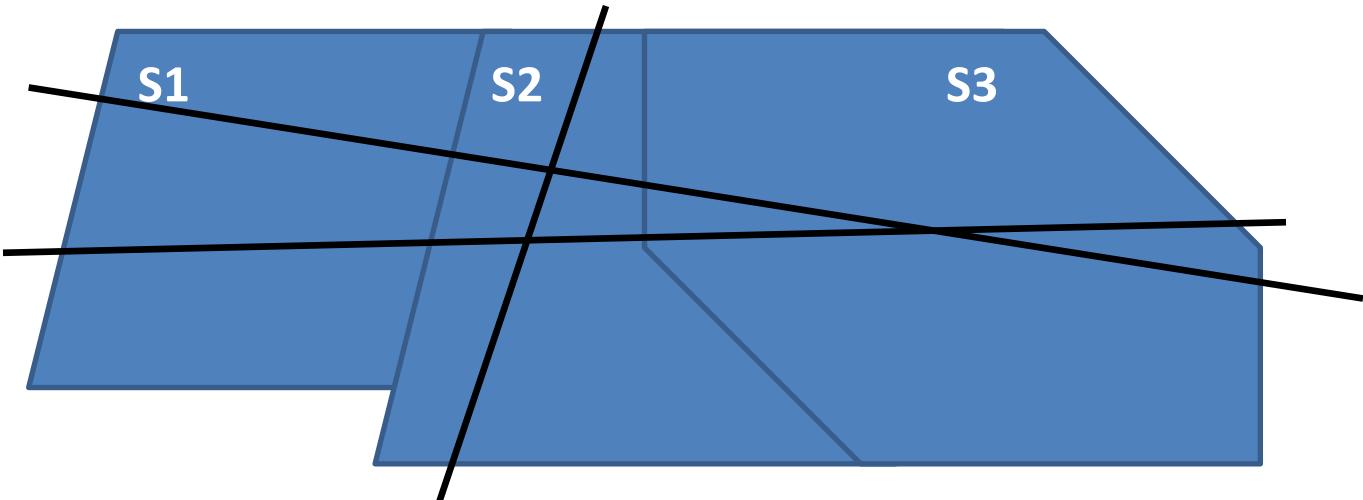
# Design of ATS sectorisations

## ATS sector:

Volume of airspace under the responsibility of one controller (usually helped by one or two extra controllers)

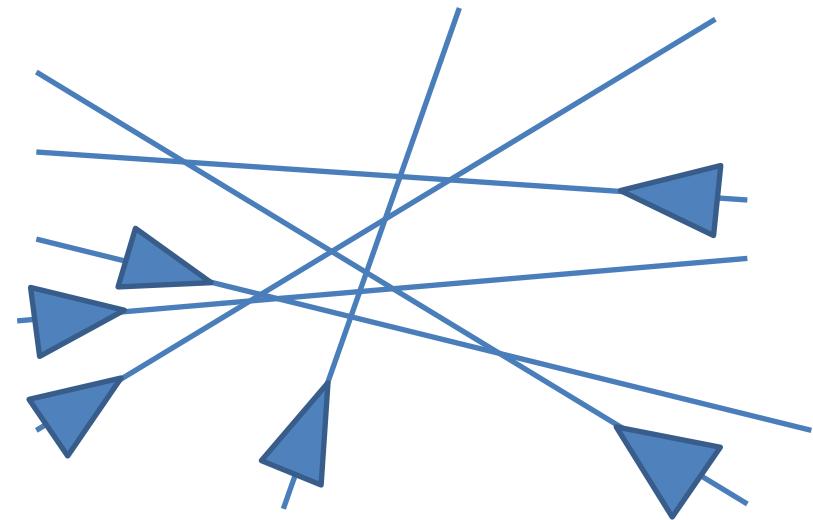
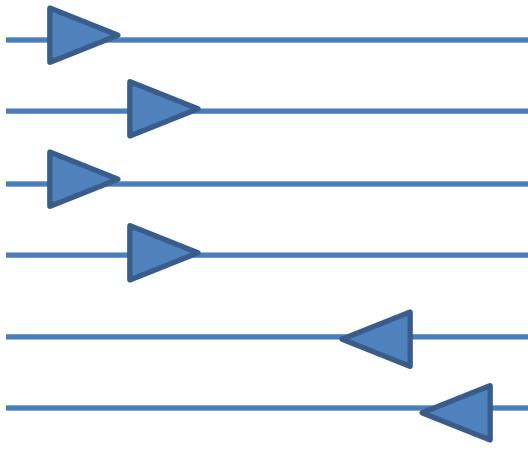
A radio communications frequency is assigned to each different sector

“Hand off” and “Hand over”: Transfer of aircraft responsibility between controllers of adjacent sectors

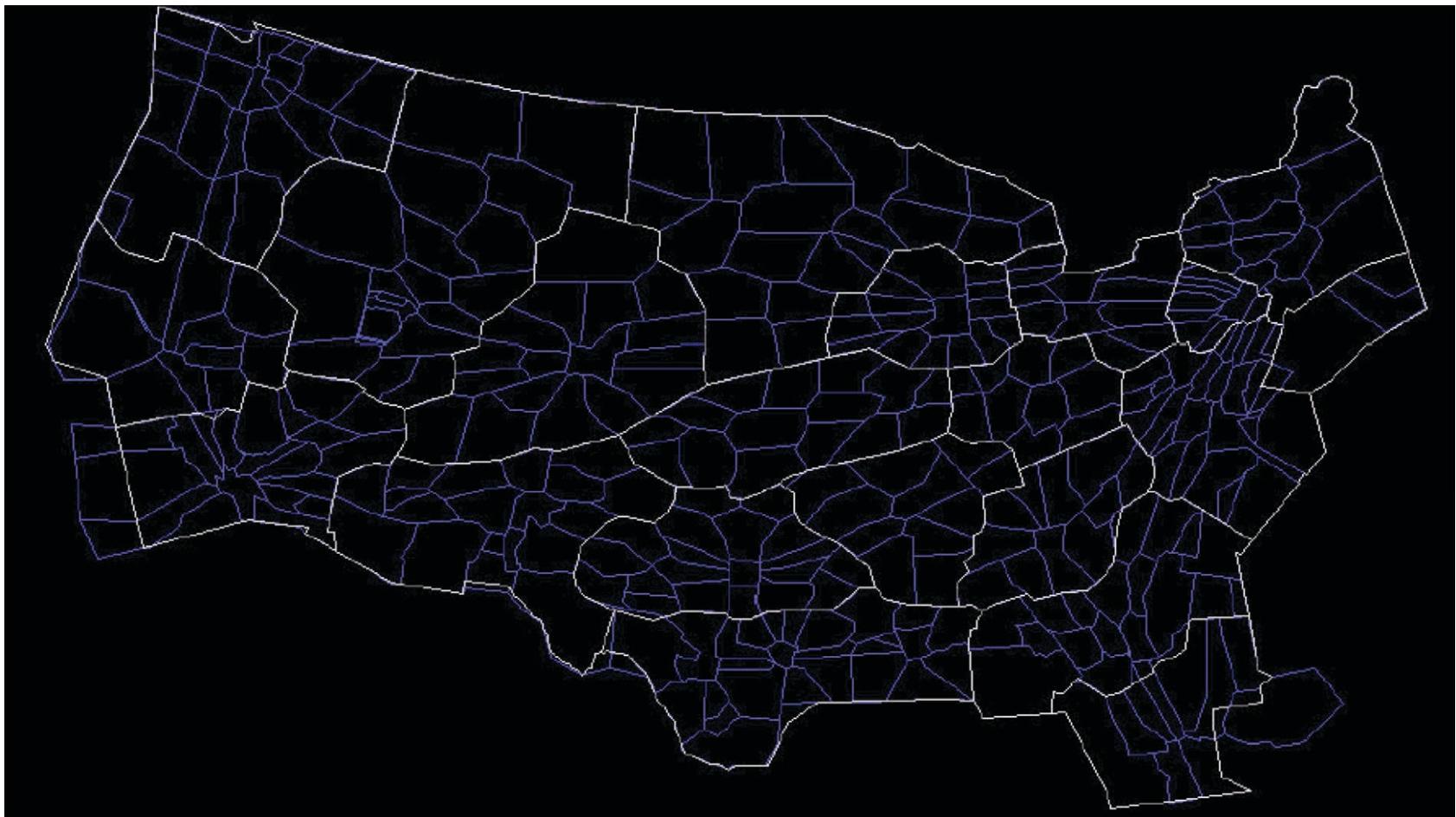


# Design of ATS sectorisations

- Size and shape of sector will vary as a function of the airspace complexity and traffic demand



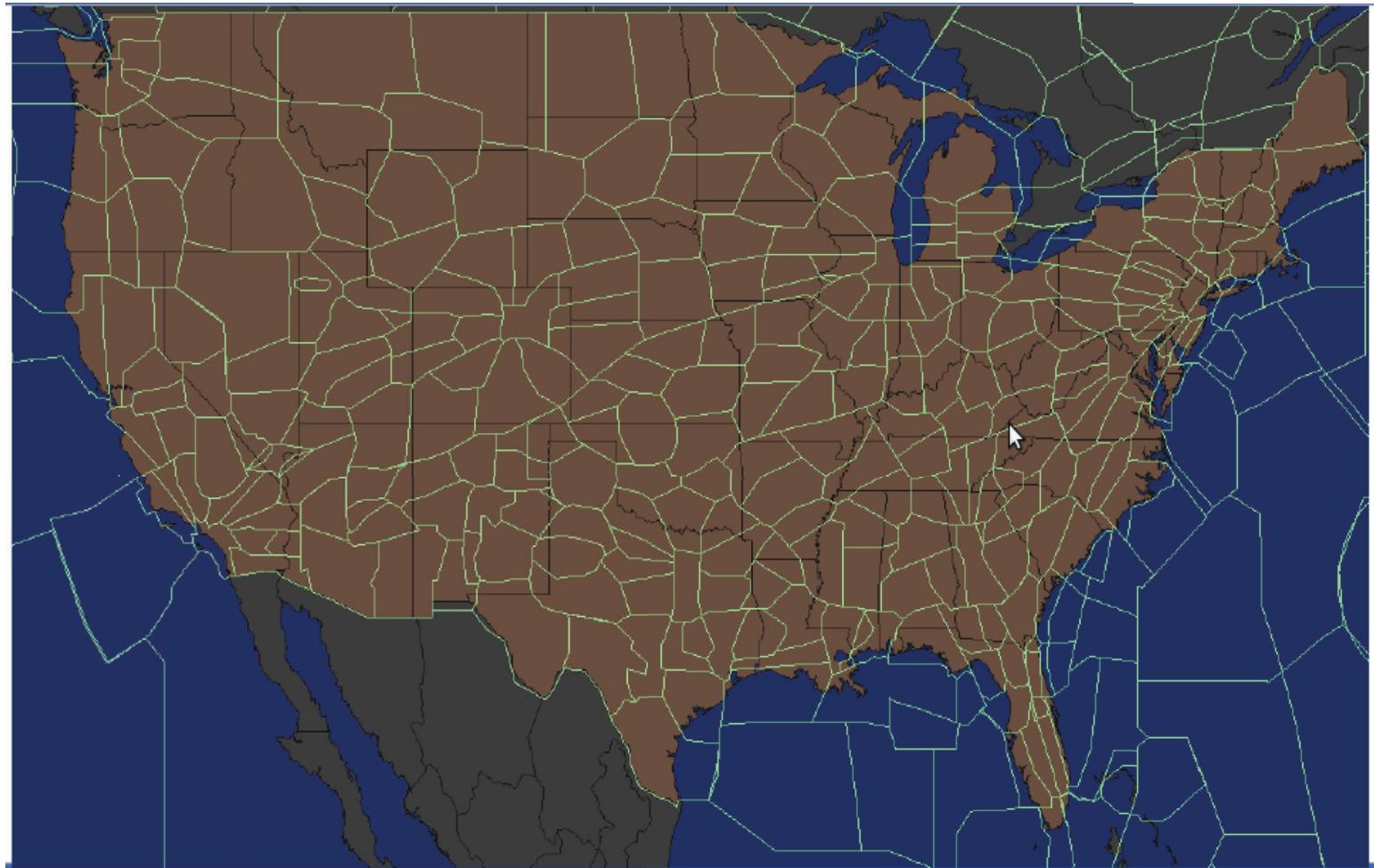
# Design of ATS sectorisations



**Example: high altitude sectors (blue) + area control centers (white) in the continental USA (radar control)**

# Design of ATS sectorisations

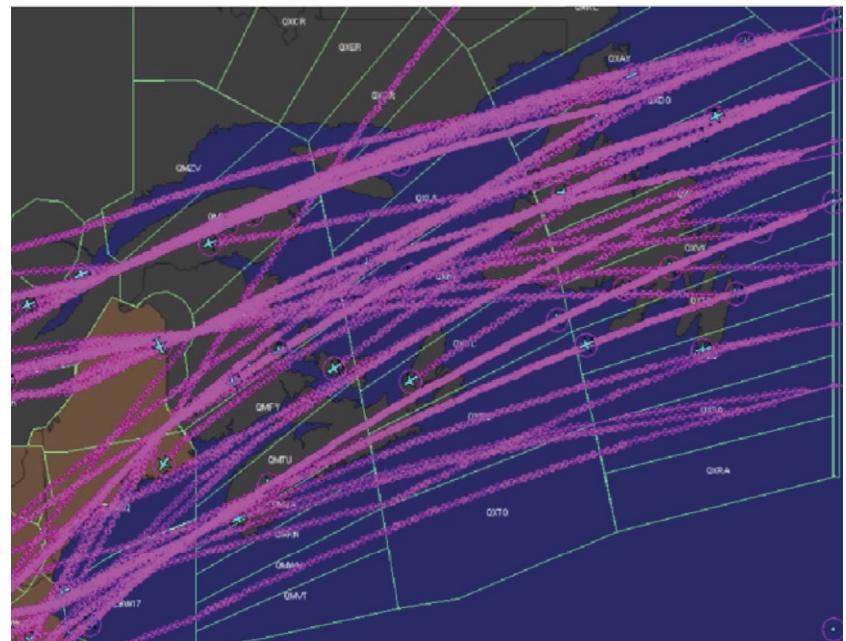
US ARTCC: High level sectors (UIR) (~260)



# Design of ATS sectorisations

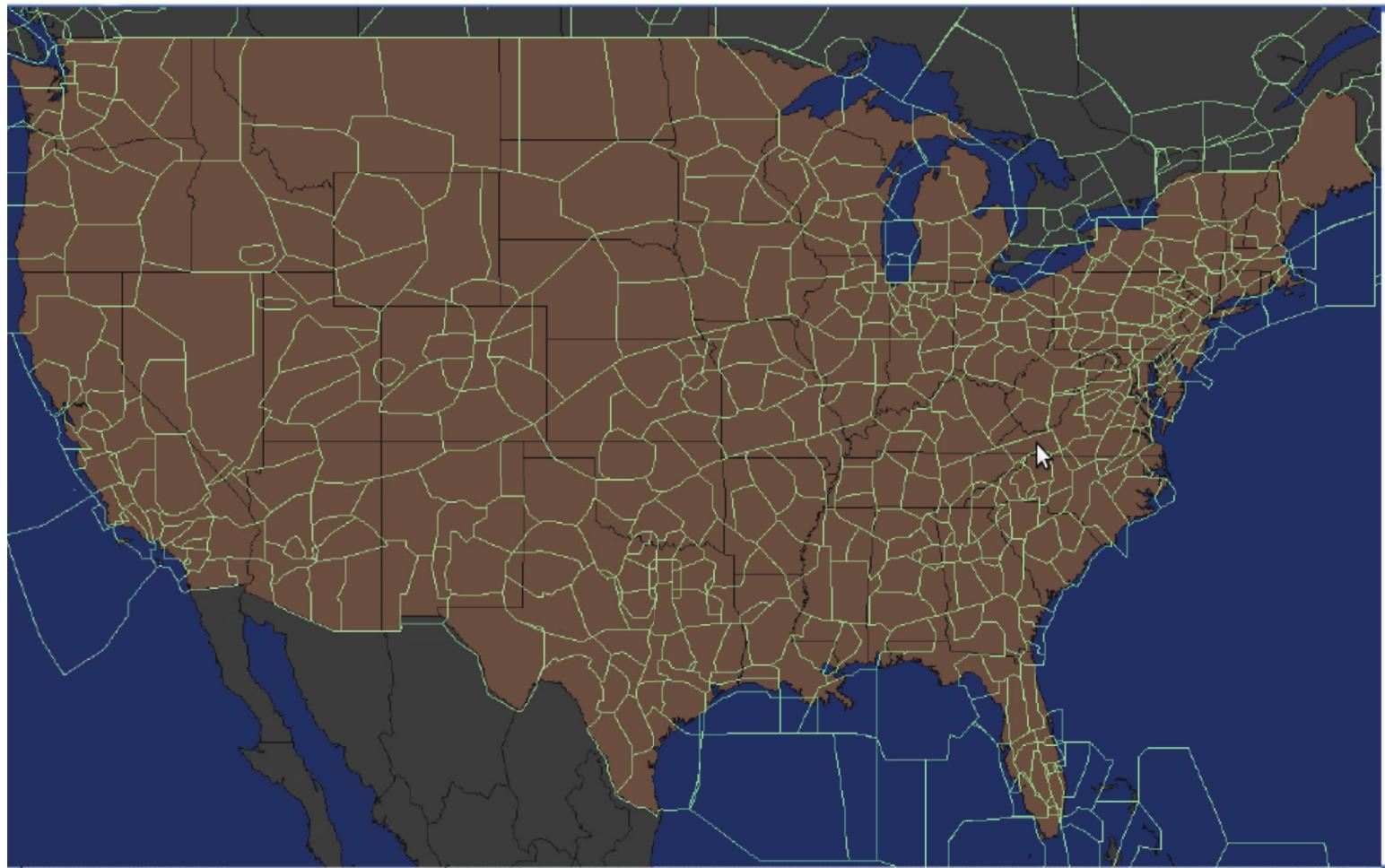


# Example: oceanic transition area UIR sectors

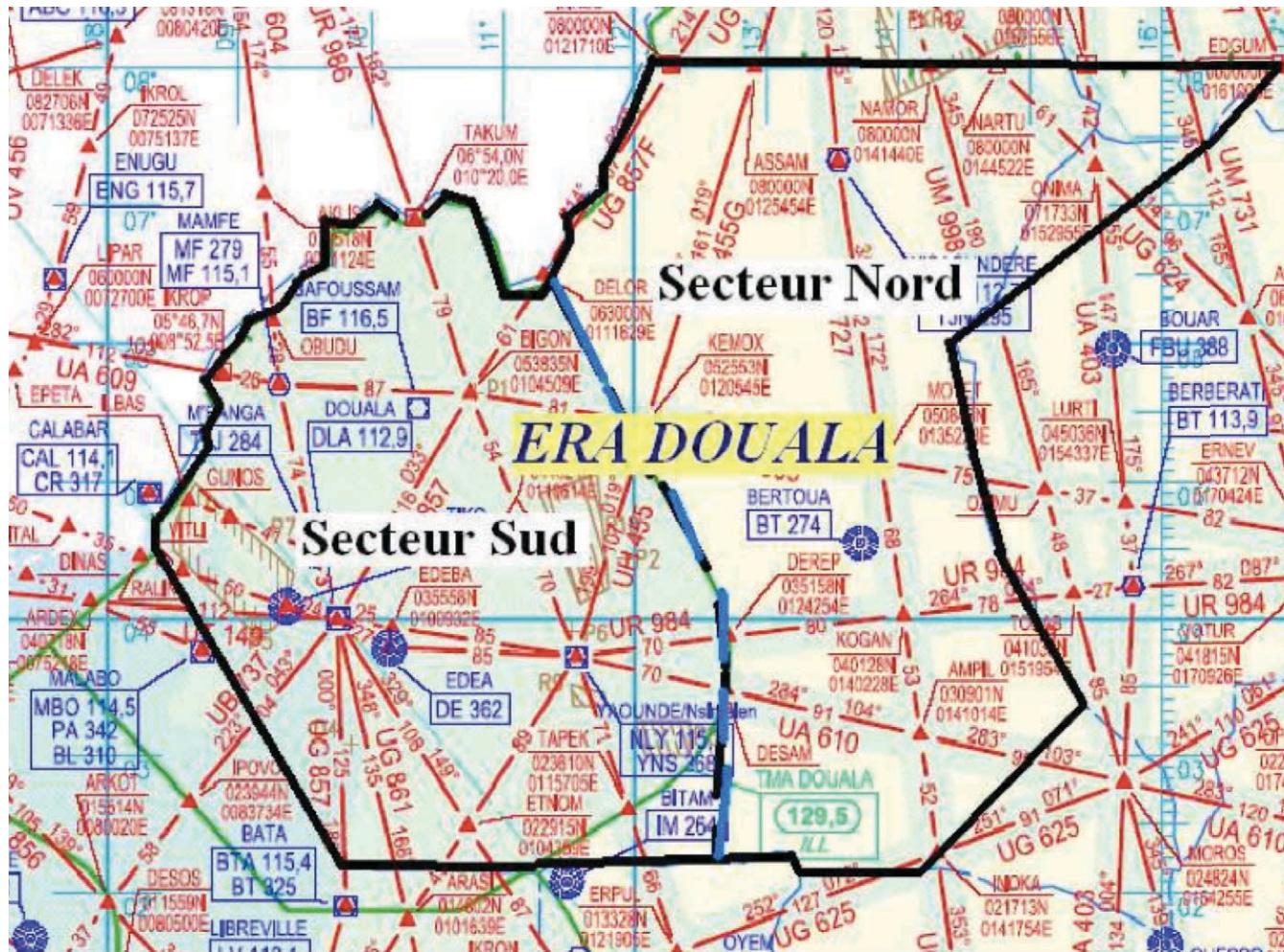


# Design of ATS sectorisations

US ARTCC: Low level sectors (FIR) (~400)



# Design of ATS sectorisations



## Example: high altitude sectors in Cameroon - Procedural control (no radar)

# Design of ATS sectorisations



# Design of ATS sectorisations

Existing sectors can be collapsed into a bigger sector if traffic demand is low enough



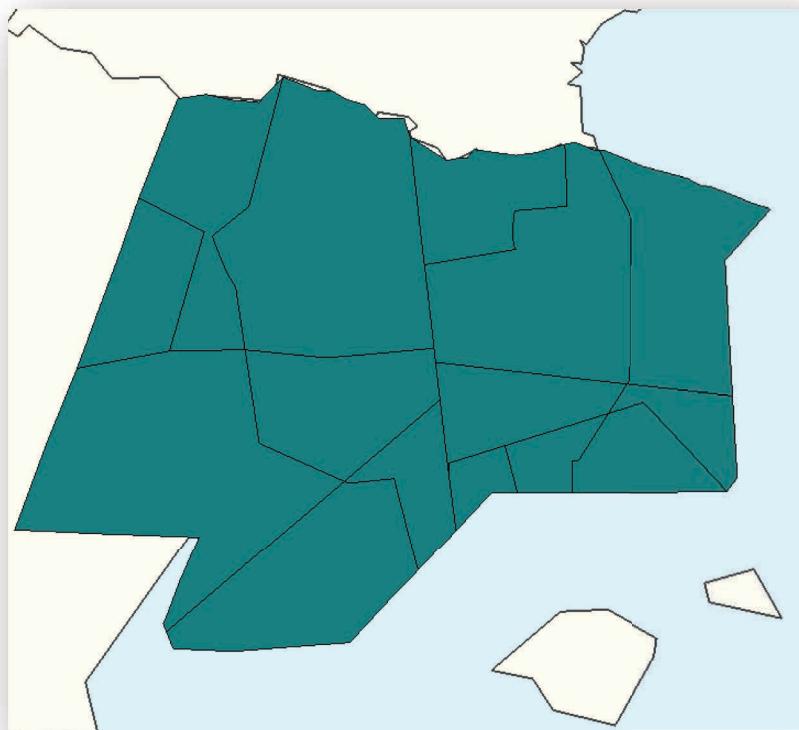
Typical night



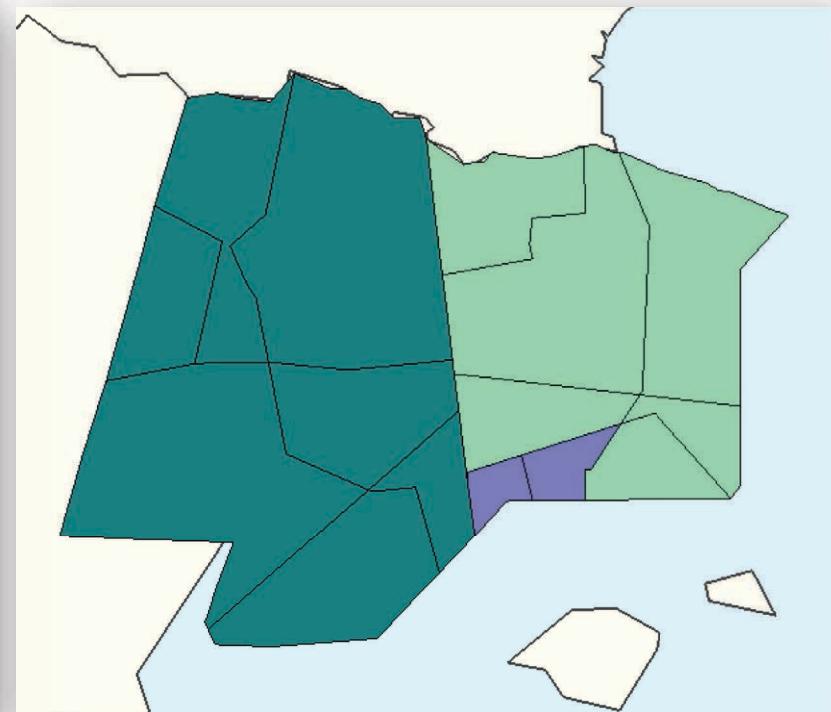
Typical day

# Design of ATS sectorisations

## Sectorisation examples: Barcelona TMA



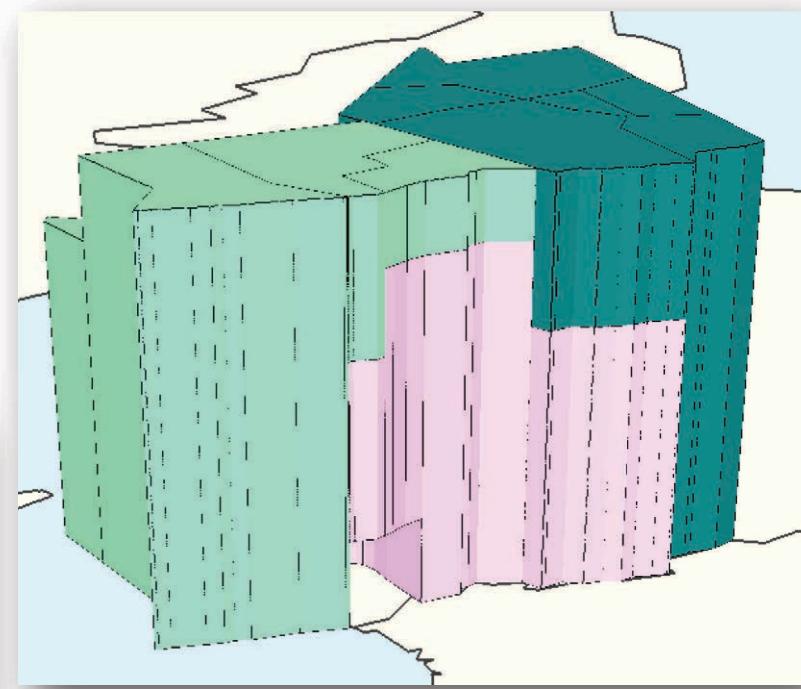
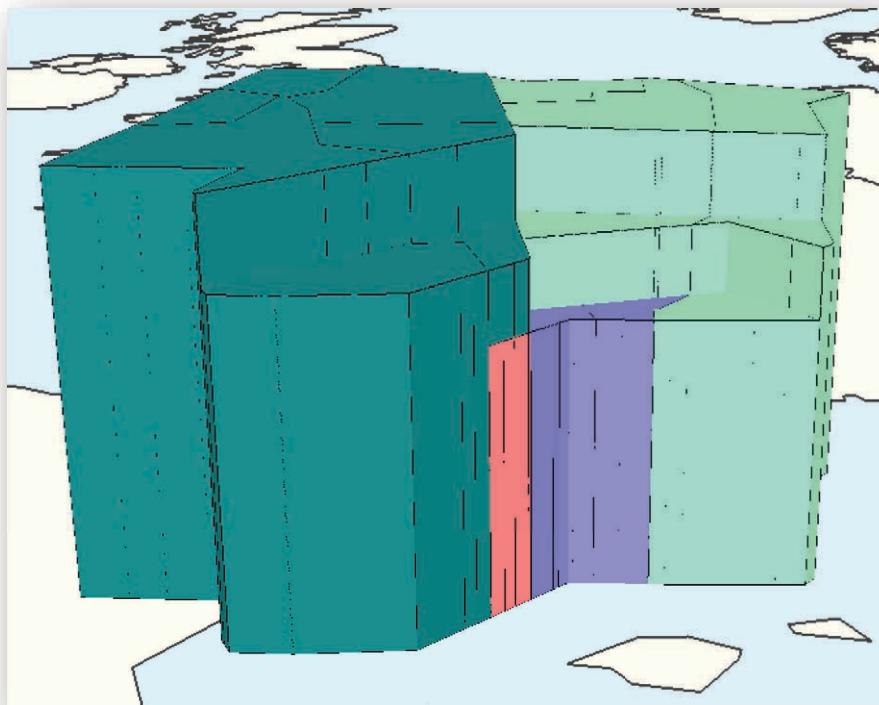
**CONF: 1  
(1 sector)**



**Conf: 5BN  
(5 sectors)**

# Design of ATS sectorisations

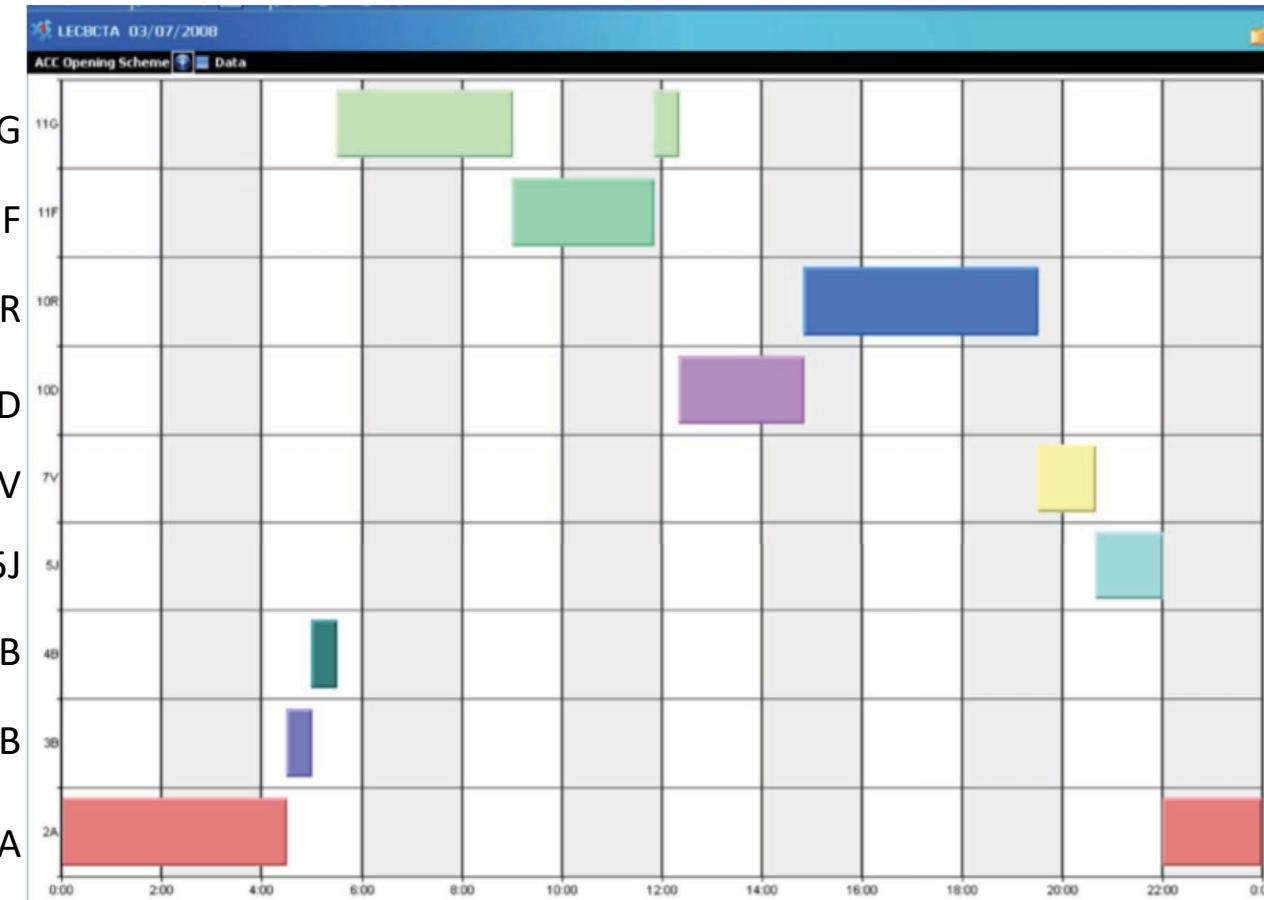
## Conf 5BN – Barcelona TMA



# Design of ATS sectorisations

## Opening scheme example: Barcelona TMA

Sectorisations  
or sector  
*configurations*



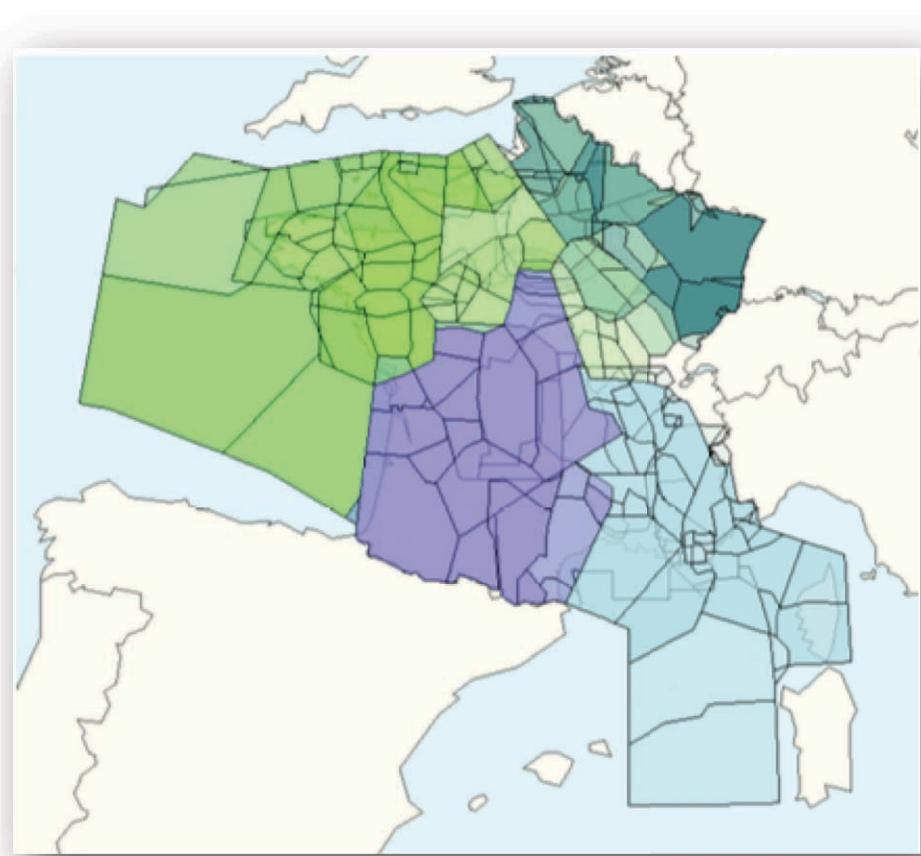
Eurocontrol MUAC  
<http://youtu.be/R2wviSUvHzs>

MUAC traffic animation  
<http://youtu.be/QK-Y1ZyrWHs>

# Design of ATS sectorisations

## Opening scheme example: French airspace

- 5 FIR/UIR
- 164 elementary sectors
- 420 collapsed sectors
- 1500 configurations
- $5.8 \cdot 10^{21}$  possible combinations per period



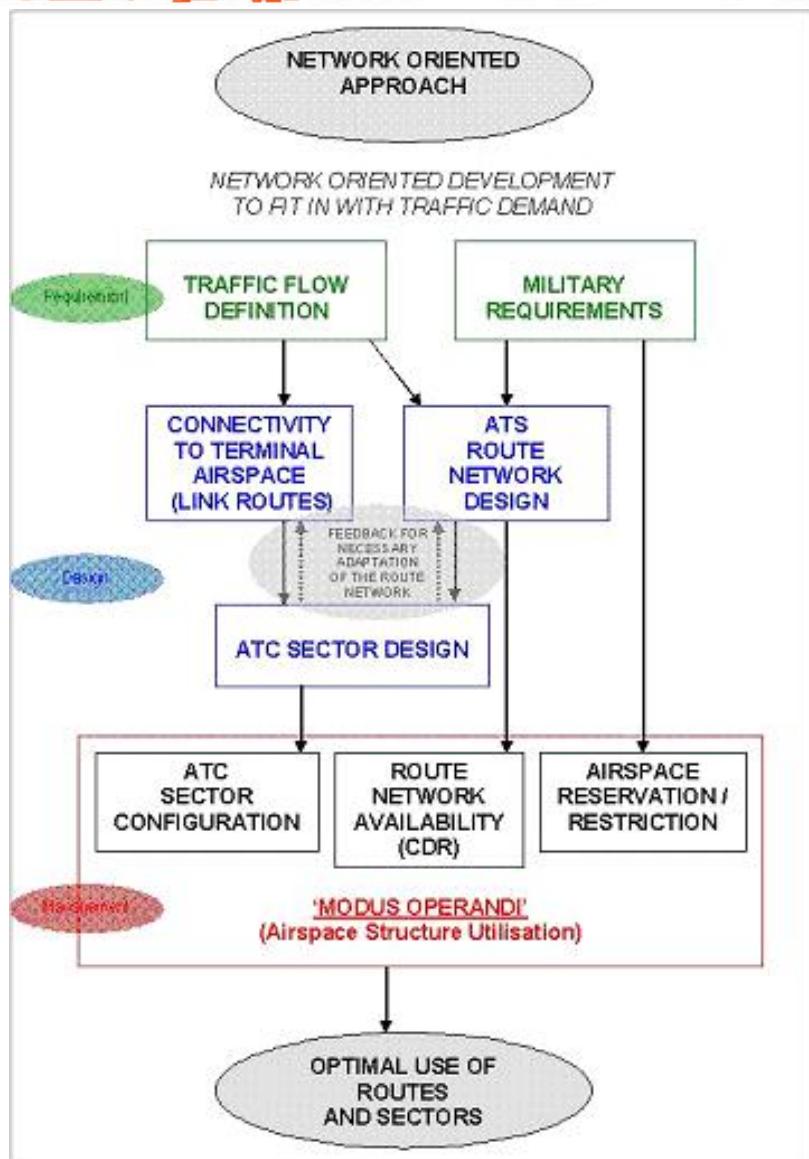
# Airspace Design and modelling

- Development of ATS Route Network and ATC Sector to deal with forecast demand
- Network orientated development:
  - Step 1: Identify current and foreseen problems
  - Step 2: Built airspace structure proposals to accommodate major traffic flows and balance ATC workload
  - Step 3: Elaborate detailed proposals and validate through regional expert groups
  - Step 4: Implementation program is agreed and carried out

<http://www.eurocontrol.int/articles/airspace-design>



# Airspace Design and modelling



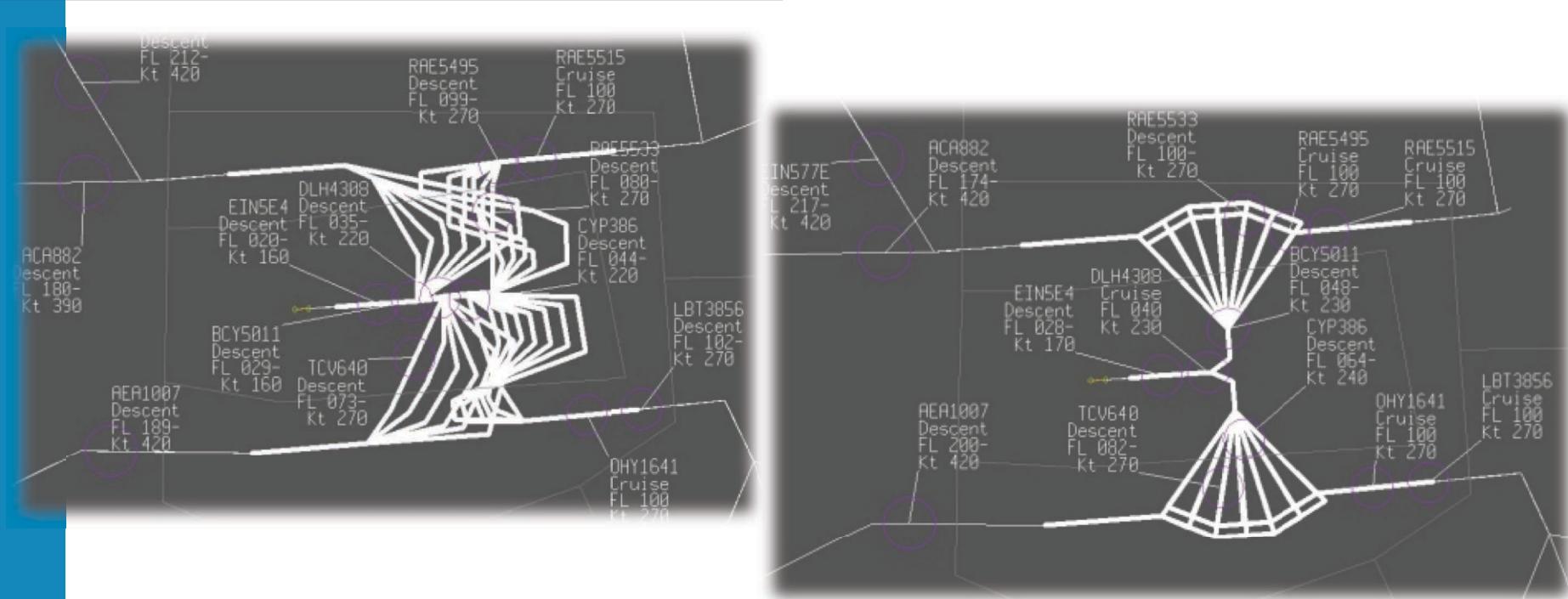
# Airspace Design and modelling

- **Using software and analytical techniques to study:**
  - Quantitative analysis of potential airspace changes
  - Validate concepts and operational plans
  - Define capacity gains
  - Identify choke points and their cause
- **Work areas:**
  - Validation of design of Airspace structures and their use
  - Validation of design of Route Networks
  - ATC Capacity Analysis
  - Analysis efficiency of ATM operations
  - Testing new ATC operational concepts
- **Example tools:**
  - Fast Time simulation tools like RAMS (Re-organized ATC Mathematical Simulator)
  - Total Airspace and Airport Modeler (TAAM )



# Airspace Design and modelling

Example: Fast-time simulation of Point Merge



<https://vimeo.com/42431187> - Jeppesen TAAM tool demo video

[http://www.eurocontrol.int/eec/public/standard\\_page/EEC\\_News\\_2008\\_1\\_PM.html](http://www.eurocontrol.int/eec/public/standard_page/EEC_News_2008_1_PM.html)

# Civil military coordination

- The military are one of the biggest 'airlines' in Europe.

The ECAC-wide State Aircraft Fleet amounts to :

- over 1,100 large aircraft (transport, cargo, tankers, maritime patrol aircraft)
  - over 3,300 combat aircraft
  - almost 2,300 light aircraft (training, reconnaissance, utility)
  - around 4,500 helicopters
  - some 400 paramilitary aircraft
- 
- Additionally, US aircraft stationed in or detached to Europe plus inbound military traffic.
  - Military operations in Europe are conducted from 150 main military airfields.



# Civil military coordination

## Military needs:

- Easy access to airspace and the freedom to operate at any given time
- Special handling by controlling agencies for priority flights (e.g. Air Defense intercept flights), time-critical missions (e.g. humanitarian relief flights) and aircraft which cannot comply with equipment mandates for civil aviation
- To be able to operate without (ground) control for certain missions
- Portions of airspace reserved for special maneuvers and exercises



# Civil military coordination

## FUA: Flexible Use of Airspace

Airspace should no longer be designated either military or civil, but should be considered as one continuum and used flexibly on a day-to-day basis.

Any airspace segregation is temporary and based on real use for a specified time period.

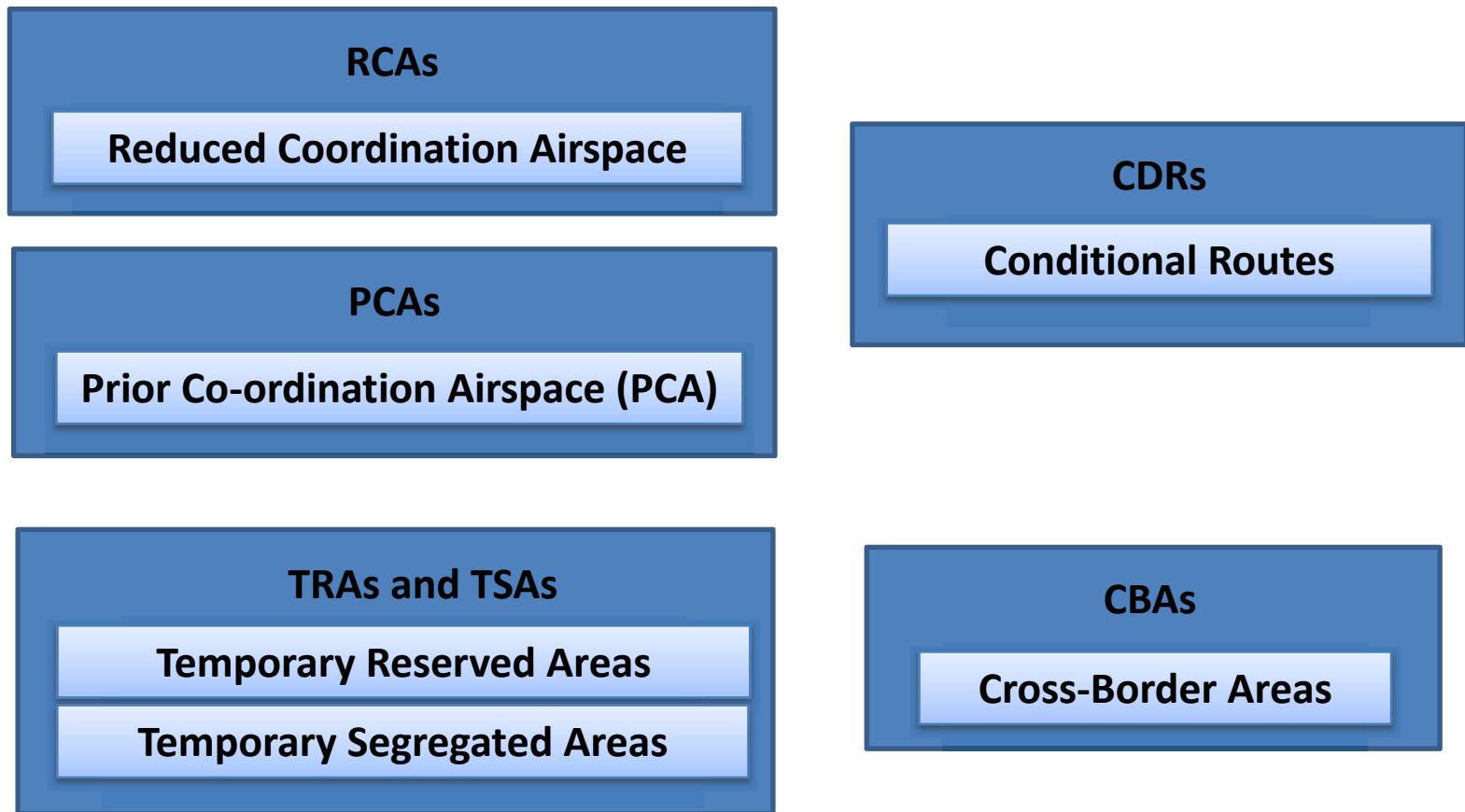


Video: FUA (1'32'')  
<http://youtu.be/eLqBCwSPT50>

<http://www.eurocontrol.int/articles/flexible-use-airspace>

# Civil military coordination

## Flexible airspace Structures



# Civil military coordination

## RCAs

### Reduced Coordination Airspace

Is a specific portion of airspace within which GAT is permitted outside the ATS route structure without requiring GAT controllers to initiate coordination with OAT controllers.

- When OAT traffic is light or has ceased, the implementation of Reduced Coordination Airspace will enable GAT to operate outside the ATS route structure without GAT controllers being required to initiate coordination.

GAT: General Air Traffic

OAT: Operational Air Traffic



# Civil military coordination

## PCAs

### Prior Co-ordination Airspace (PCA)

Military activities can take place on an ad-hoc basis with individual GAT transit allowed with Letter of Agreements (LoA) between civil and military ATS

GAT: General Air Traffic  
OAT: Operational Air Traffic



# Civil military coordination

## TRAs and TSAs

### Temporary Reserved Areas

Are areas that are temporarily reserved and allocated for the exclusive use of specific users. Other traffic might transit under ATC clearance

### Temporary Segregated Areas

Are areas that are temporarily reserved and allocated for the exclusive use of specific users.

- **TSAs will supplement or replace, when possible, current Danger or Restricted Areas.**
- **TSAs will be allocated on a daily or hourly basis for specific periods of military-type airspace uses.**



# Civil military coordination

CBAs

**Cross-Border Areas**

Are TSAs or TRAs established over  
international boundaries

- **CBAs will be established by States to allow military training and other operational flights to be carried out on both sides of a border.**



# Civil military coordination

## CDRs

### Conditional Routes

Are non-permanent ATS routes or route portions which can be planned and used under specific conditions

- **Conditional Routes will be established through areas of potential segregation to complement the ATS route network.**
- **CDRs will be made available either through national AIPs for specific regular times, or through national Airspace Users Plans and Conditional Route Availability Messages.**



# Civil military coordination

## SEGREGATION OF AIRSPACE

### JOINT USE OF AIRSPACE

- the Reduced Co-ordination Airspace allows GAT transit without prior co-ordination.

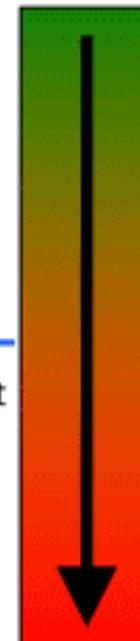
### SHARED USE OF AIRSPACE

- the Prior Co-ordination Airspace allows a shared use of airspace with military activities located outside the major traffic flows providing for the optimum GAT flight profile.
- the Temporary Reserved Area allows the transit of the area under specific co-ordination procedures.

### SEPARATE USE OF AIRSPACE

- the Temporary Segregated Area reserves airspace for the exclusive use of specific users.

## NOT SEGREGATED



RCA

Published in LoAs for  
ATS Providers  
information only.

PCA

LoA

TRA

AIP

TSA

Published in AIPs for  
all Airspace Users  
and ATS Providers  
Information

## FULLY SEGREGATED

Degree of Airspace Segregation – Choice between RCA, PCA, TRA & TSA

RCA: Co-ordination airspace

PCA: Prior Co-ordination Airspace

TRA: Temporary Reserved Areas

TSA: Temporary Segregated Areas

# Civil military coordination

## CDR (and TSA) categorisation

CDR 1

Permanently plannable during  
the times published in AIP

- Expected to be available for most of the time
- Plannable in the same way as all permanent ATS routes
- In the event of short notice unavailability, re-routing around active TSA on ATC instructions

CDR 2

Non-permanently plannable

- Daily allocated to respond to ATS capacity imbalances
- Plannable only in accordance with daily AUP/CRAM
- Part of pre-defined routing scenario

CDR 3

Not plannable

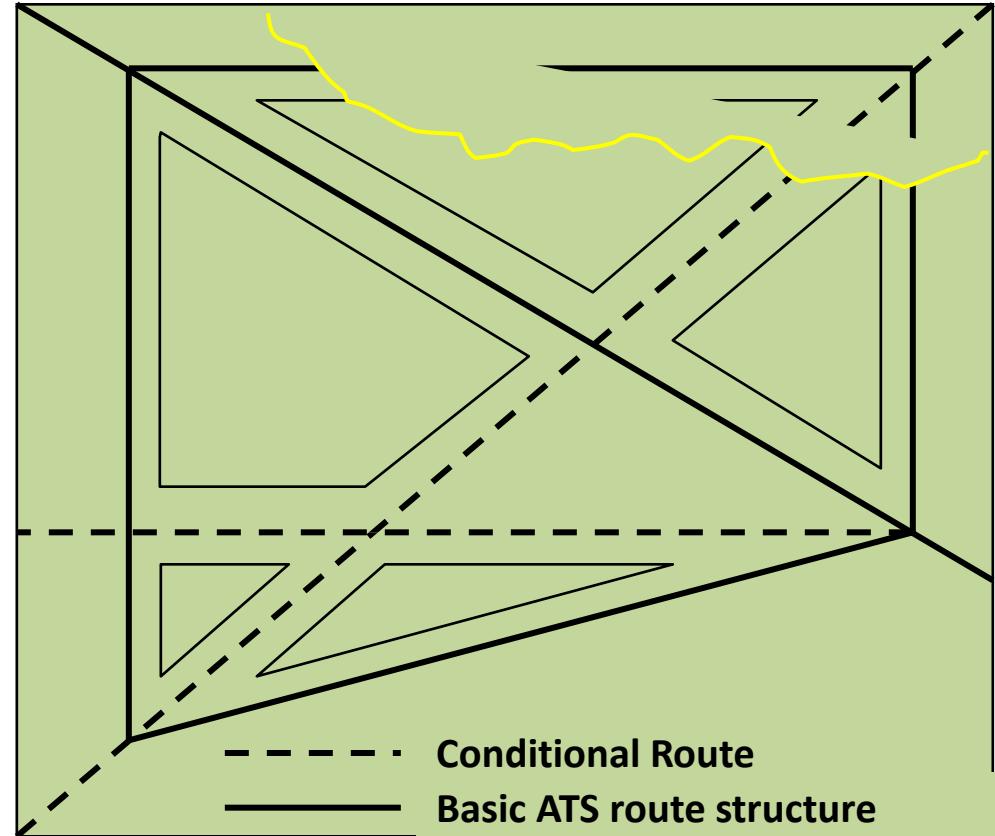
- Usable on ATC instructions only
- Used as short notice routing

### CDR Categorisation



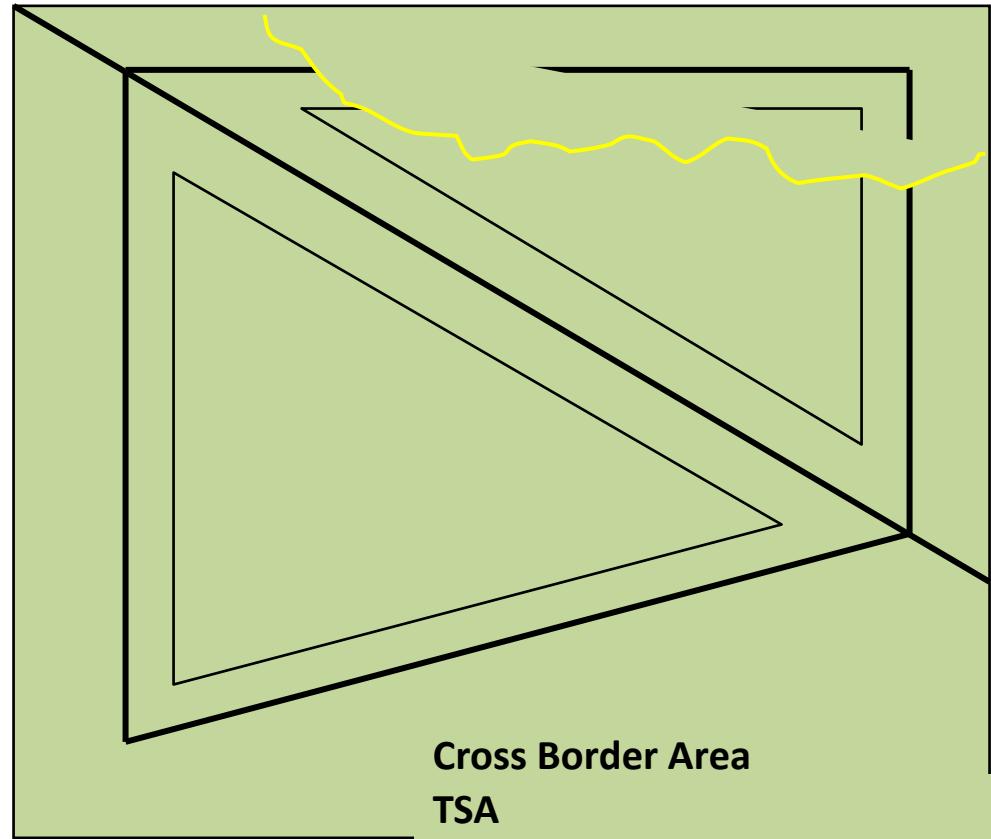
# Flexible Use of Airspace

The application of the FUA structures and procedures would lead, for the same portion of airspace, to a permanent basic ATS route network, complemented by CDRs allocated at pre-tactical level for the duration of specific times, or...



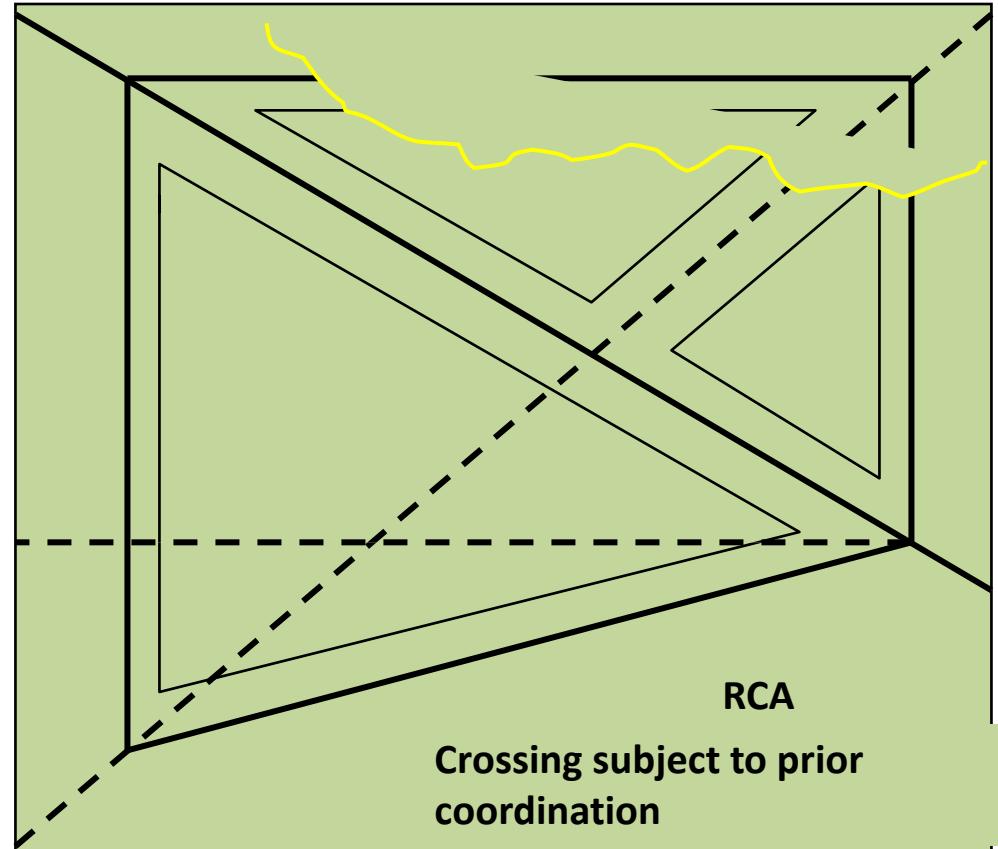
# Flexible Use of Airspace

Temporary segregated Areas (TSAs) and Cross Border Areas (CBAs) also allocated at the pre-tactical level for specific periods, or...



# Flexible Use of Airspace

Airspace which can be used safely by both OAT and GAT without implementing segregated airspace.



# Flexible Use of Airspace

## Benefits of FUA

- ATC capacity increase
- GAT delays reduction
- Efficient separation between OAT and GAT
- Real-time military/civil coordination enhancement
- Reduction of airspace segregation needs
- The use of TSAs brought more closely in line with military needs



# Flexible Use of Airspace

## Development of the FUA

Strategic Level  
Level 1

Definition of national  
airspace policy pre-  
determined airspace  
structures

Pre-tactical Level  
Level 2

Day-to-day  
allocation of  
airspace according  
to users  
requirements

Tactical Level  
Level 3

Real-time use of airspace



# Thank you!!

# Gràcies!!

