Infraestructures del
Transport Aeri

# Separation and Collision Avoidance

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Escola d'Enginyeria de Telecomunicació i Aeroespacial de Castelldefels

UNIVERSITAT POLITÈCNICA DE CATALUNYA

# Index

- **Separation classification**
- **Separation Assurance & Collision Avoidance**
- **Trajectory Synchronization**

# Index

- **Separation classification**
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  - Radar
- **Separation Assurance & Collision Avoidance**
- **Trajectory Synchronization**

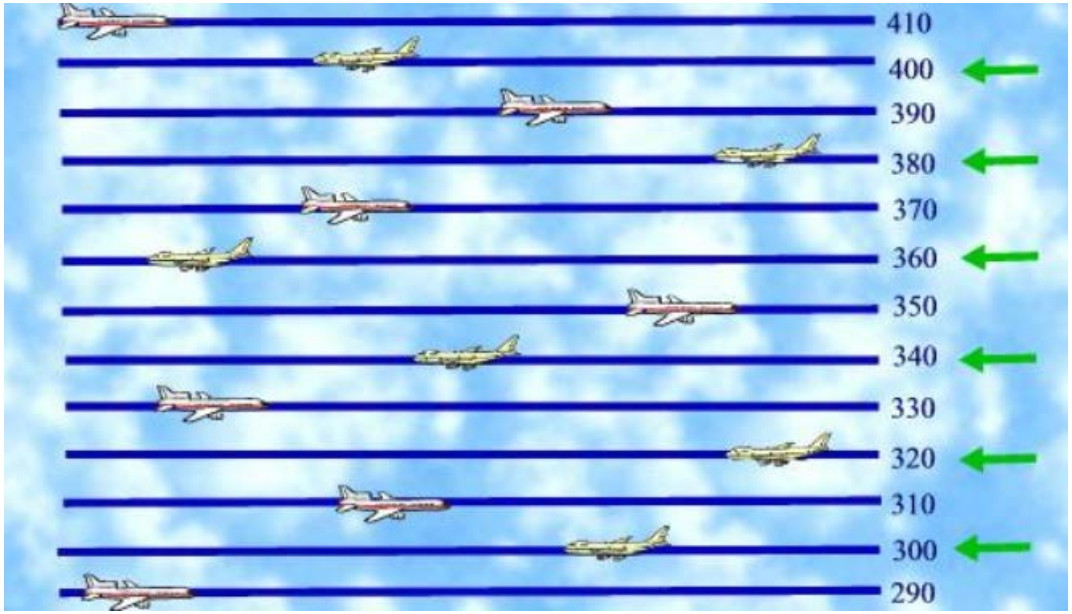
# Vertical separation

**Standard Vertical Separation**

- 1000 ft < FL280
- 2000 ft > FL280

**In RVSM (Reduced Vertical Separation Minima) areas:**

- 1000 ft < FL410
- 2000 ft > FL410

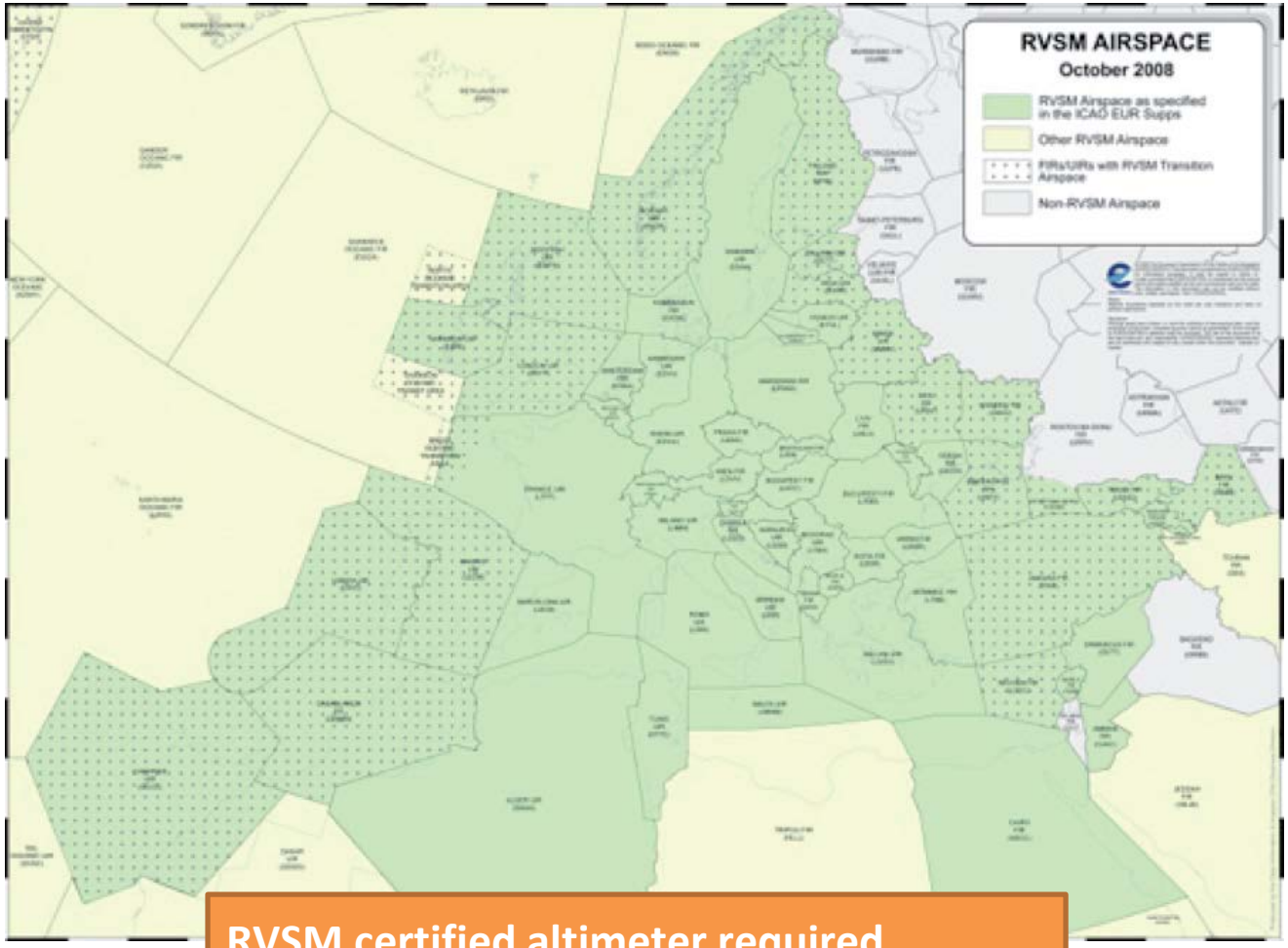



***Additional FL between 290 and 410***

See also:

http://www.icao.int/ESAF/Pages/rvsm-home.aspx
https://www.eurocontrol.int/eur-rma
http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/air_traffic_services/rvsm/

# Vertical separation




**RVSM certified altimeter required**
**RVSM certified autopilot required**
**Specific airworthiness certificate required**

# Horizontal separation

## Separation methods

- Radar separation
- Procedural separation
- Visual separation

**Radar separation: 3NM – 5NM**

## Separation assurance

- Lateral separation
- Longitudinal separation
- (Vertical separation)

**Longitudinal separation:**

- **Time-based separation (3 to 15min)**
- **DME based separation (10NM to 20NM)**
- **Mach number separation (5 to 10 min)**
- **RNAV based separation**

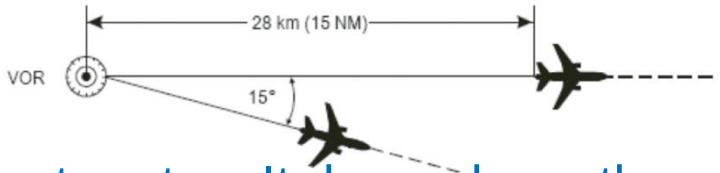
## Factors of influence

- Same, reciprocal or crossing tracks
- Same altitude or climbing/descending traffic
- Aircraft speeds
- Wake turbulence

**More detailed information in**: ICAO Doc. 4444 – Chapter 5

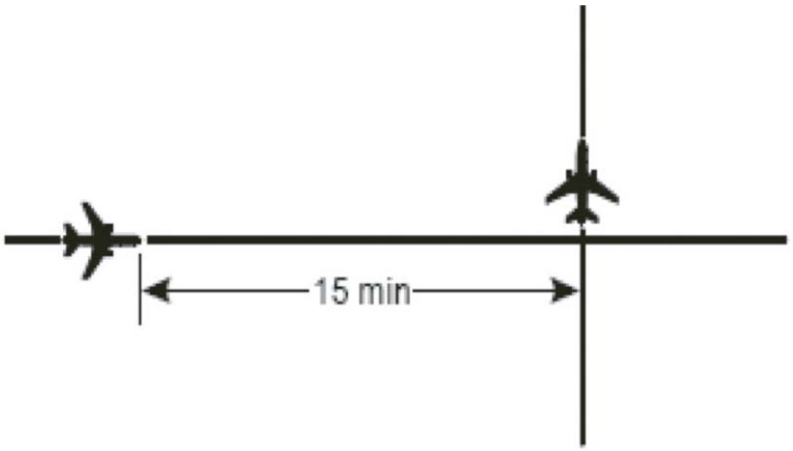
# Horizontal separation

## Lateral




It is applied to aircraft in different routes. It depends on the existence of route lateral guidance and the navigation system (navaids or dead-reckoning).


## Longitudinal




It is applied to aircrafts with the same track angle.
It could be defined by time or distance

# Horizontal separation

## Wake turbulence (ICAO)

Note: National regulations may differ from ICAO standards!

- **Heavy (H)**
  (m ≥ 136,000 kg)

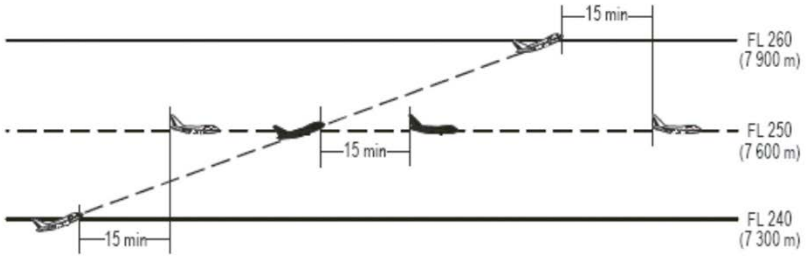

- **Medium (M)**
  (7,000 kg ≤ m ≤ 136,000 kg)

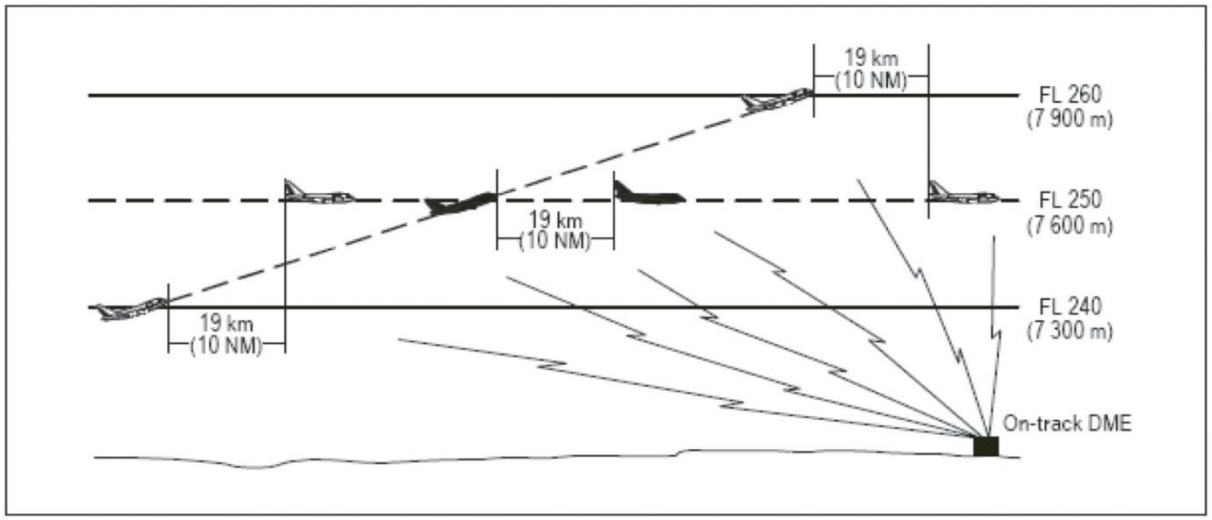

- **Light (L)**
  (m ≤ 7,000 kg)


# Horizontal separation

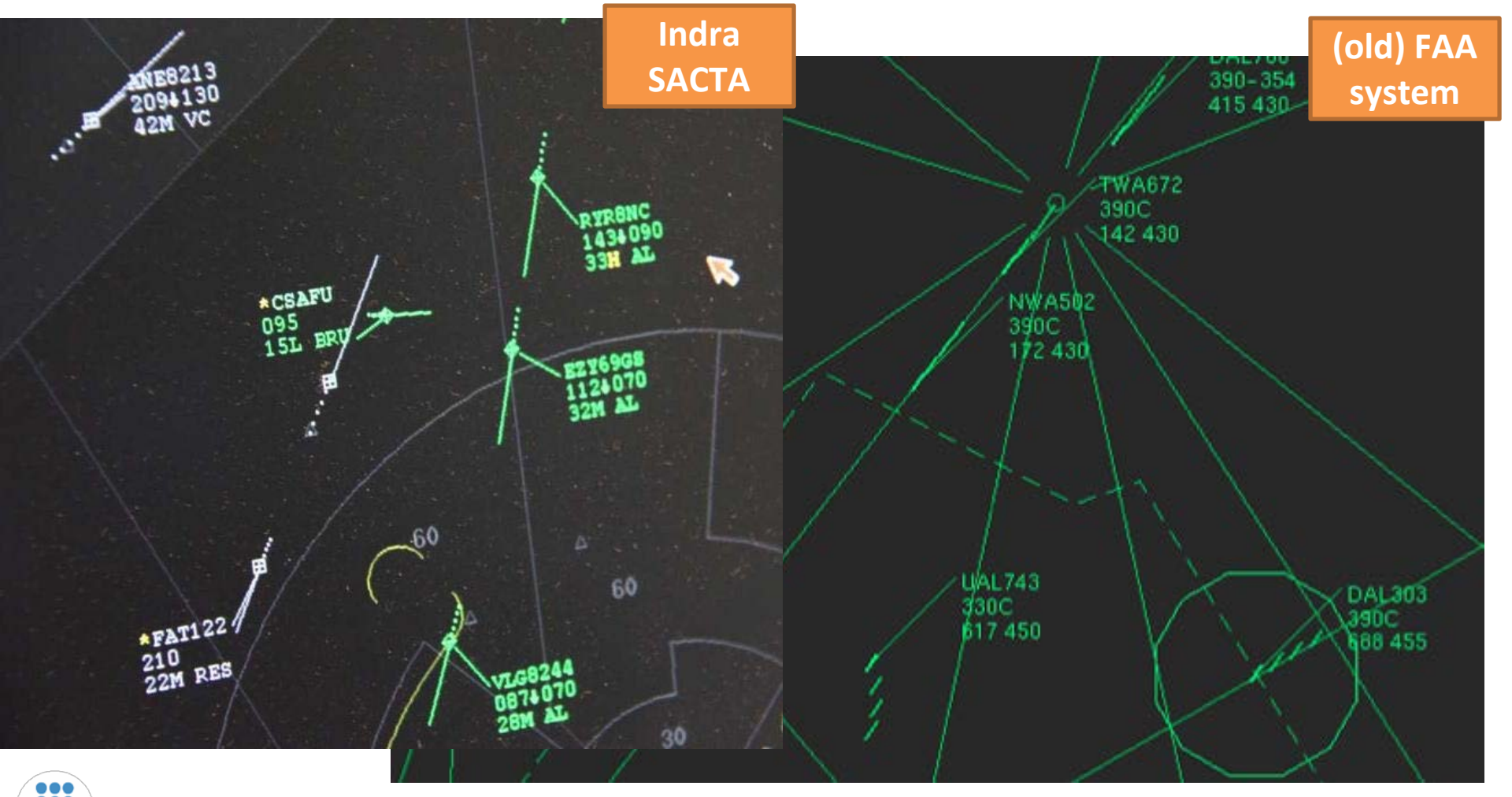
## Combined separation

It is a combination of Vertical and Horizontal separation: up and down



# Radar Separation

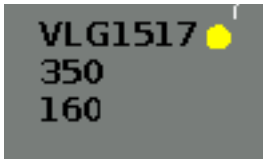


# Visual Separation

**Example: close parallel approaches at KSFO**


# Automated Warning Systems

## Medium Term Conflict Detection: MTCD

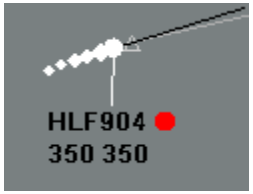



**MTCD** contextual warning

Goal: enhance capacity by reducing ATCO workload and preserving safety limits

How?

MTCD processes info from other information systems (Trajectory Prediction) and Flight Data Processor.




**MTCD** warning

A conflict is defined if any of aircrafts' routes will not comply with minimum separation criteria.

Eurocontrol ATC training and tools: http://youtu.be/ZS7VdfJsRzw

# Automated Warning Systems

## Short Term Conflict Area: STCA

Computation of 3D future position based on current position and Mode C info (ID + Alt).

Acoustic & Visual warning if a future position does not comply with min separation criteria.

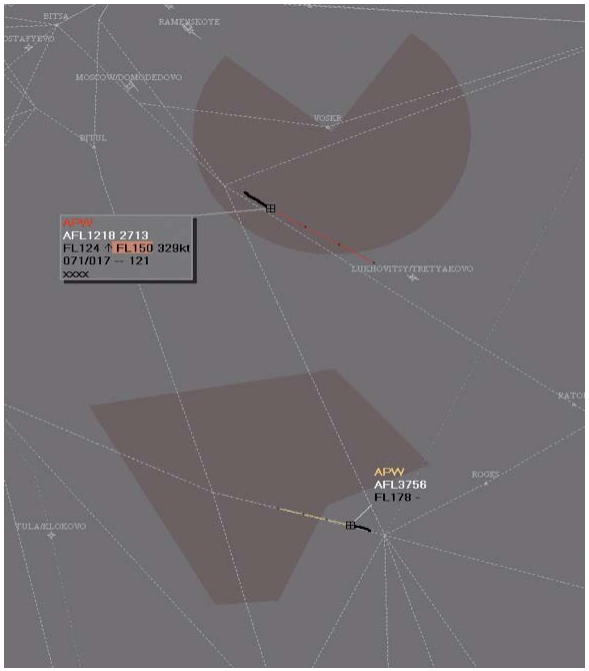

## Minimum Safety Altitude Warning: MSAW

Avoid terrain collision. Based on info provided in Mode C.

# Automated Warning Systems

## Approach Path Monitor: APM

Intended to warn the ATCO about increased risk of controlled flight into terrain accidents by generating an alert of aircraft proximity to terrain or obstacles during **final approach**.




## Area Proximity Warning: APW

It uses surveillance data and flight path prediction to warn the controller when an aircraft is, or is predicted to be, flying into a volume of notified airspace, such as controlled airspace, danger areas, prohibited areas and restricted areas.

It will warn about real or potential intrusions up to 2 minutes.

# Automated Warning Systems

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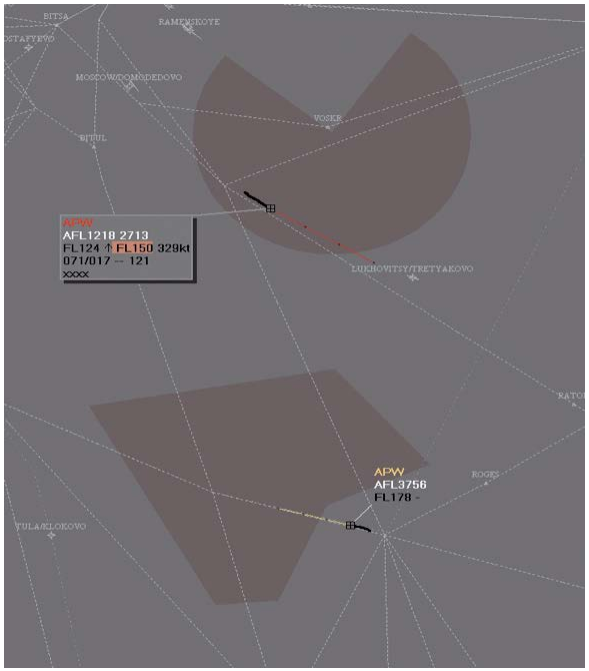


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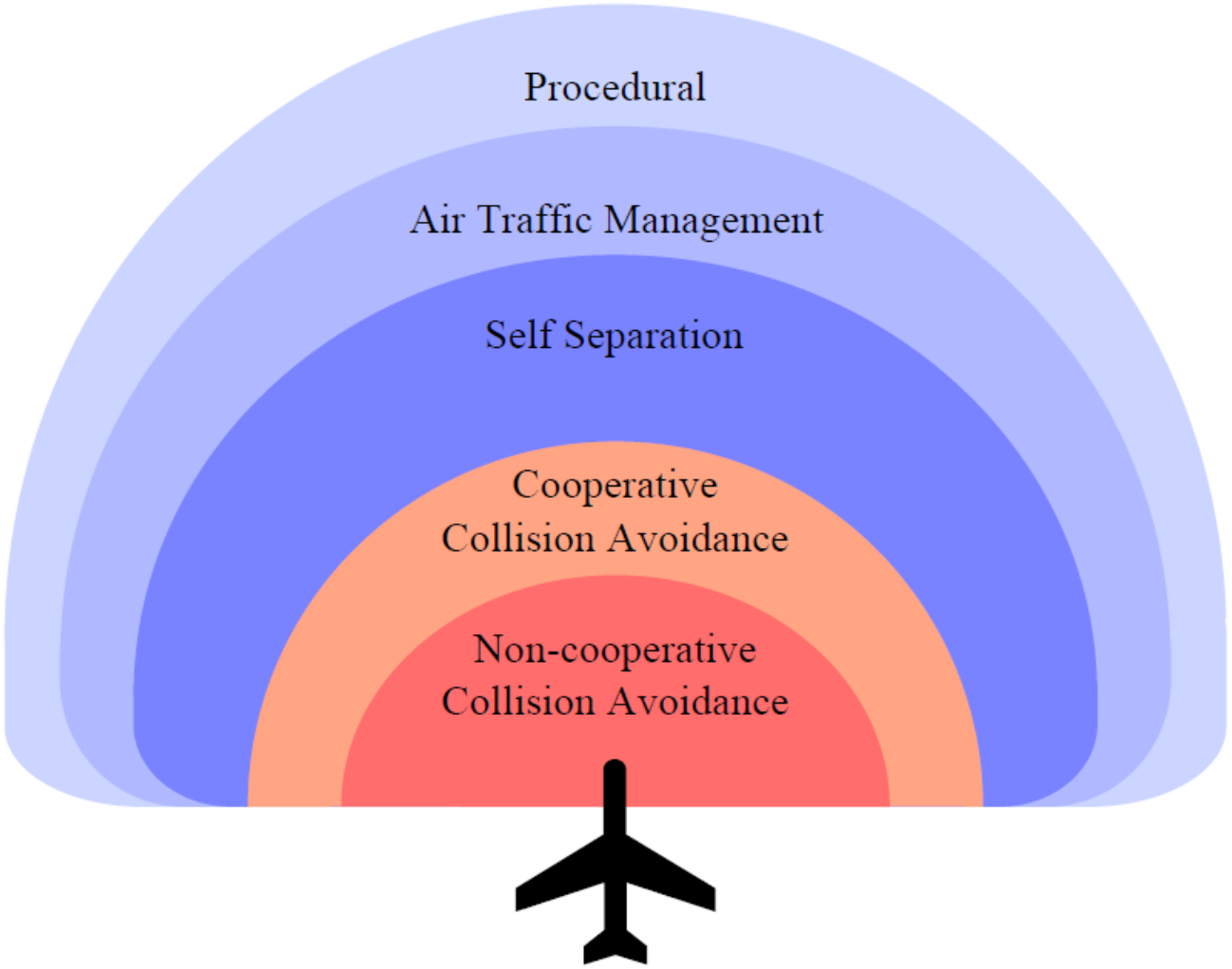
    - Air Traffic Management
    - Self-Separation (ASAS)
    - Collaborative Collision Avoidance (ACAS)
- Trajectory Synchronization

# Classification

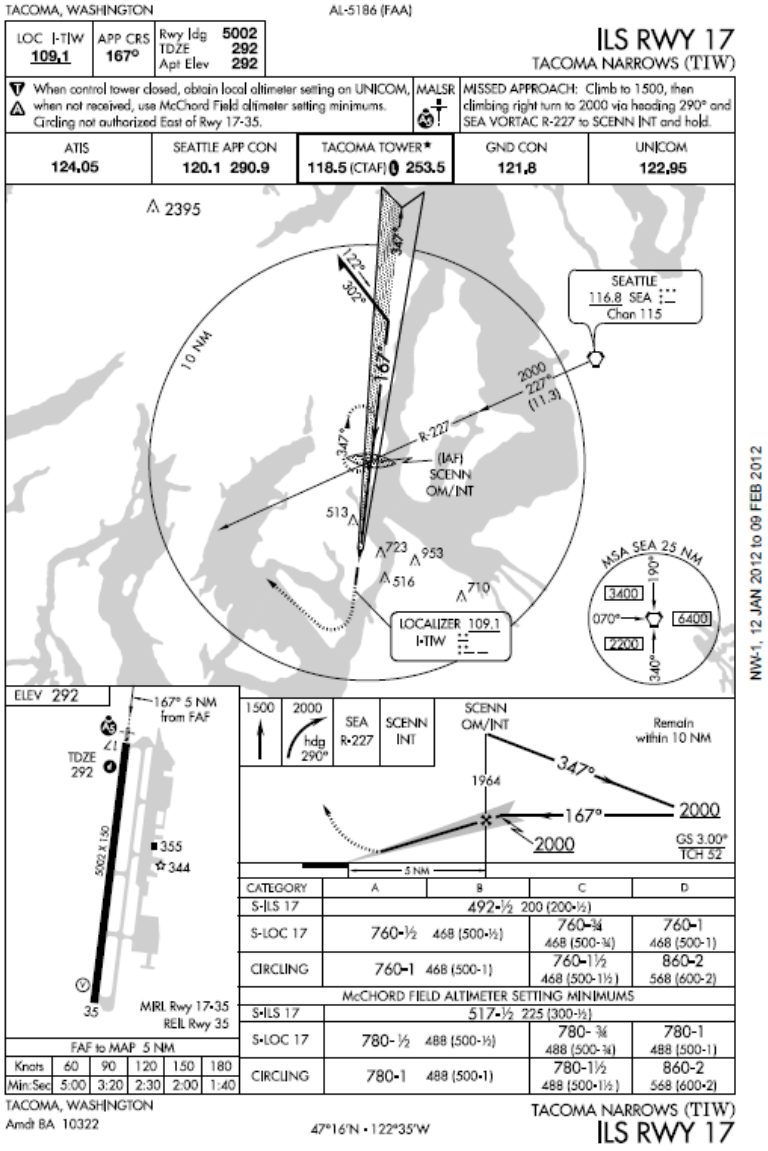


# Procedural Control

## Charateristics

- Procedural control is a method of providing Air Traffic Control Services **without** the use of radar.
- It is used in different regions of the world where radar coverage is either prohibitevely expensive or is simply not feasible, i.e:
  - specific sparsely-populated land areas
  - Oceans
- … or as a back-up system in radar failure case.

# Procedural Control



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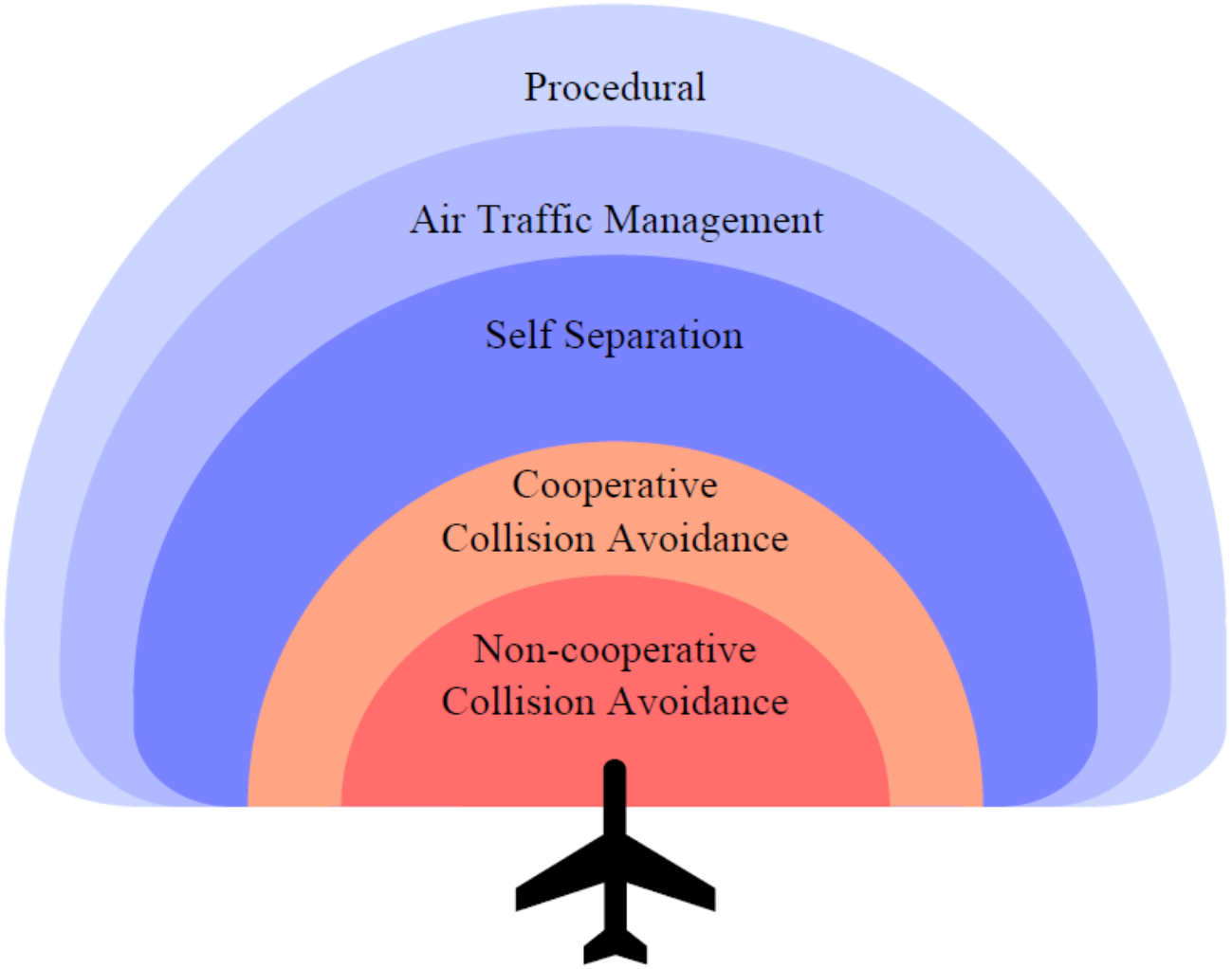
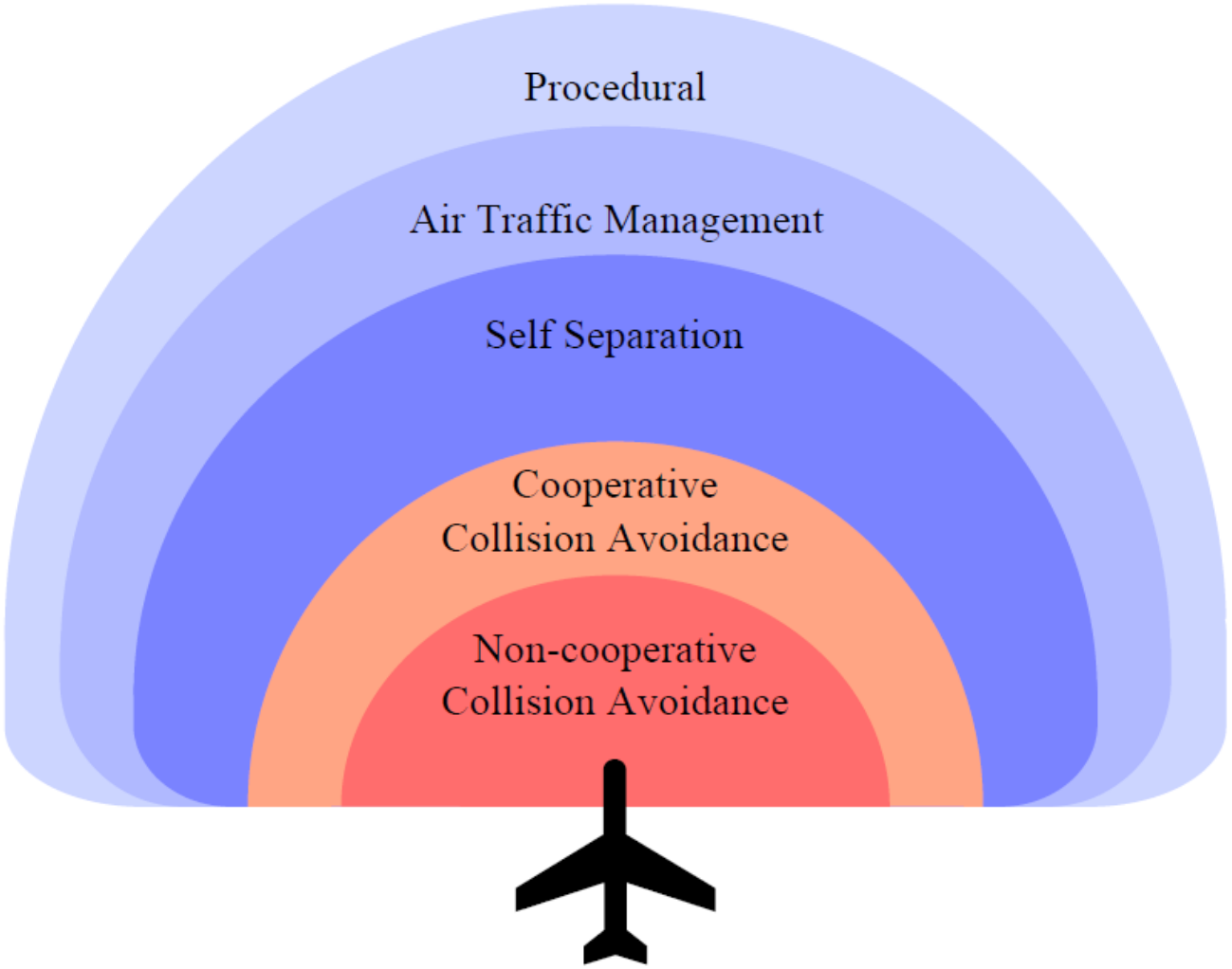


## Types

- Ground Control
- Local Control
- Flight data / Clearance Delivery
- Approach & Terminal Control
- En-Route

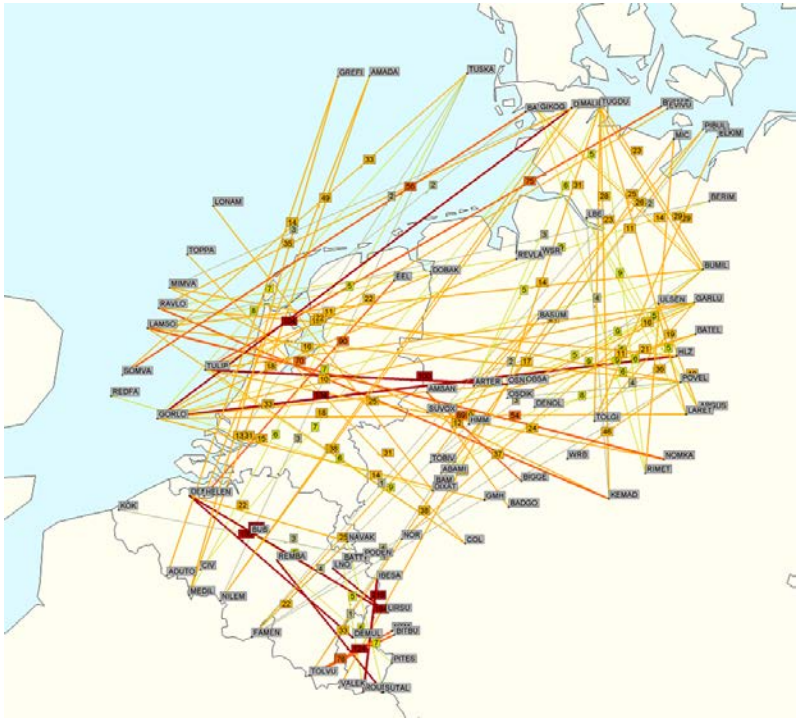
# Classification



# Self-Separation (ASAS)

## Airborne Separation Assurance System

- The ASAS is an aircraft system that enables the flight crew to maintain aircraft's separation from others.
- It also provides flight information concerning the surrounding traffic.



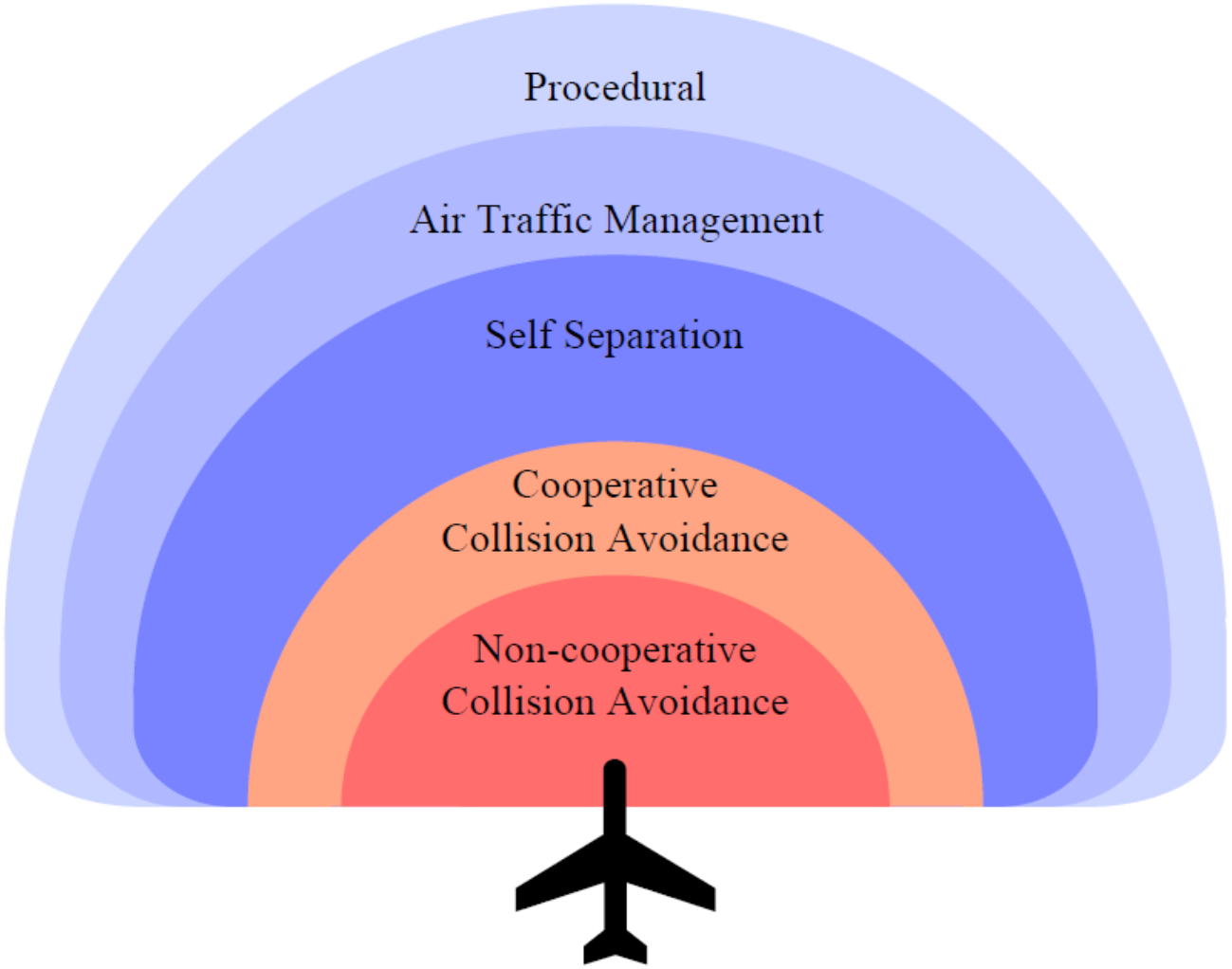
Background: Free Flight Concept

# Self-Separation (ASAS)

## Potential Gains

- Safety
  - Enhanced cockpit Situational Awareness
  - Autonomous modes of operation
  - Guidance presented directly to Flight Crew
- Capacity & Flight Efficiency
- Cost reductions
- Environmental benefits

# Classification



# Cooperative Collision Avoidance

## Airborne Collision Avoidance System (ACAS)

- The ACAS II is based on **SSR transpoder** signals and it was introduced in order to reduce the risk of mid-air or near mid-air collisions
- Interrogates in Mode C & S transponders of nearby ACFTs (*intruders*) – from replies tracks (alt,range,..) alert the pilot if appropiate.
- Available Commercially as TCAS:
  - Traffic-Alert and Collision Avoidance System
- It serves at last-resort safety net irrespective of any separation standards

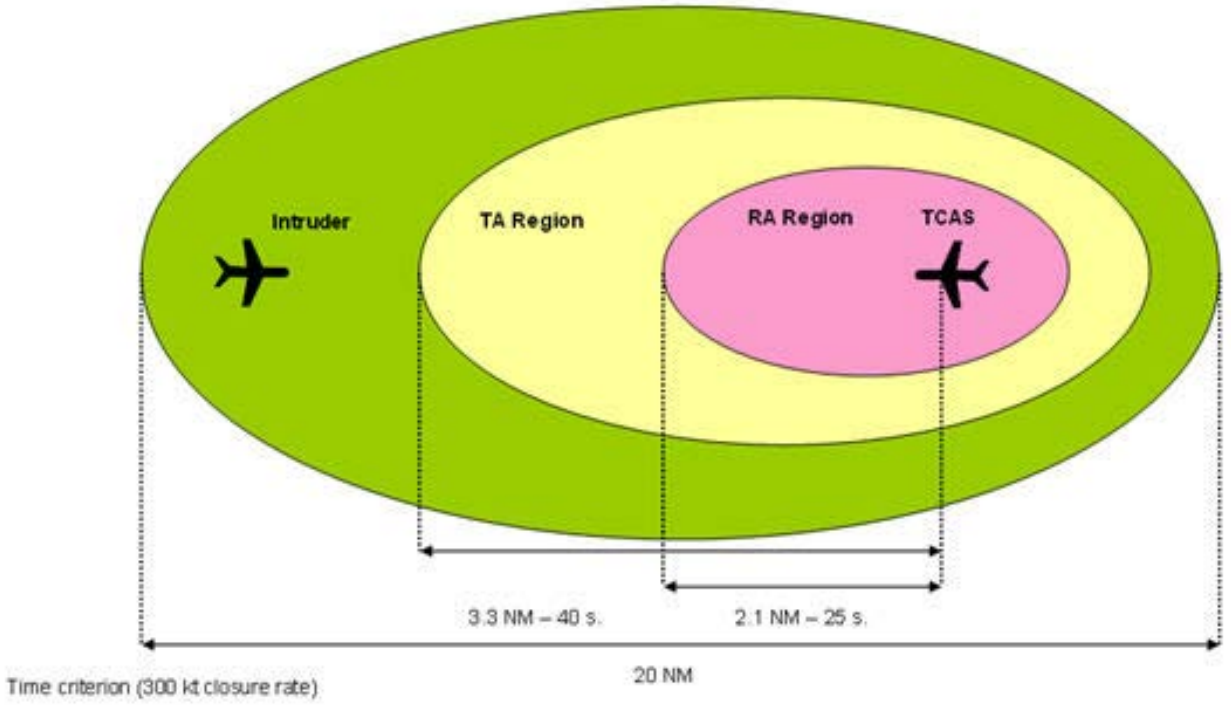
# Cooperative Collision Avoidance

## Information provided

- Traffic Advisory (TA):
  It is intended to assist the pilot in the visual acquisition of the conflicting aircraft and aware the pilot for potential RA

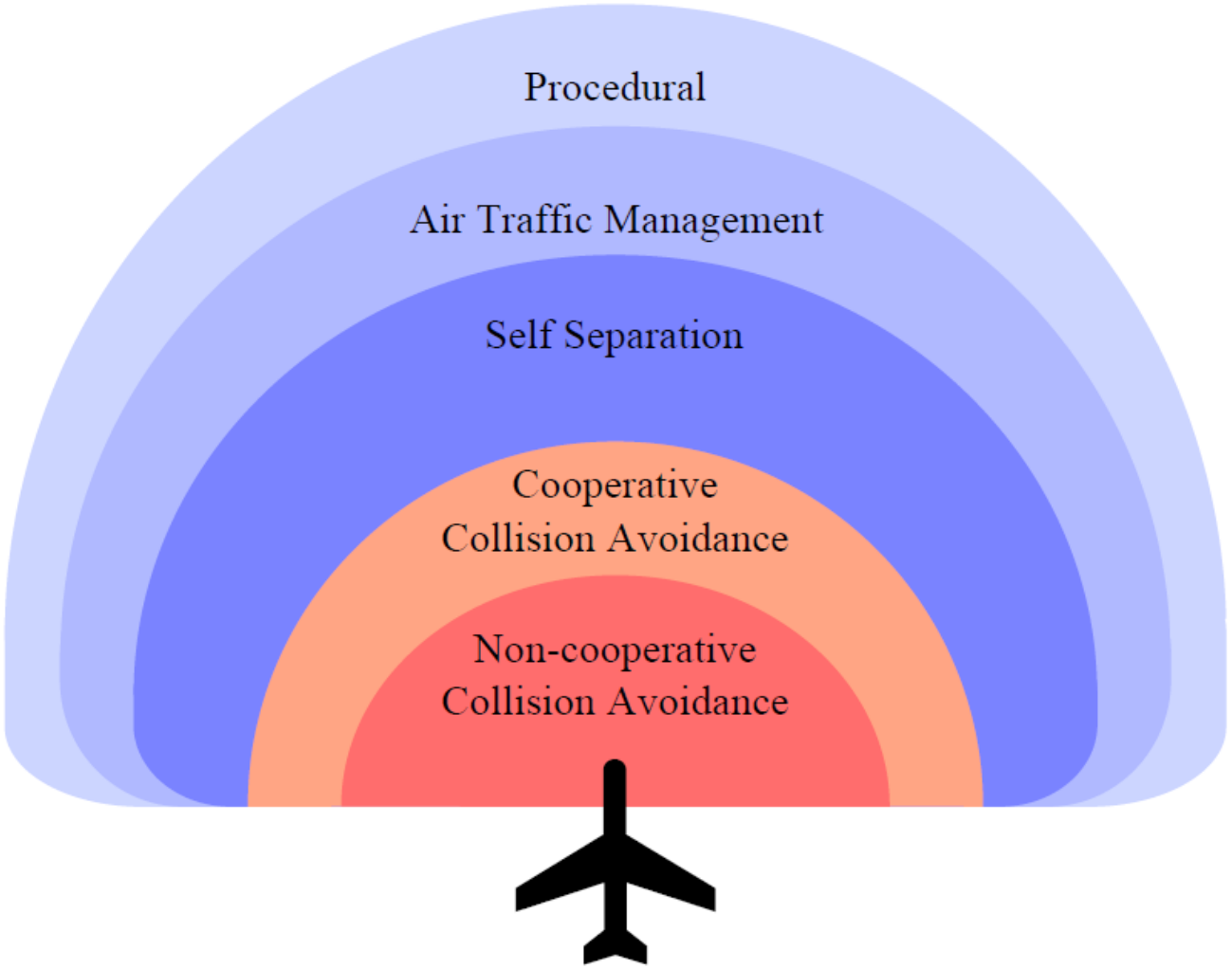
- Resolution Advisory (RA):
  If a risk of collision is established by ACAS II, an RA will be generated
  - RAs tell the pilot the range of vertical speed at which the aircraft should be flown to avoid the threat aircraft.
  - The visual indication of these rates is shown on the flight instruments.

## Protection Volume




Example of ACAS Protection Volume between 5000 and 10000 feet

# Classification



# Thank you!!

# Gràcies!!

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# Trajectory synchronisation

**Holding patterns at strategic waypoints**

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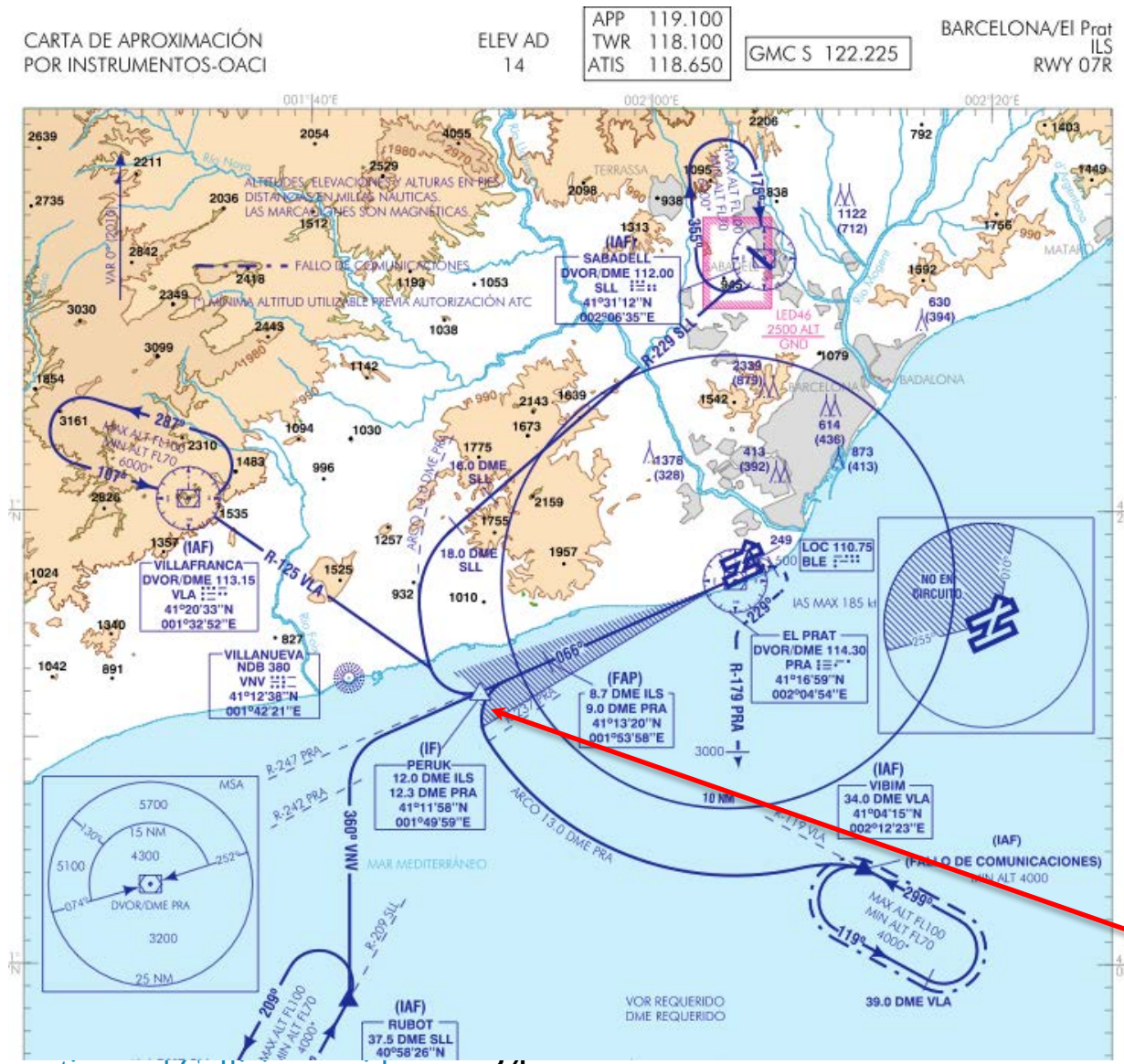
- **Trajectory Synchronization**

# Trajectory synchronisation



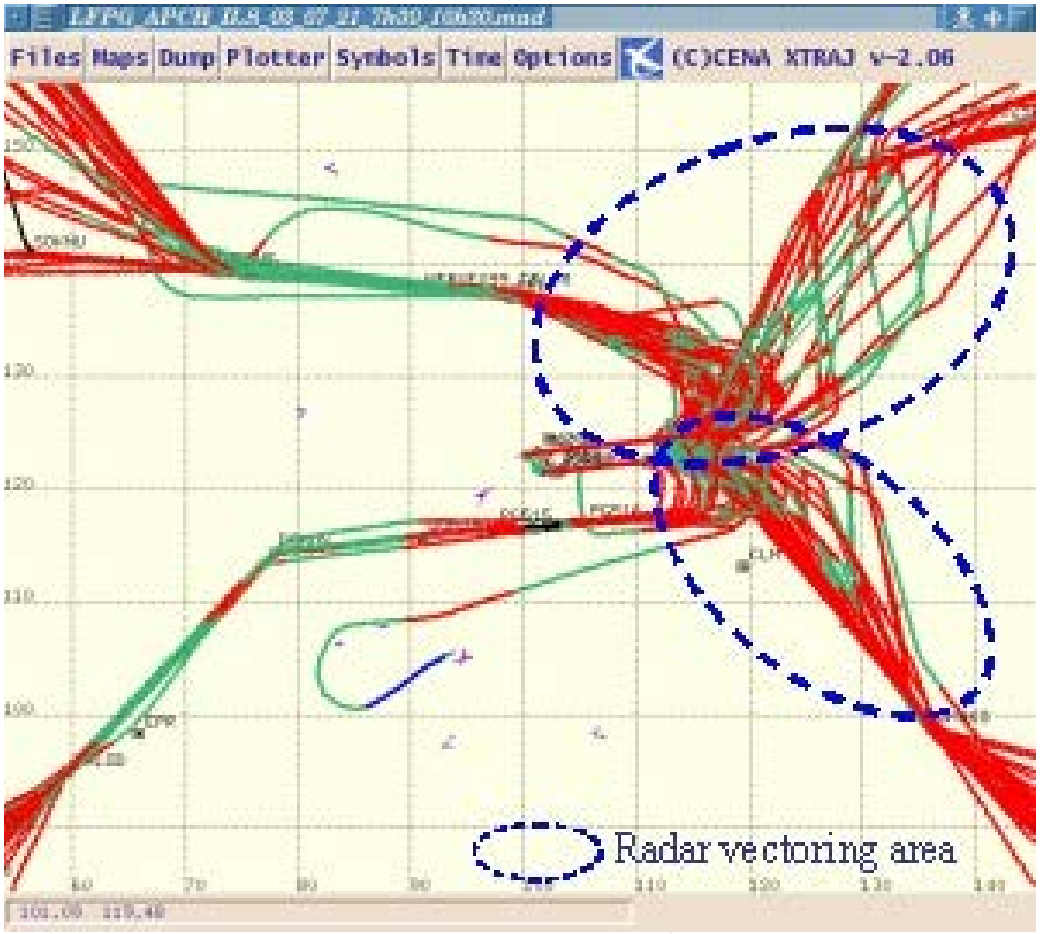

**Barcelona TMA**

**Radar Vectoring**

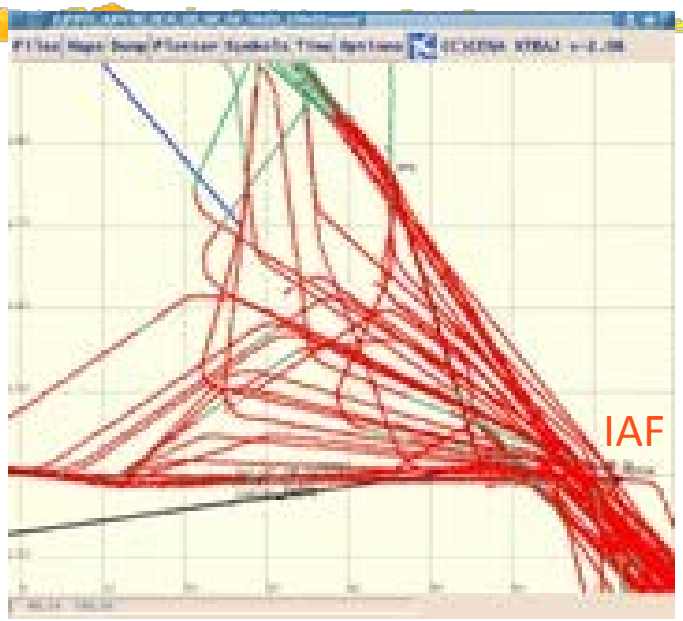
**Traffic Merging points (IF)**

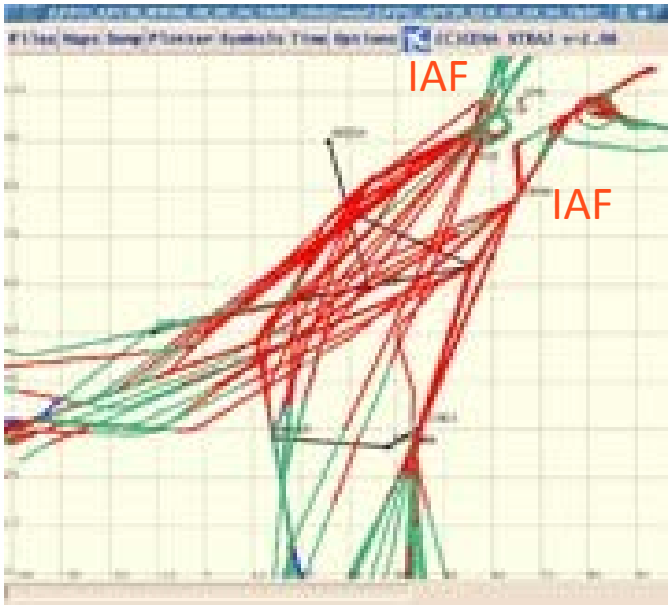
# Trajectory synchronisation

**Radar Vectoring**



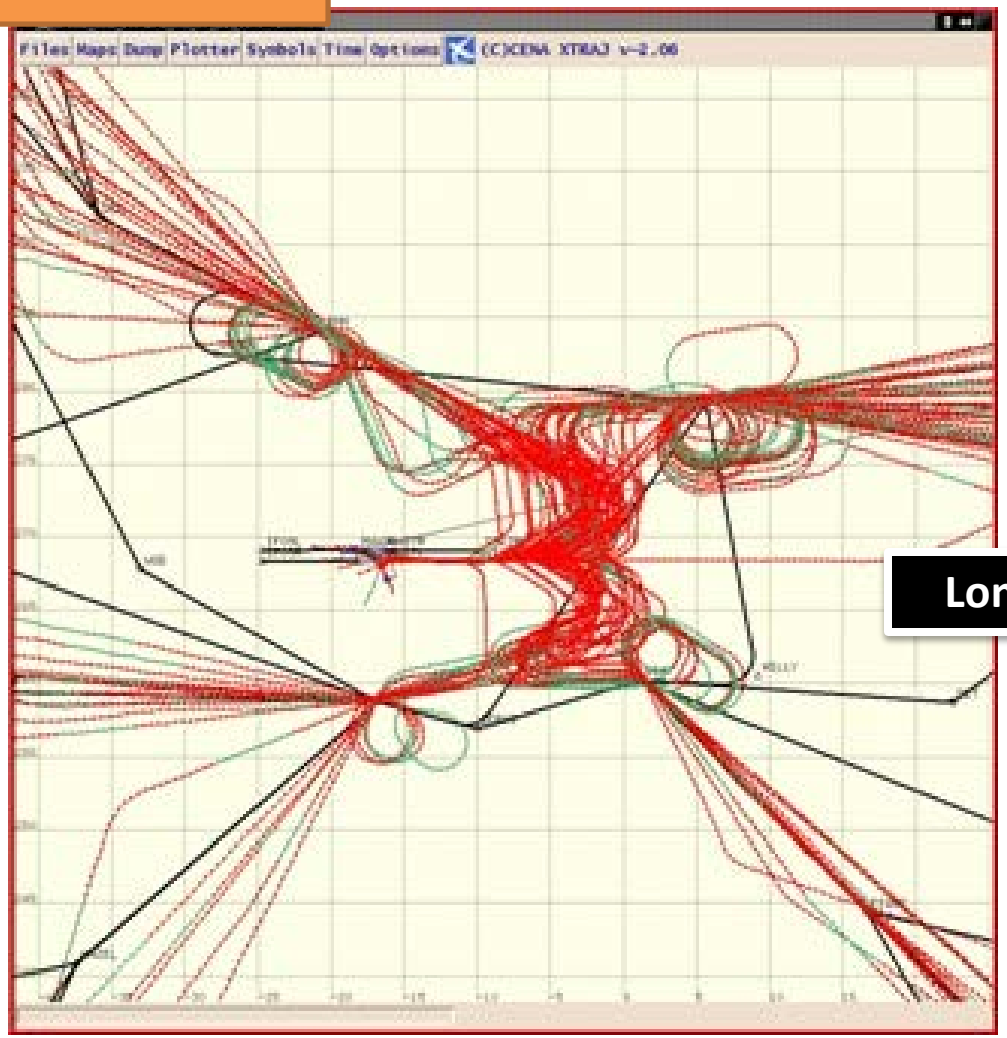

**Paris TMA**

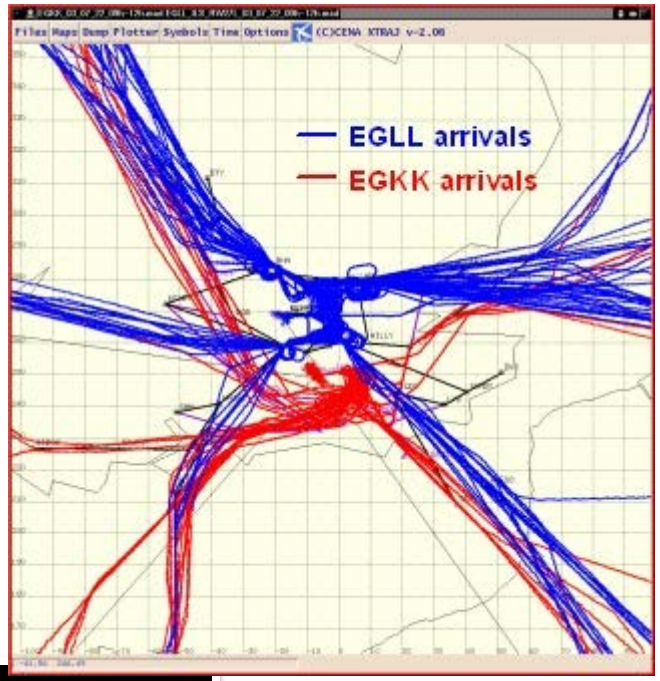


# Trajectory synchronisation

**Radar Vectoring**



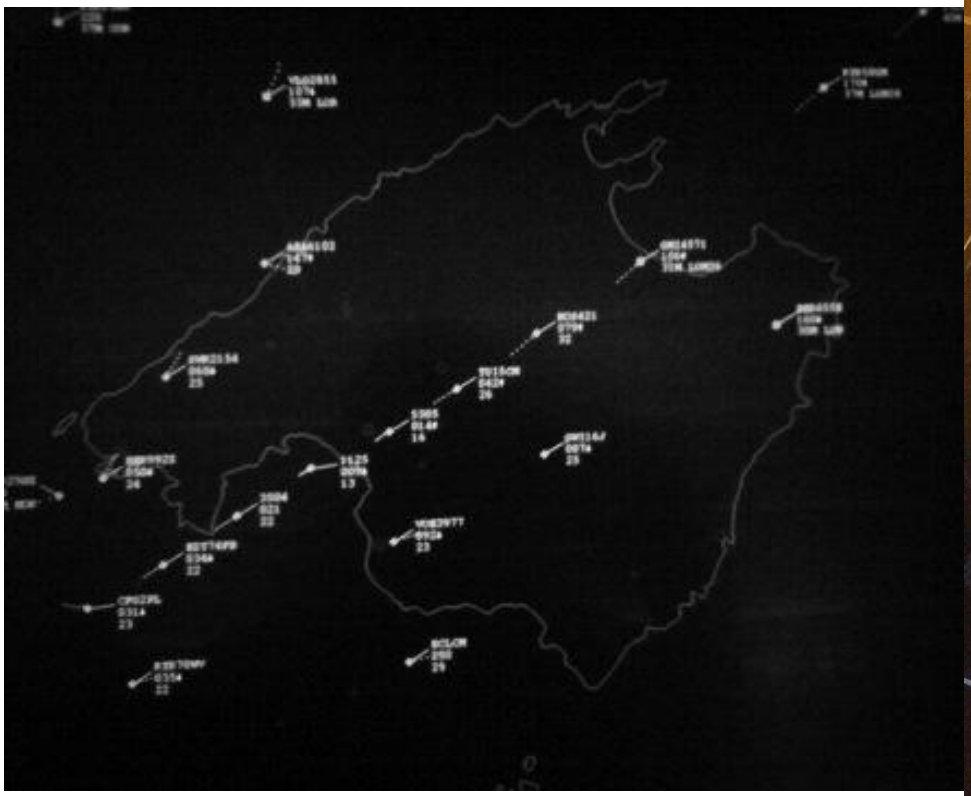




**London TMA**

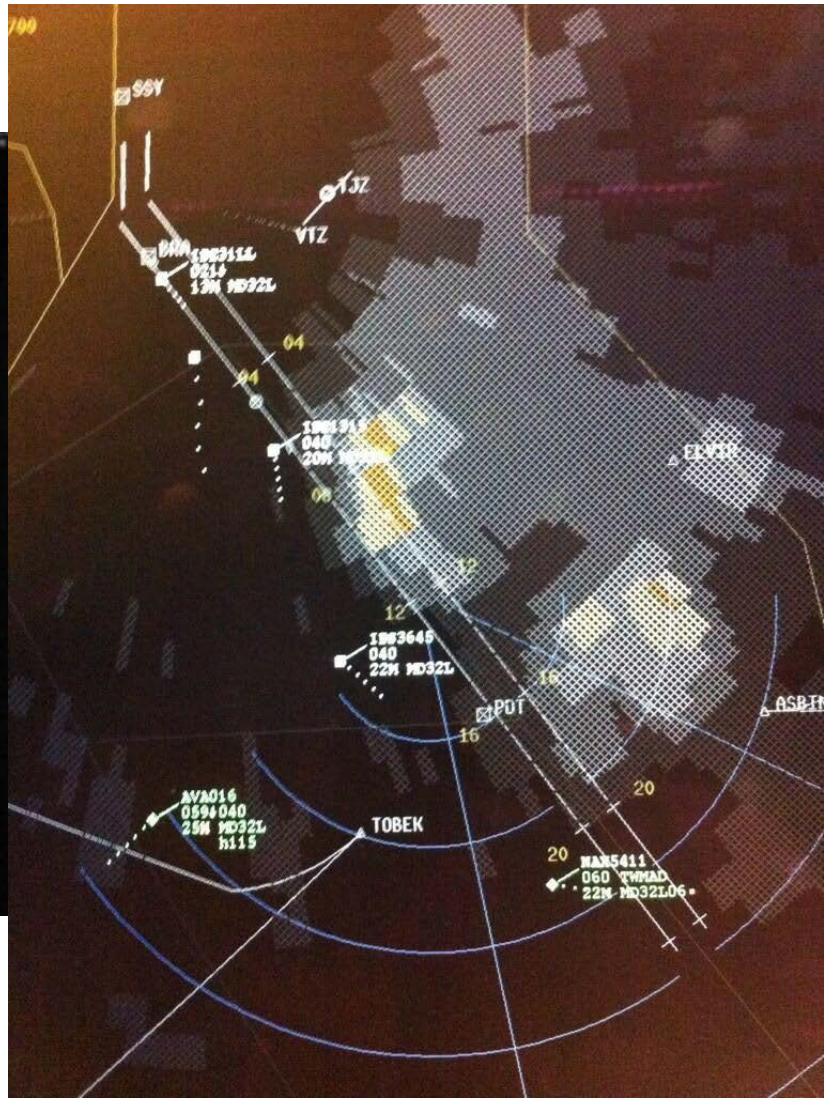
**Example**: Middle East 24h
http://youtu.be/bERzVm9TT8Q

# Trajectory synchronisation

**Radar Vectoring**



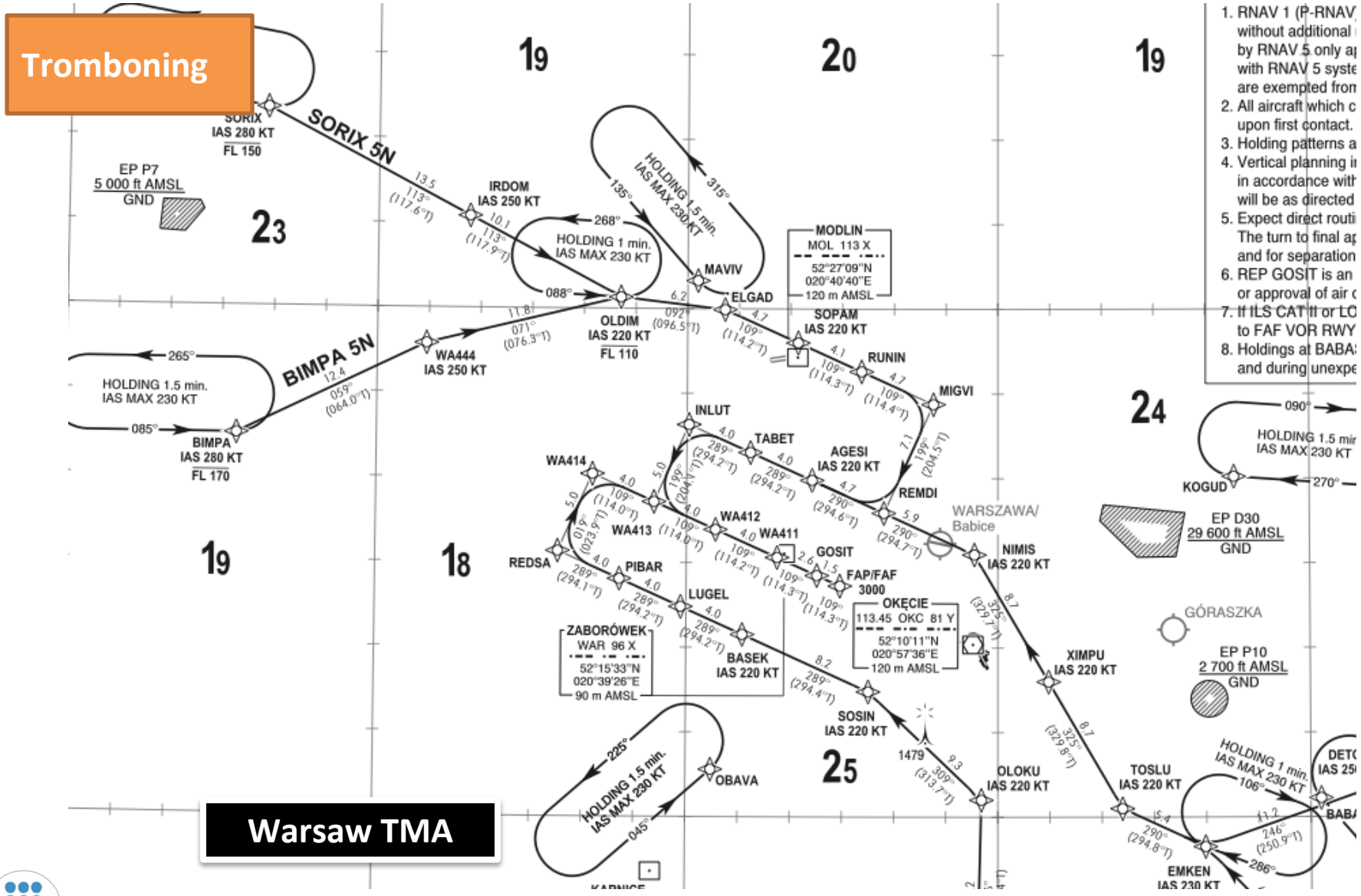
**Palma TMA**




**Madrid TMA**

# Trajectory synchronisation

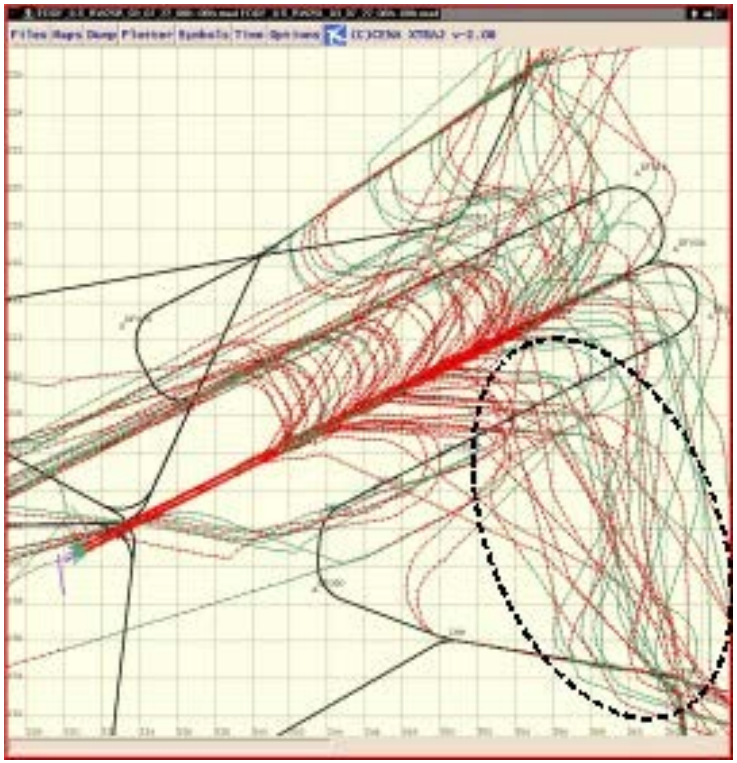
**Tromboning**



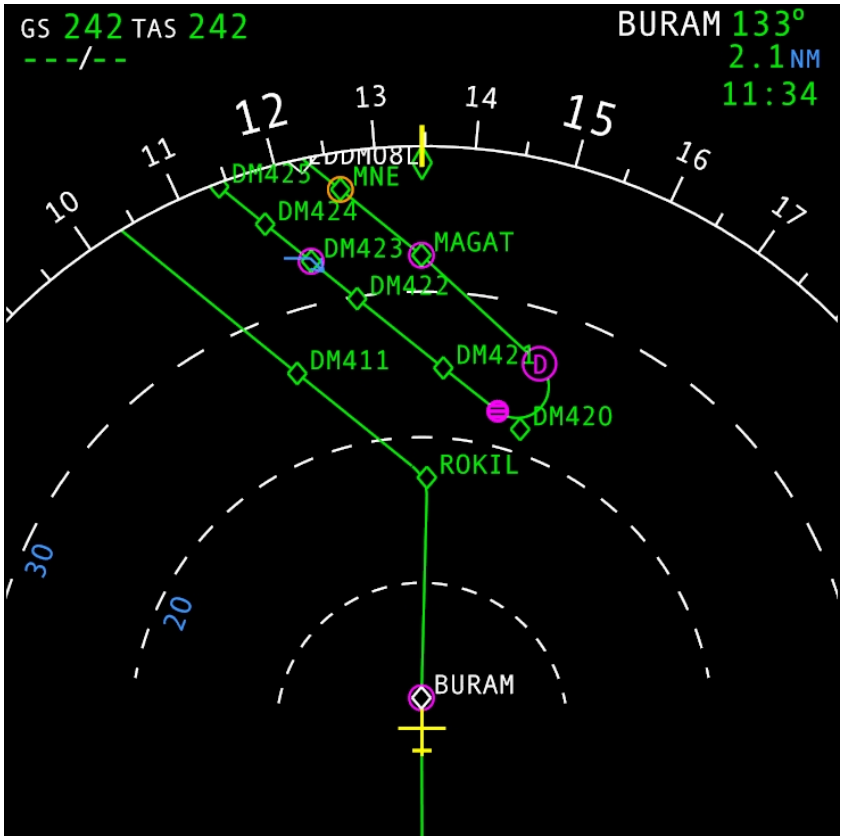

**Warsaw TMA**

# Trajectory synchronisation

**Tromboning**



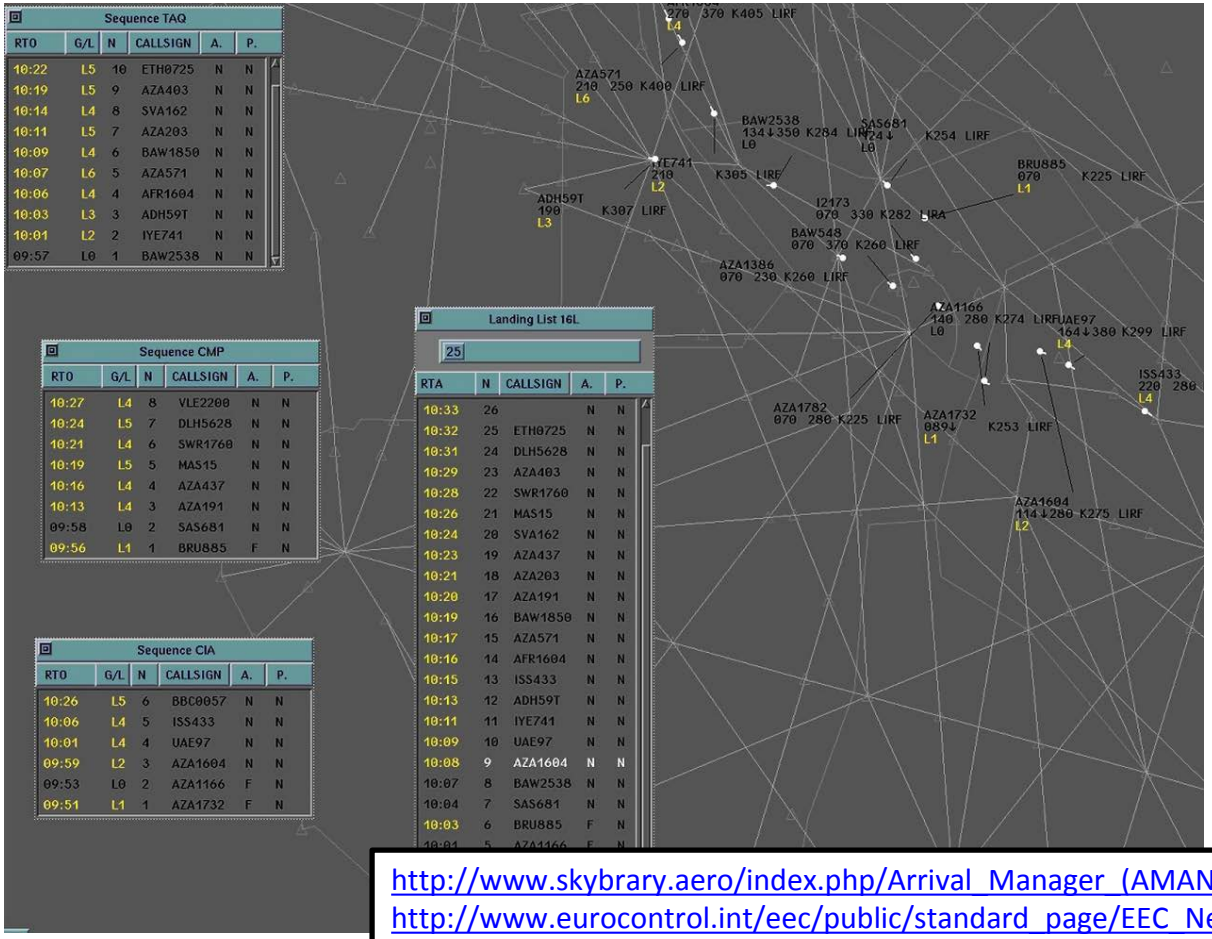
**Frankfurt TMA**



# Trajectory synchronisation

## AMAN (Arrival Manager) and DMAN (Departure Manager)

Predicts trajectories on ground and advise ATC on an arrival/departure sequence.




**In the (near) future: 4D trajectories!!**

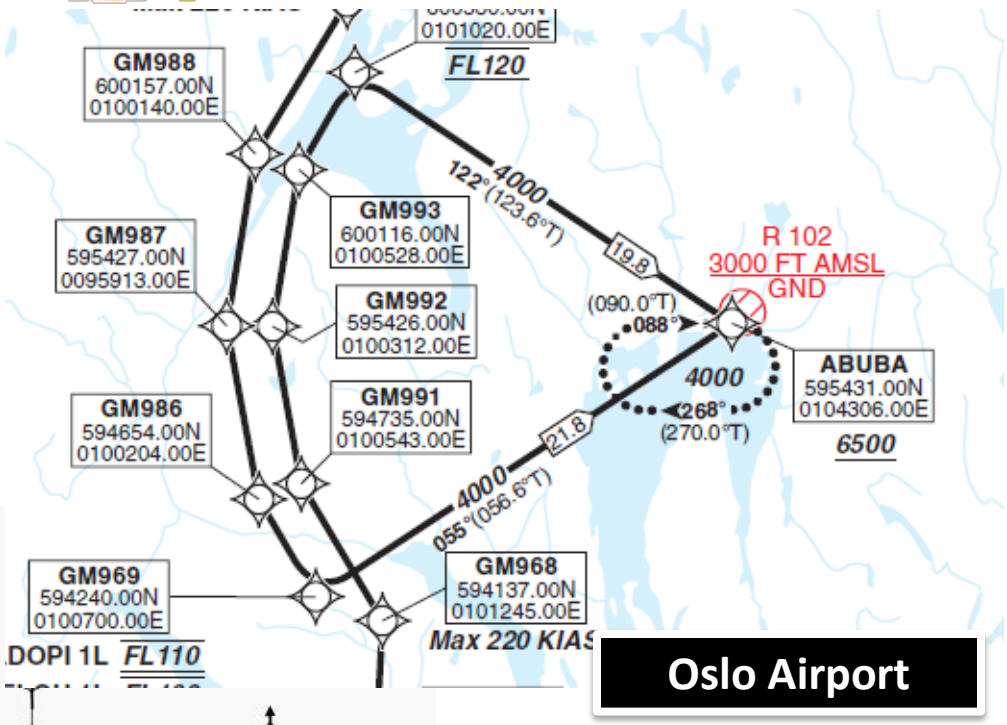
http://www.skybrary.aero/index.php/Arrival_Manager_(AMAN)
http://www.eurocontrol.int/eec/public/standard_page/EEC_News_2005_2_AMAN_Overview.html

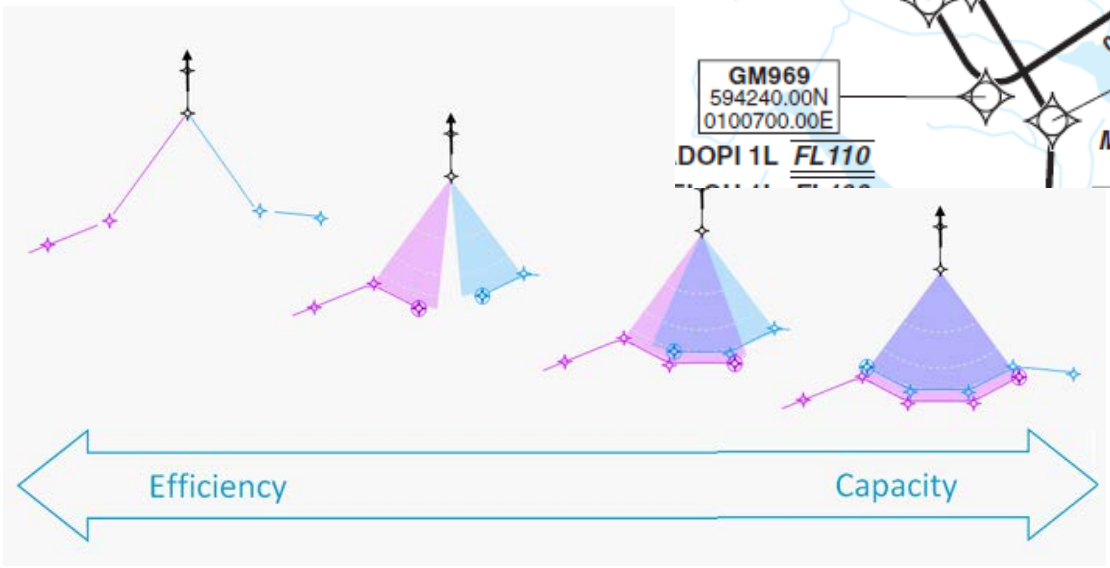
# AMAN

- The AMAN system interacts with several systems, including the host Flight Data Processing System (FDPS) and Radar Data Processing System (RDPS).
- When 2 or more aircraft are predicted at or around the same time on the runway it plans a sequence, generating new ‘required’ times that need to be applied to the flight(s), in order to create/maintain the sequence.
- AMAN outputs the required time for the ATCO in the form of Time to Lose/Time to Gain information. ATCO is the responsible for finding and applying an appropriate method (vectoring, path stretching, speed changes or holding) for the aircraft to meet its time or position in the sequence.

# Trajectory synchronisation

## Point merge




https://www.eurocontrol.int/services/point-merge-concept

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