

Infraestructures del Transport Aeri

Air Traffic Services (ATS)

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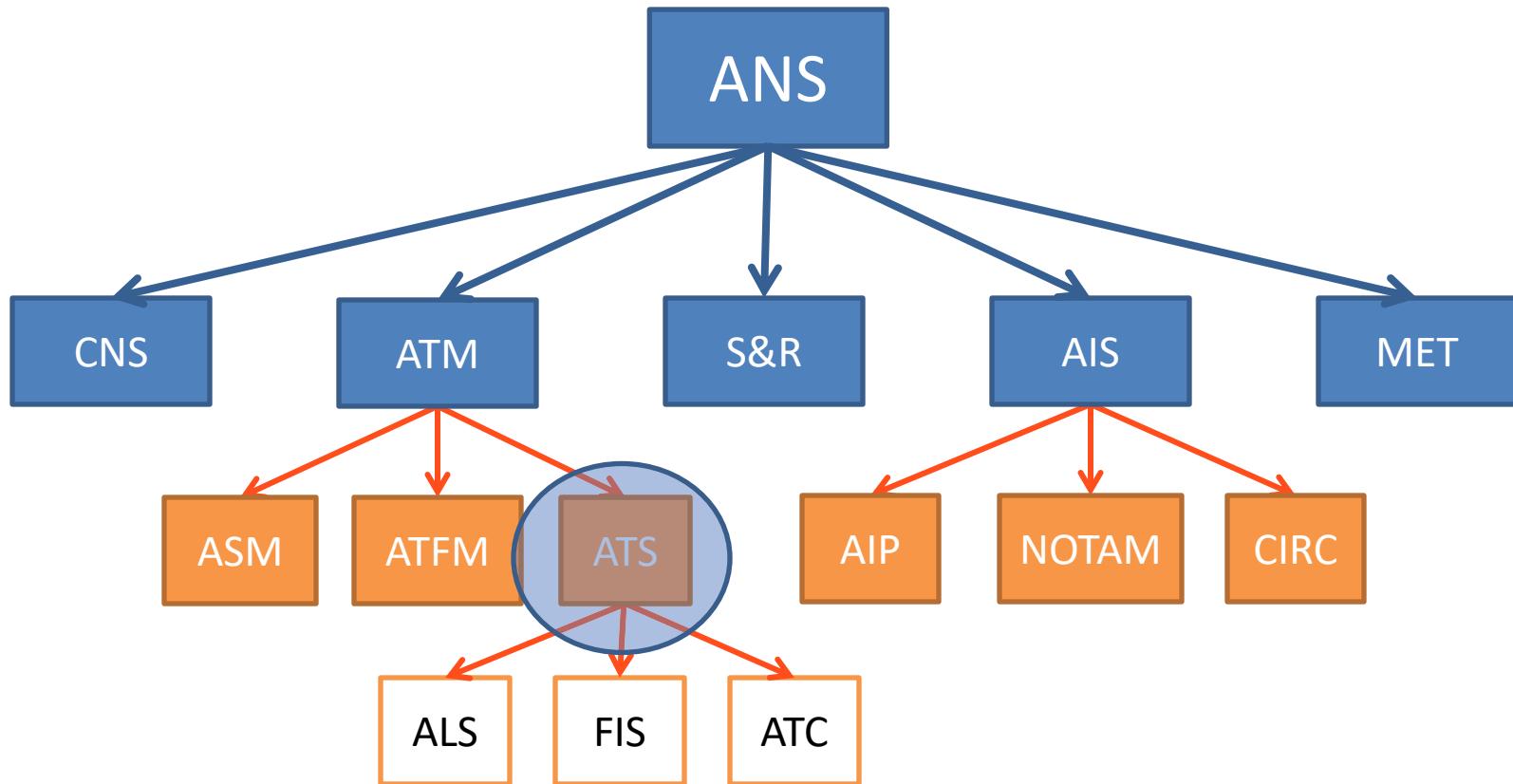
September 2019 – Version 3.1



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

Introduction

ATS Objectives

- Prevent collisions between aircraft (air and ground). ATC
- Expedite and maintain an orderly flow of air traffic. FIS
- Provide advice and information useful for the safe and efficient conduct of flights. ALS
- Notify appropriate organisations regarding aircraft in need of search and rescue aid, and assist such organisations as required. ALS

ICAO Annex 11: Air Traffic Services

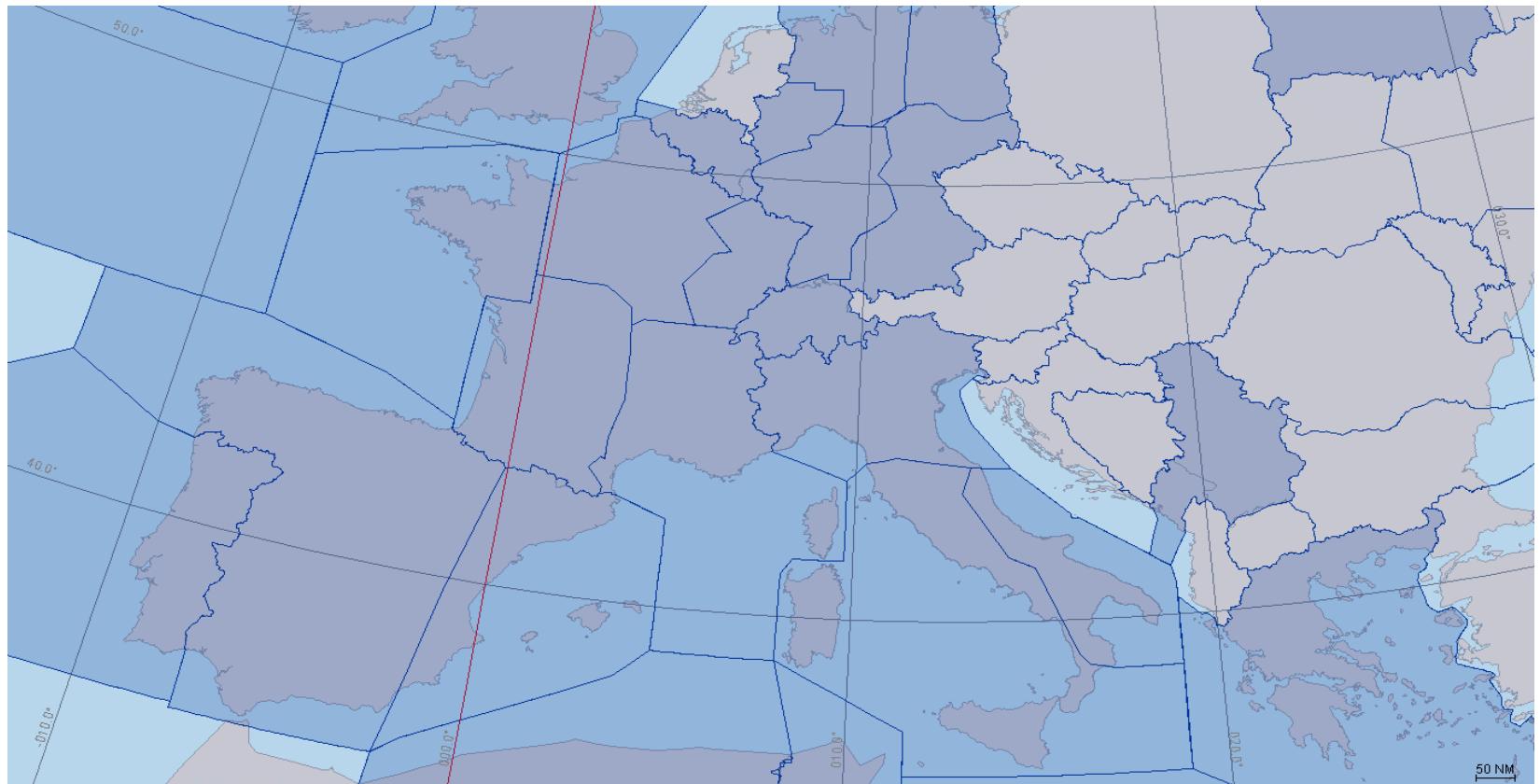
ICAO Doc. 4444: Procedures for Air Navigation Services: Air Traffic Management.



Introduction

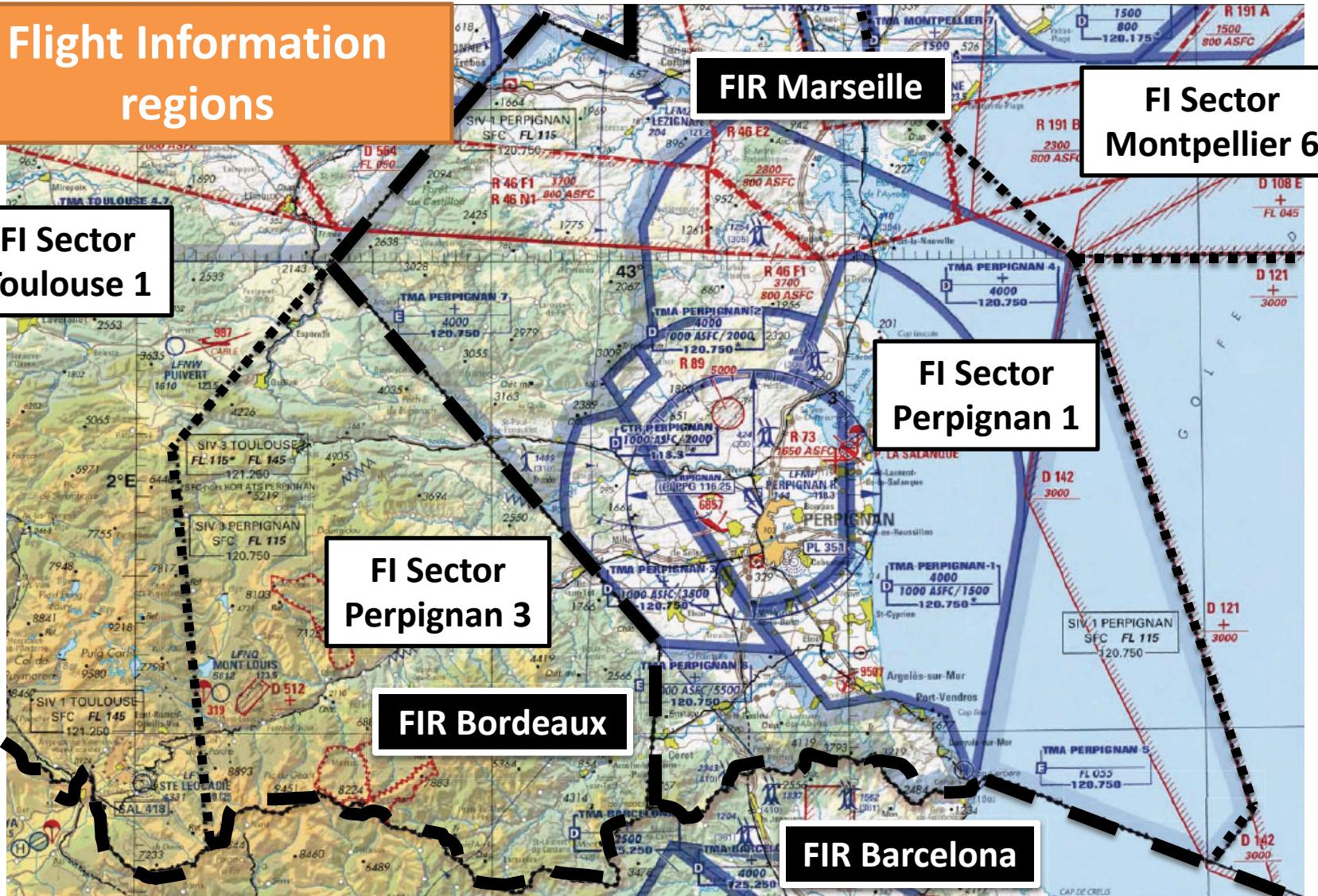
Flight Information Regions (FIR)

Alert and Flight Information services provided



Introduction

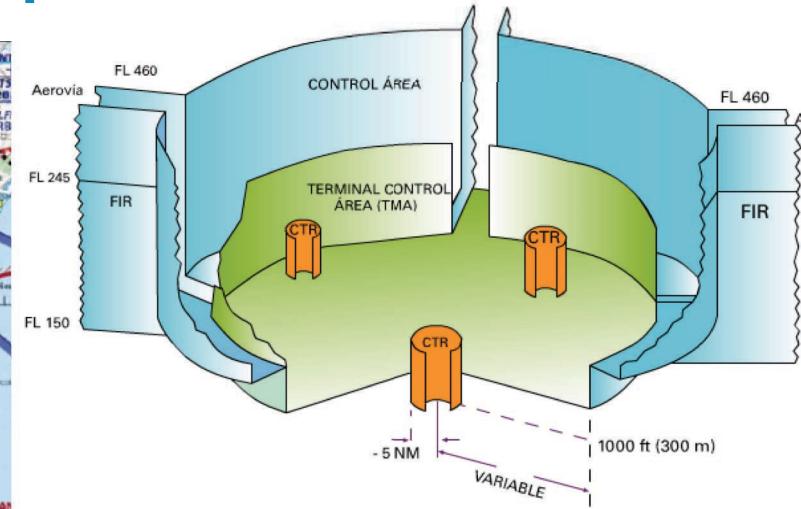
Flight Information regions



Introduction

Control Areas and Control Zones

Air Traffic Control services provided



Different ATC services as a function of Airspace Class

Introduction

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 (ATC)	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!

Alert Services

Alert Services shall be provided to:

- All traffic provided with also ATC
- Any aircraft known or believed to be the subject of unlawful interference
- As far as possible: All other traffic having filed a flight plan or known by the ATS.

ATS shall notify search & rescue centers according to:

- Uncertainty phase
- Alert phase
- Distress phase



Uncertainty phase (INCERTFA)

- No communication with the aircraft in **30 min**
- Aircraft fails to arrive within **30 min** of ETA

Alert phase (ALERTFA)

- Subsequent attempts to communicate fail
- Aircraft fails to land within **5 min** after landing clearance and no communication is received
- Information has been received indicating the aircraft is impaired, but not forced landing is required
- Aircraft is known or believed to be the subject of unlawful interference



Distress phase (DETRESFA)

- Subsequent attempts to communicate fail
- Fuel on board is insufficient for safe landing
- Information has been received indicating the aircraft is impaired and a forced landing is likely

Special emergency transponder codes

7700: Distress

7600: Lost communications

7500: Unlawful interference

Emergency or guard frequency: 121.50 MHz



Alert Services

- The radio telephony distress signal **MAYDAY** and the radio telephony urgency signal **PAN-PAN** (or **PAN-PAN MEDICAL**) shall be used at the commencement of the first **distress** and **urgency** communication respectively.

Examples of urgency or distress situations:

- EZY5CM Pan-pan <http://youtu.be/gYUo8G-gtGE>
- Thomsonfly 263H bird-strike <http://youtu.be/9KhZwsYtNDE>
- BA038 runway accident Headrow <http://youtu.be/IJNVVIBPi8M>
- US1549 Hudson ditching: <http://youtu.be/pWpSAfF6ell>
[\(http://youtu.be/MSPsrhCPt-0 for subtitles\)](http://youtu.be/MSPsrhCPt-0)



Flight Information Services

Flight Information Services shall be provided to:

- All traffic provided with also ATC
- Any aircraft known by the ATS

Provision of the following information:

- AIRMET and SIGMET
- Weather conditions at dep/des or alternate aerodromes
- Volcanic activity and radioactive/toxic releases
- Changes in the serviceability of navigation aids
- Changes in condition of aerodromes
- Collision hazards (airspace classes C,D,E,F and G)
- Any other information likely to affect safety
- For flight over water: any available information of surface vessels in the area



Flight Information Services

Information provision

- Air traffic controller operator (ATCo)
- Aerodrome Flight Information Service (AFIS) operator
- ATIS (Automatic Terminal Information Service)
- AWOS (Automated Weather Observing System)
- VOLMET (METARs, TAFs, AIRMET and SIGMET broadcasts in VHF/HF)

Types of messages

- Direct transmission with acknowledgement
- General call unacknowledged
- Broadcast
- Data-link

ATIS at London City: http://youtu.be/4J_s_2wVfDs
Honk-kong VOLMET http://youtu.be/P_IIKbbN-HQ

ATIS at Salt Lake City: <http://youtu.be/u9tsggUYMQs>
ATCo tricks a pilot in Las Vegas: <http://youtu.be/S9h3FYqEhkM>



Air Traffic Control

Air Traffic Control services shall be provided to:

- All IFR flights in airspace classes A, B, C, D and E
- All VFR flights in airspace classes B, C and D
- All special VFR flights (SVFR)
- All aerodrome traffic in controlled aerodromes

Air Traffic Control services:

- Area control service
- Approach control service
- Aerodrome control service

Air Traffic Control main tasks:

- Gather and process data
- Issue clearances
- Coordinate clearances with other ATC units

Air Traffic Control Main Tasks

Data gathering and processing

- Visual contact with aircraft and other vehicles
- Voice position reports
- Surveillance systems (PSR, SSR, ADS,...)
- Transponder codes and modes
- Flight plans and flight intentions
- Correlation between transponder codes and flight plans

From the information received the ATC shall determine the relative positions of known aircraft to each other



Air Traffic Control Main Tasks

Clearances

- Flight crew must read back the following clearances:
 - IFR clearance delivery (mandatory for all IFR **before** take off)
 - ATC route clearances
 - Clearances and instructions to enter, land on, take off on, hold short of, cross and backtrack on any runway.
 - Runway-in-use, altimeter settings, SSR codes, level instructions, heading and speed instructions, transition levels
- Typical elements on a IFR Clearance delivery:
 - Clearance airport (or FIX)
 - Route (SID, initial heading, vectors, airways, STAR,...)
 - **Cruise** altitude + **initial** altitude
 - Departure Frequency
 - Transponder code

Iberia pilot does not read-back at JFK <http://youtu.be/lOc6MM2jsTE>



Air Traffic Control Main Tasks

Coordination

- Before transferring control of an aircraft to other sectors/units
- Whenever aircraft might conflict with aircraft under the control of another unit
- Communicate relevant parts of the flight plan and if available position, track, altitude, speed, 4D data...
- Coordination conditions and procedures established in **Letters of Agreements (LoA) between units.**
 - Example: Exit Flight Level (XFL), exit point(s)...
- Telephone coordination required when LoA conditions are **not** met (insufficient separation, different XFLs, transfer to unexpected sector,...)



Air Traffic Control Main Tasks

Civil-military coordination

SEGREGATION OF AIRSPACE

JOINT USE OF AIRSPACE

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

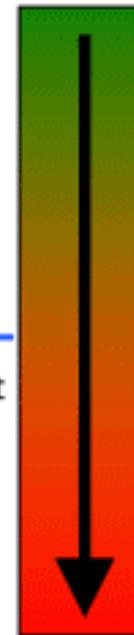
SHARED USE OF AIRSPACE

- 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



PUBLICATION

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

TRA: Temporary Reserved Areas

PCA: Prior Co-ordination Airspace

TSAs: Temporary Segregated Areas

Types of Air Traffic Control

Radar

- Separation based on radar and/or ADS positions.

Procedural

- Separation based on:
 - Time separation
 - Strategically separated procedures
 - Aircraft crew position reports
 - Vertical separation
- Used in when radar not available or radar position is not accurate enough
- Procedural approaches: only **one aircraft per approach** (other aircraft **must hold**)

Example: EUROCONTROL video on ADS advantages <http://youtu.be/JKr0q80KakE>



Radar Control

Tactical Controller (Executer, R-Side, *Radariste...*)

- In charge of sector ground/air communications
- Issues clearances and manages strips
- Detects/solves short term conflicts in the sector
- Ensures exit flight levels and points
- Executes transfers

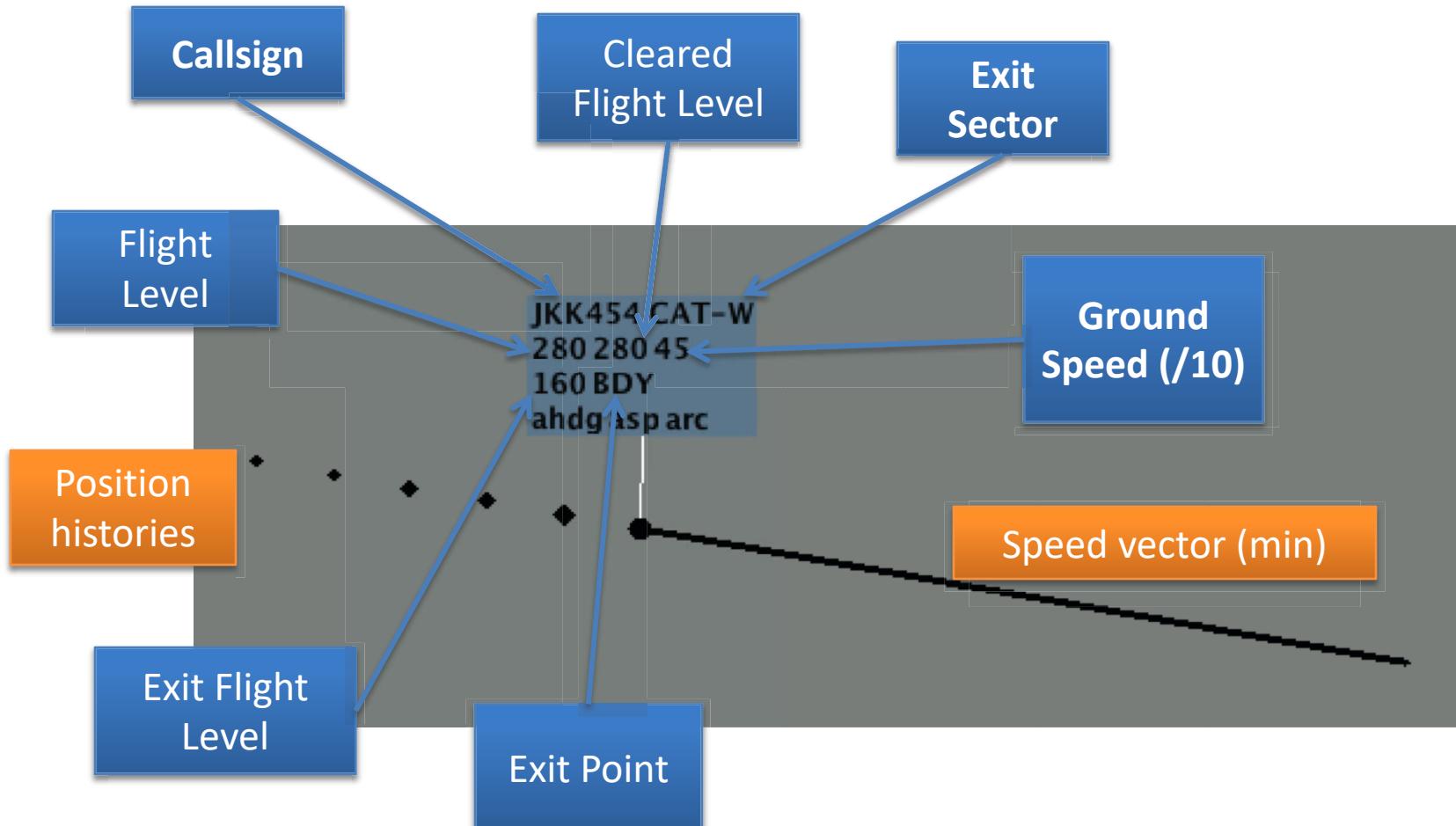
Strategic Controller (Planner, D-Side, *Organique...*)

- Receive and sort incoming strips (flights)
- Anticipates traffic conditions by looking at the upstream sectors
- Detects long term conflicts and assists tactical controller
- Ensure coordinations
- Define exit flight levels and points
- Communicates with the ATC supervisor



Radar Control

Human Machine Interface (HMI) example (Eurocontrol)

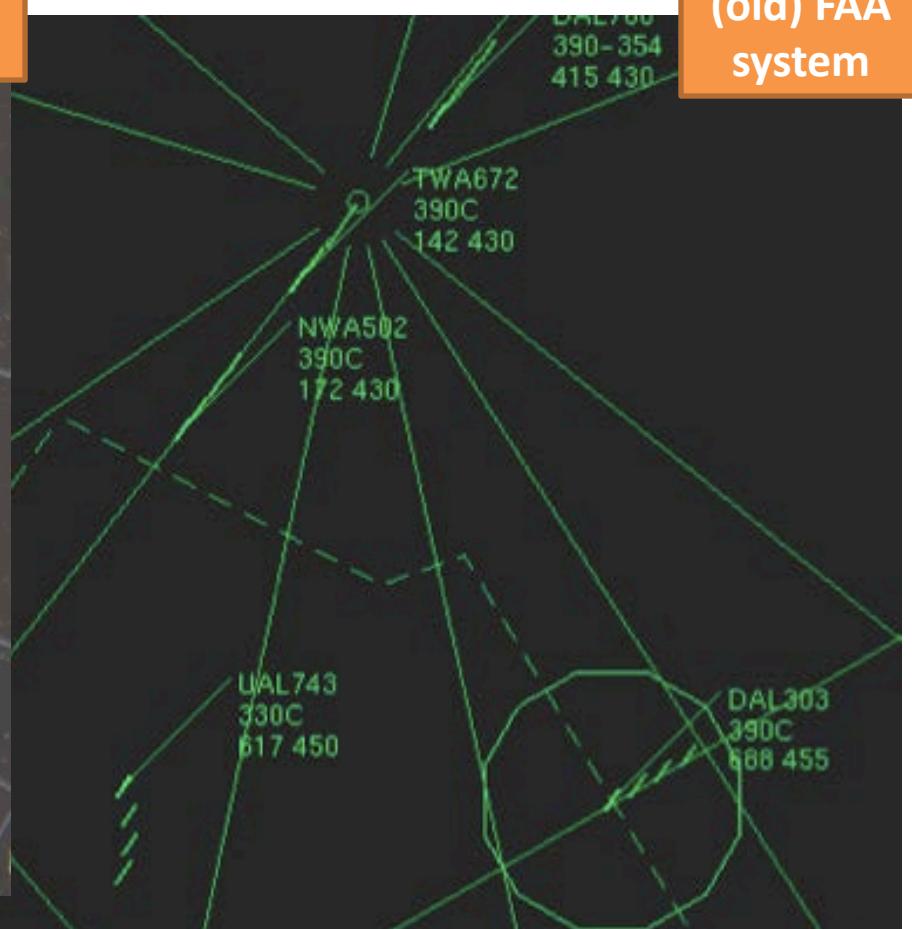


Radar Control

Human Machine Interface (HMI) examples



Indra
SACTA



(old) FAA
system

Air Traffic Control History



1929 Archie League,
the first air traffic
controller, on duty at
the St. Louis airport

Visual flight data
acquisition
Visual Clearances:
red/checkered flags
(and no coordination...)

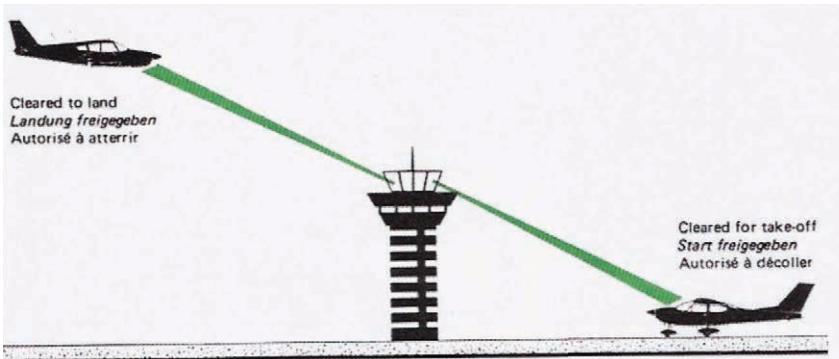
Air Traffic Control History



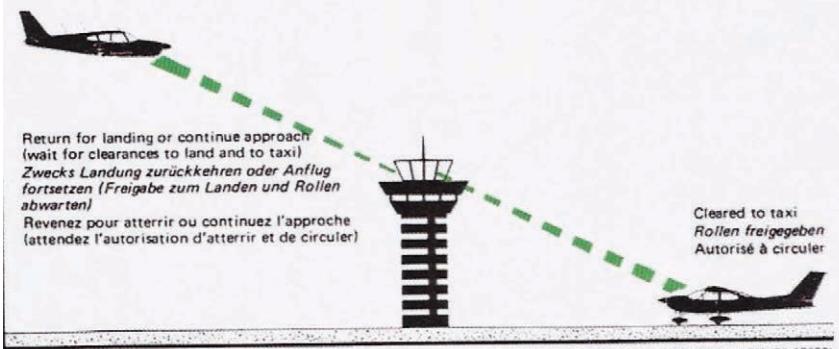
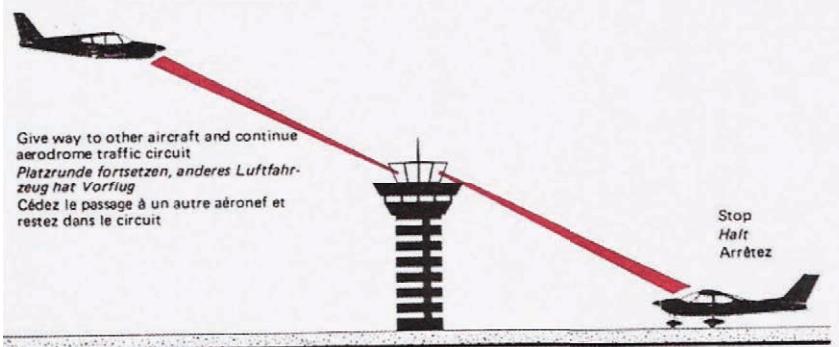
Visual acquisition still used nowadays!!
Tower control: Air Traffic Zone (ATZ)



Air Traffic Control History



Visual clearances still
used nowadays!!
**Radio failure
contingencies only**



Air Traffic Control History



Procedural control
with position reports
from pilots

Air Traffic Control History



Procedural control
with position reports
from pilots

Air Traffic Control History



Procedural control with position reports from pilots and relative bearings with ground stations (direction finders)



Direction finder



Air Traffic Control History

Procedural control
using progress “strips”
(+ position reports + direction
finding)



Source : Information Services Department
圖片來源：政府新聞處

Air Traffic Control Centre in 1960's showing air traffic control enroute sector positions. Aircraft position reports received from pilots were regularly updated onto paper-stripboards.

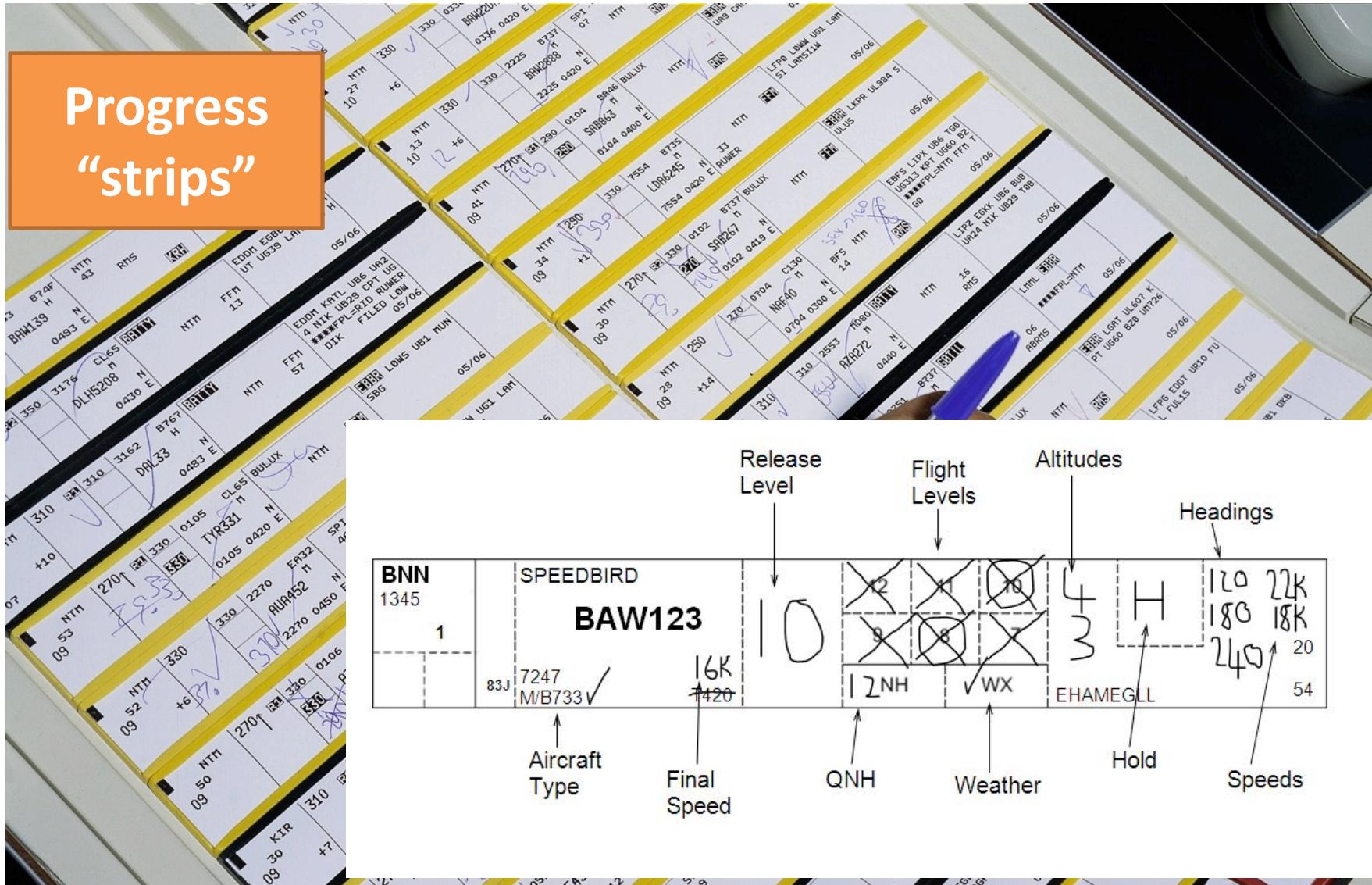
Air Traffic Control History

Progress
“strips”



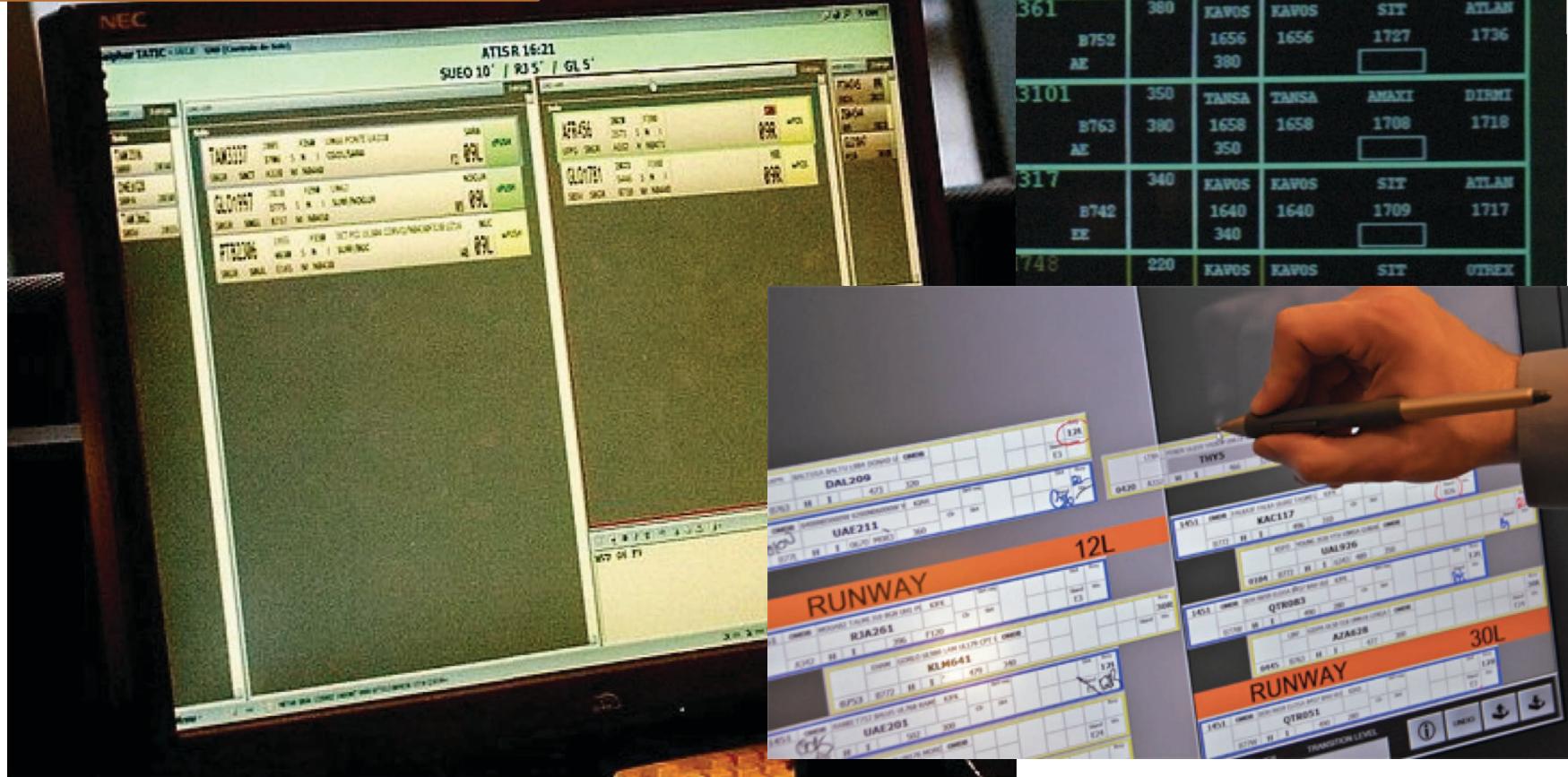
Air Traffic Control History

Progress
“strips”



Air Traffic Control History

Electronic
progress “strips”



Air Traffic Control History

Radar?



Air Traffic Control History

Radar



Air Traffic Control History



Example of
ATC facility

Air Traffic Control History



Old Barcelona
ACC (El Prat)

Air Traffic Control History



New Barcelona
ACC (Gavà)



Air Traffic Control Services

Air Traffic Control facilities (ICAO):

- Area Control Centre (ACC)
- Approach Control Centre (APP)
- Aerodrome Control Tower (TWR)

Note: National regulations may differ from ICAO standards!

Example: Air Traffic Control facilities in USA

- Air Traffic Control System Command Center (ATCSCC)
- Oceanic Area Control Center (OACC)
- Air Route Traffic Control Center (ARTCC)
- Terminal Radar Approach CONtrol (TRACON)
- Air Traffic Control Tower (ATCT)
- Flight Service Station (FSS) → only FIS provided



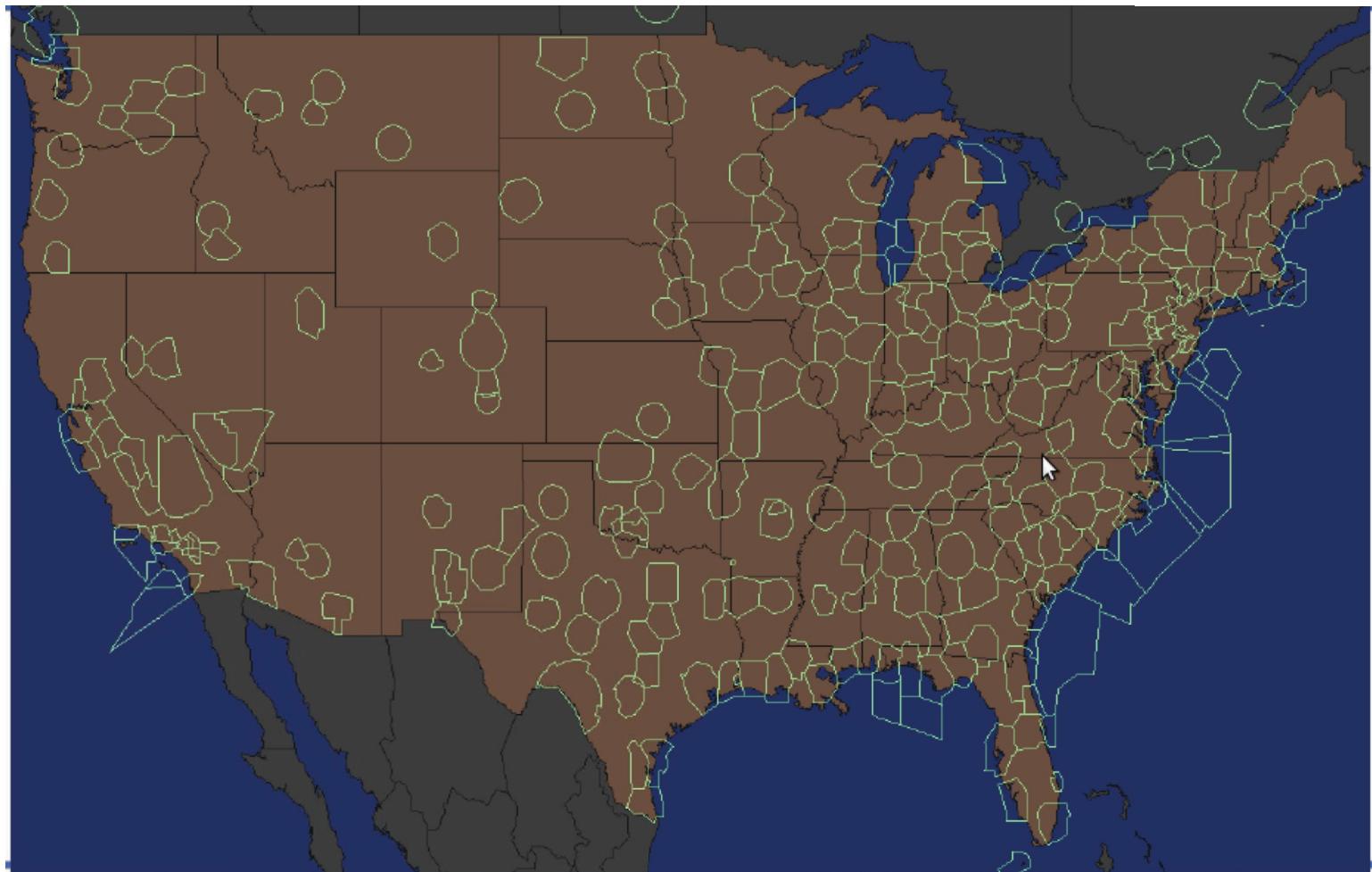
Air Traffic Control Services

US ARTCC (20 centers)



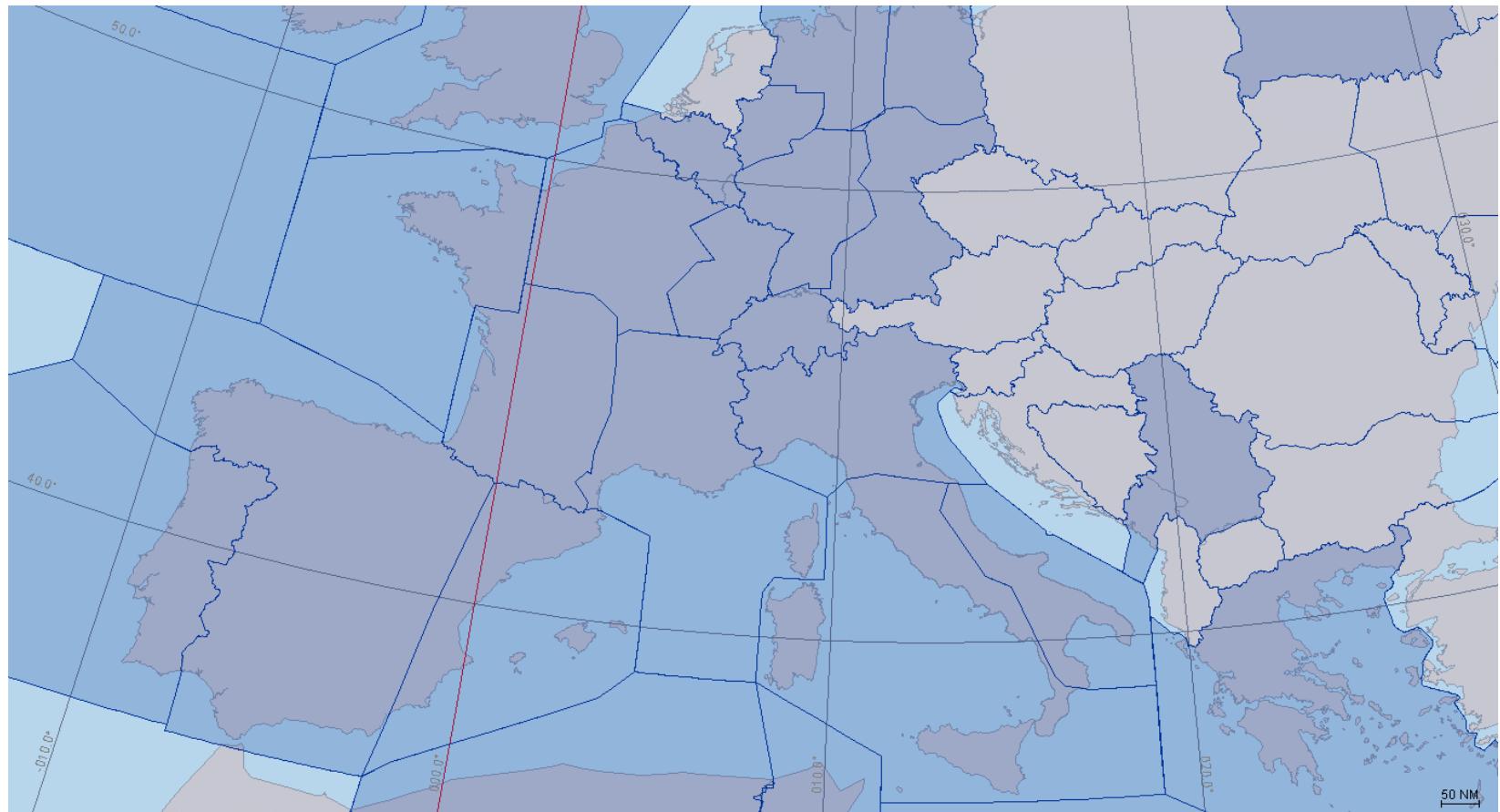
Air Traffic Control Services

US: TRACONS/ATCT (~160)



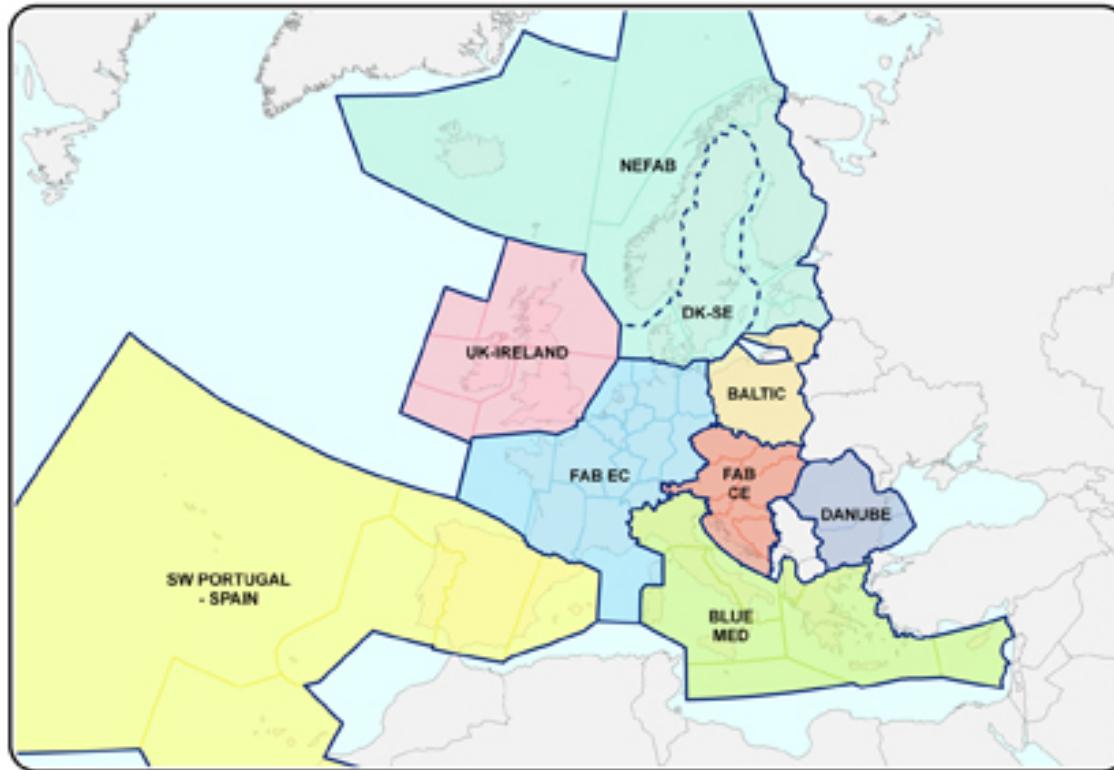
Air Traffic Control Services

Europe: segmentation by state boundaries



Air Traffic Control Services

Single European Sky program

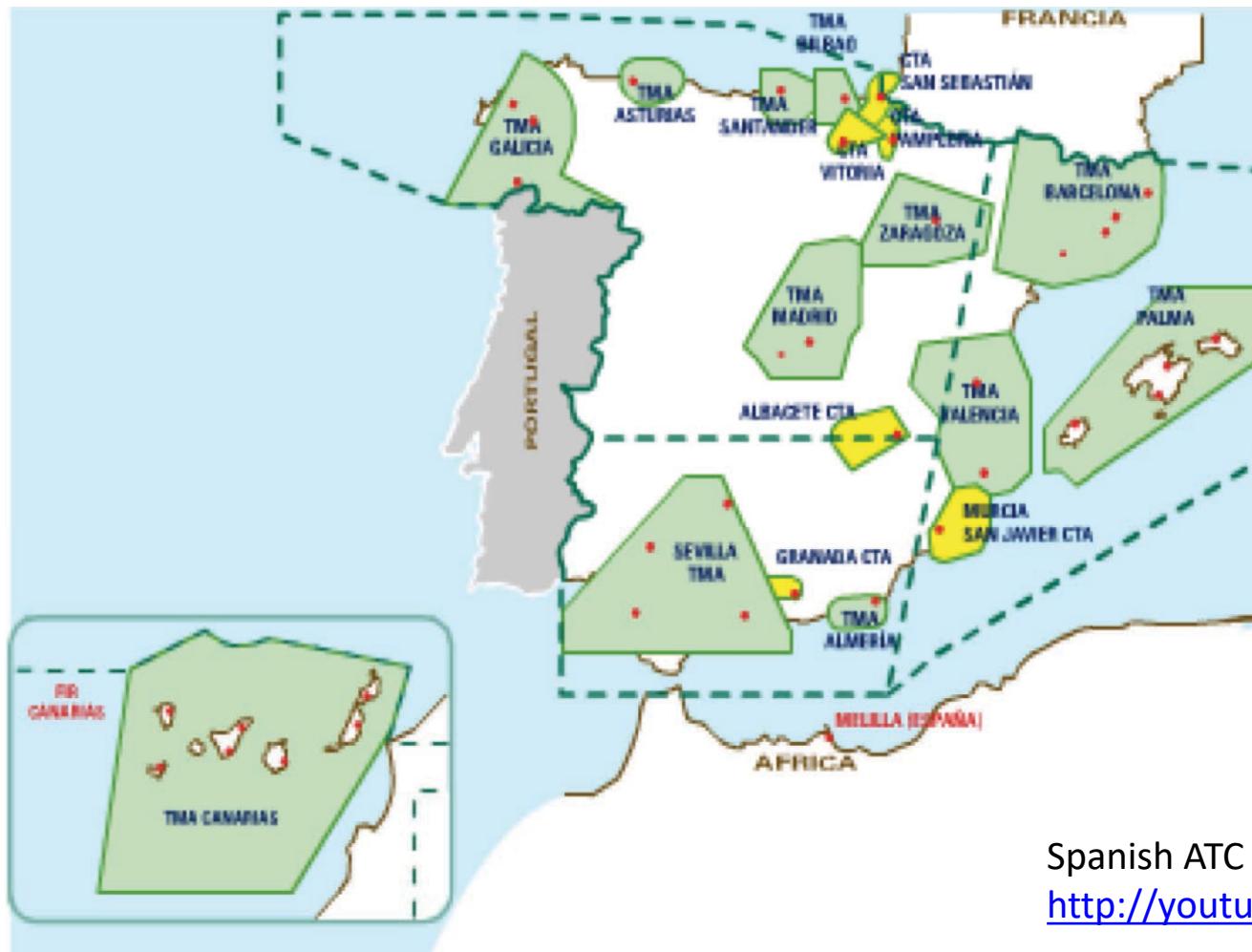


FAB:
Functional
Airspace Blocs

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>

Air Traffic Control Services

Spain



Spanish ATC services and SACTA:
<http://youtu.be/0zleCMr4dwg>

Air Traffic Control Dependencies

Flight Data / IFR Clearance Delivery

- Final authorization of IFR flight plan
- Specific departure information details
- Automatic Terminal Information System (ATIS)

Typical elements in a IFR Clearance delivery:

Clearance airport (or FIX)

Route (SID, initial heading, vectors, airways, STAR,...)

Cruise altitude + initial altitude

Departure Frequency

Transponder code



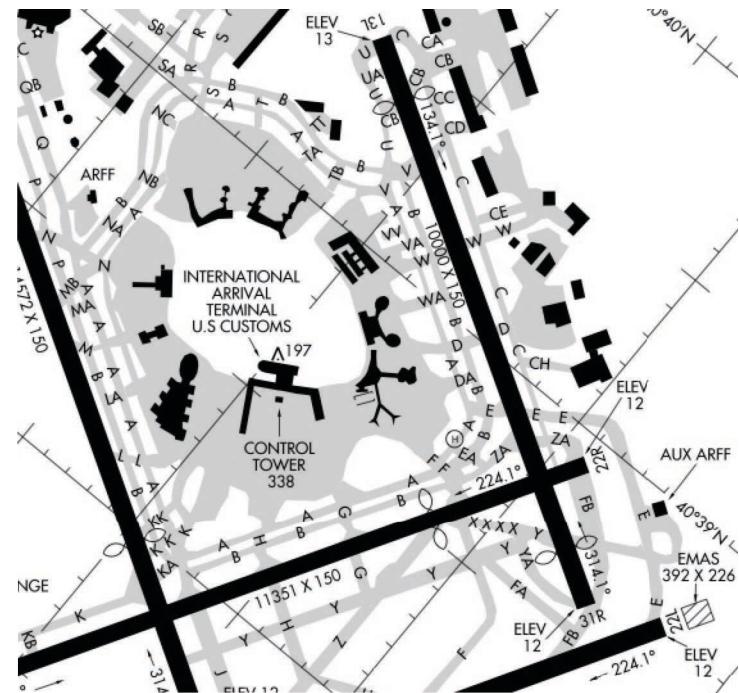
Air Traffic Control Dependencies

Ground Control (GND) Ground Movement Control (GMC)

- Aircraft and other vehicles on ground, except those on the active runway(s) (taxiways, apron, parking gates, etc.)
- Issues start-up and push-back clearances
- Manages taxi operations

Example: A tough day in JFK ground...

<http://youtu.be/7BMDkwfkXv0>



Air Traffic Control Dependencies

Control Tower (TWR)

- Aircraft (and other vehicles) on the active runways
- Airborne aircraft that have visual contact with the runways and/or within the Aerodrome Traffic Zone (ATZ).
- Issues takeoff and landing clearances.
- Guarantees separation between aircraft
- established on the ILS.
- Manages traffic in aerodrome traffic patterns.

Example: Very dangerous runway incursion in Providence airport

<https://www.youtube.com/watch?v=qUDFY5qlTSA>

<https://www.youtube.com/watch?v=equVF3ULVw8>



Air Traffic Control Dependencies

Approach Control (APP)

- Departing and arriving traffic and interfering traffic in transit
- Sequence and merge traffic to landing runway(s)
- De-conflicts arrivals with departures
- Issues approach clearances
- In busy TMAs, radar control (radar vectoring) may be given
- In busy TMAs specific Departure Control (DEP) positions may exist

Example: 747 approach into Hong Kong
<http://youtu.be/lkugVZfKTk0>



NASA

Air Traffic Control Dependencies

Area Control (En-route control)

- . Climb to Cruise, start descend
- . Ensure aircraft separation and flight efficiency

Examples:

ATC barcelona area control

<http://youtu.be/4B6-wwyF2w4>

Flight simulation Rome-Milan

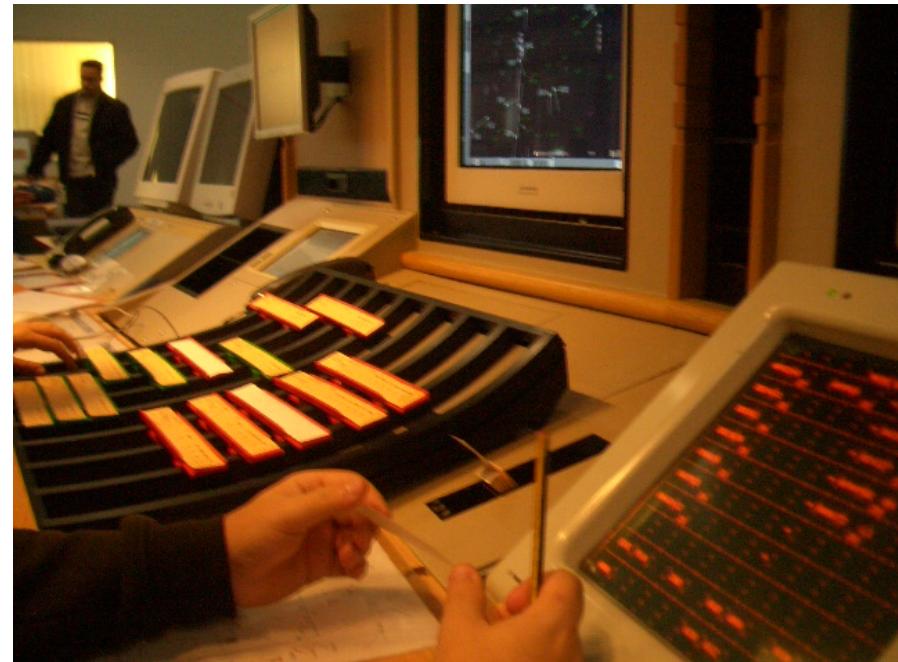
<http://youtu.be/AnSRS9N4RrQ>

BBC in Swanwick ATC

<http://youtu.be/dyDXCwe1REQ>

FAA Video. This is ATC

<http://youtu.be/M9roMBwOX8s>

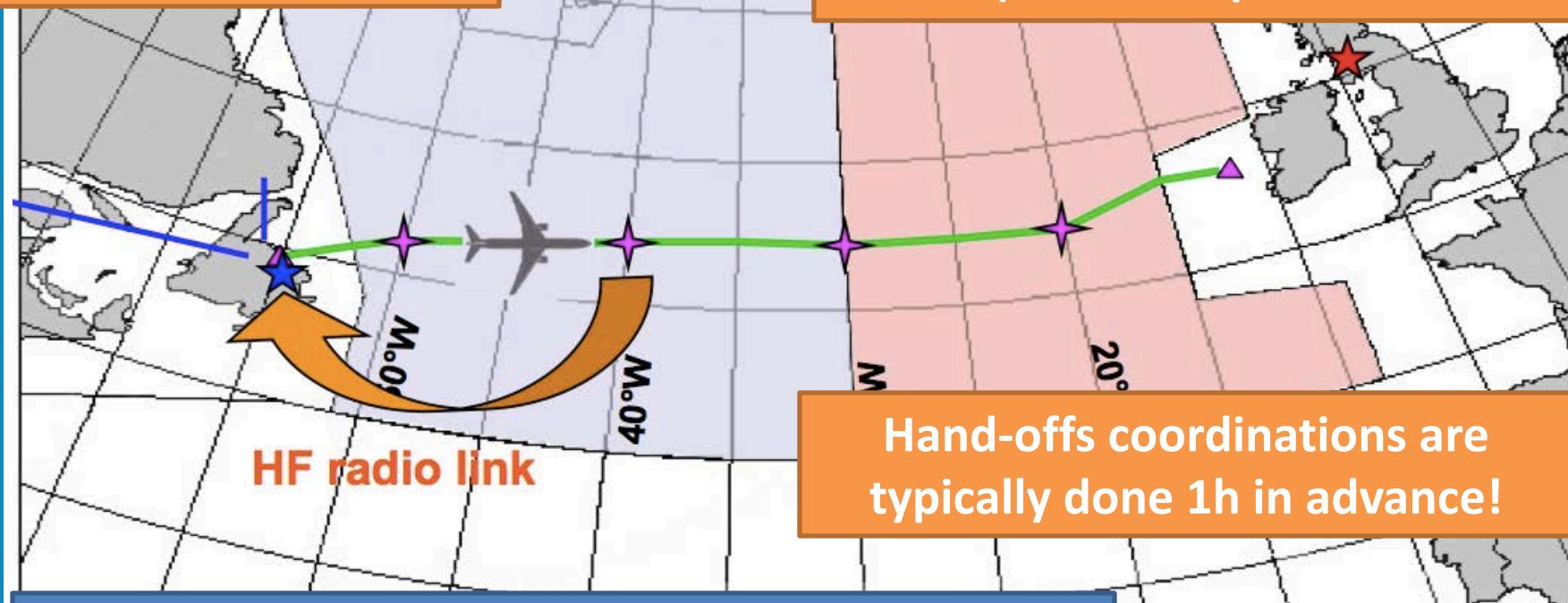


Air Traffic Control Dependencies

Area Control: Oceanic control

Position report every 10° via HF radio

In some cases, need for radio operator to pass messages (relay service) between pilots and ATC!!



Hand-offs coordinations are typically done 1h in advance!

Solution: SATCOM voice and/or datalink, ADS, ...

Air Traffic Control Dependencies

Area Control: Oceanic control

Example: New York Oceanic strip

	Current waypoint/ degree of longitude reporting point	Time at waypoint	Estimated time at next reporting point	Next reporting point	Altitude	Reporting point after next	Estimated time at reporting point after next	Route of flight
Aircraft ID	RAM201	1	BOBTU	01	35		4337	KJFK ./ . BOBTU 4400N/
Aircraft type	H/B763/Q	0121				4500	05000W 4300N/04000W	
Sector number	T472 G530					0200	4200N/03000W 3900N/	
	19 19						02000W LUTAK BEXAL	
	404	03					OSTED OST2A	
Computer ID							GMMN/0705	
Flight Strip Number								



ATC Cognitive model

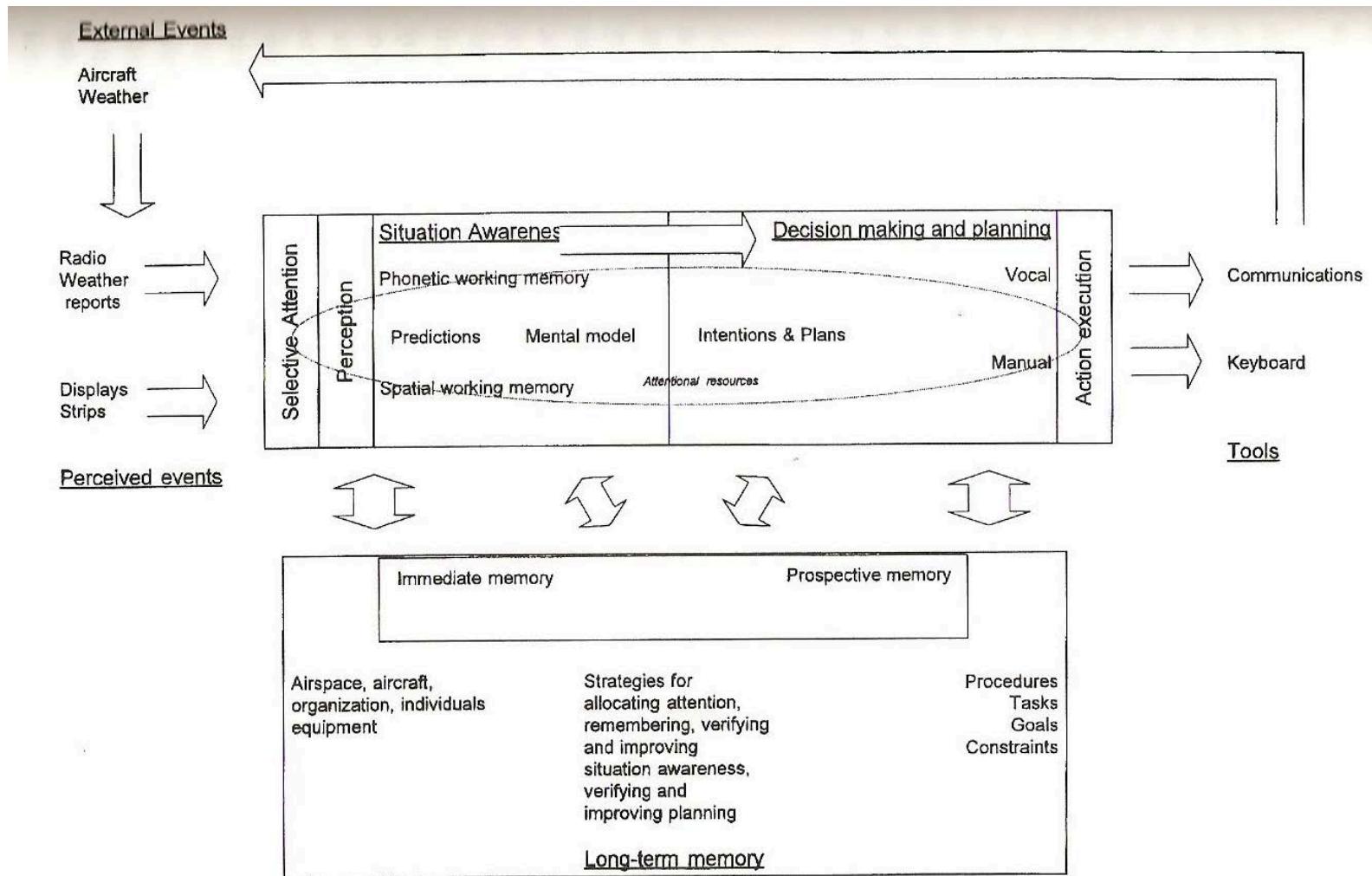


Diagram taken from: Wickens, C. D., Mavor, A. S., & McGee, J. P. (1997). *Flight to the Future: Human Factors in Air Traffic Control*. National Academy Press

ATC Workload

Routine Control Load	Airspace Load
Number of controlled aircraft	Number of controlled aircraft
Sector flight time	Sector flow organization coefficient
Proportion of standard aircraft	Mean airspeed
Proportion of non-standard aircraft	Sector area
Proportion of terminal area hand-offs	Mean aircraft separation
Proportion transitioning	
Proportion of VFR to IFR "pop-ups"	

FIGURE 6.2 Some airspace load variables in air traffic control. Source: Adapted from Arad (1964).

Estimating ATC workload ->
Sector capacity is modelled and
estimated!

More information: Brooker, P. (2003). *Control workload, airspace capacity and future systems*. Human factors and aerospace safety 3(1). Ashgate publishing

Some more videos/audios

Close encounters movie: Primary target... <http://youtu.be/KW10xCub3Kg>

Communication problems...

- Bird Strike Swiss in Russia: <http://youtu.be/IICb8p9SvvM>
- Chinese pilot in trouble in JFK: <http://youtu.be/HQETCmzCOFE>

Some more recordings at Headrow (with subtitles)

<http://youtu.be/3s92ofHJ2A8>

<http://youtu.be/2WYCQY6MXEE>

<http://youtu.be/r6NnH140HUw>

<http://youtu.be/qq7EiHNRnSc>

<http://youtu.be/2NYve-Z8xDM>

Lake constanza mid-air collision <http://youtu.be/2pKe93ckmXI>





Thank you!!

Gràcies!!

