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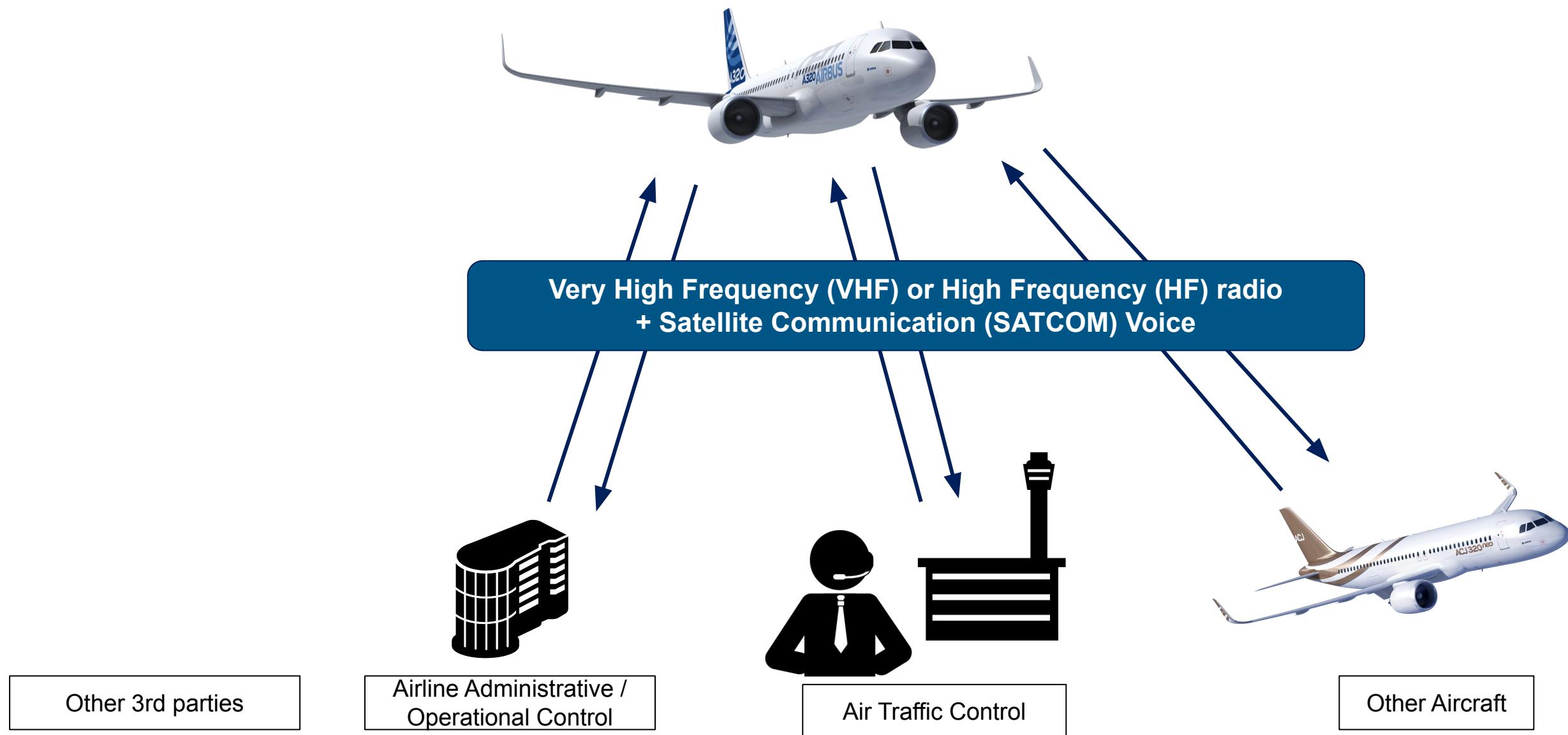
# Flight Management System - Datalink

## ISAE Master training course

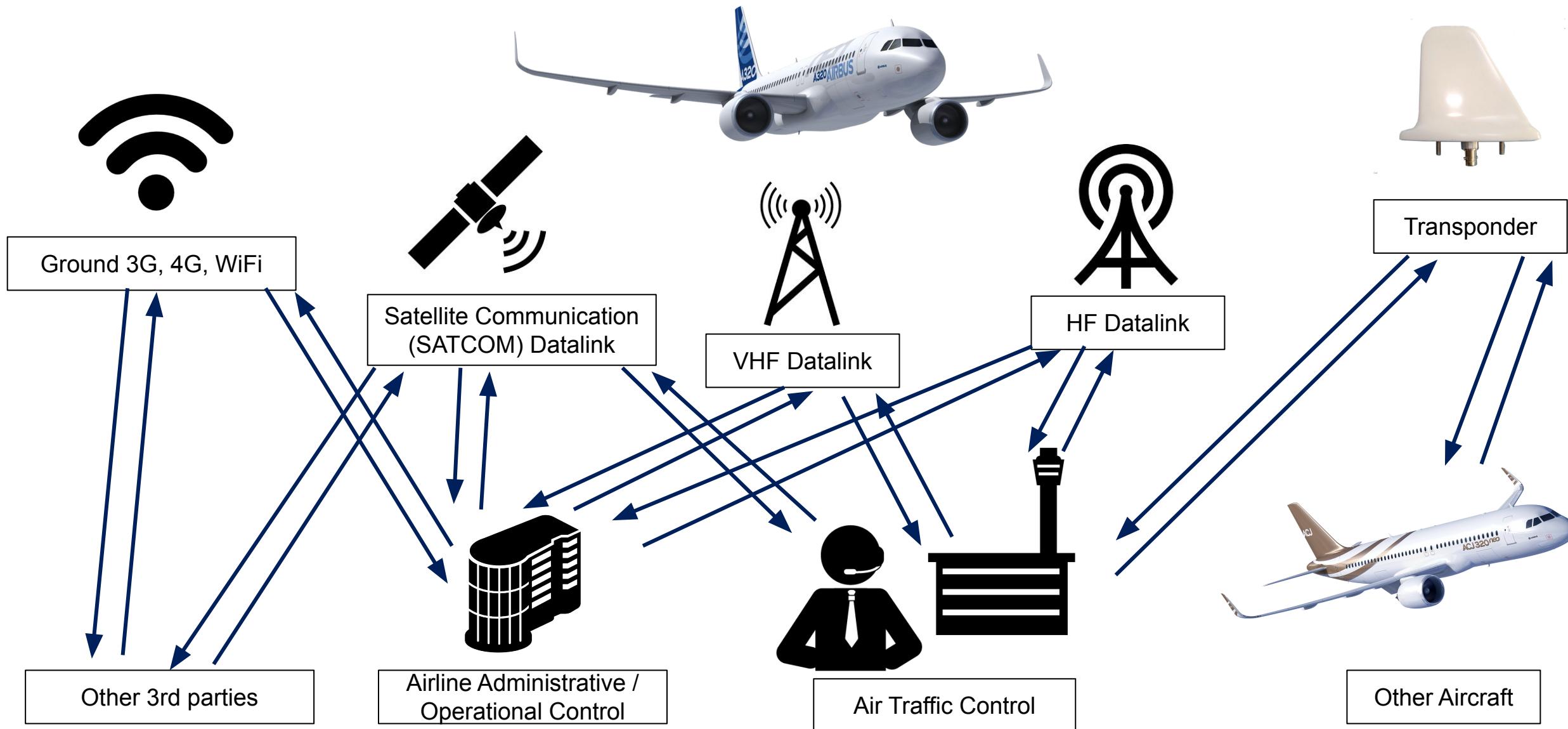
Clement SELLES - clement.selles@airbus.com  
February 2022

**AIRBUS**

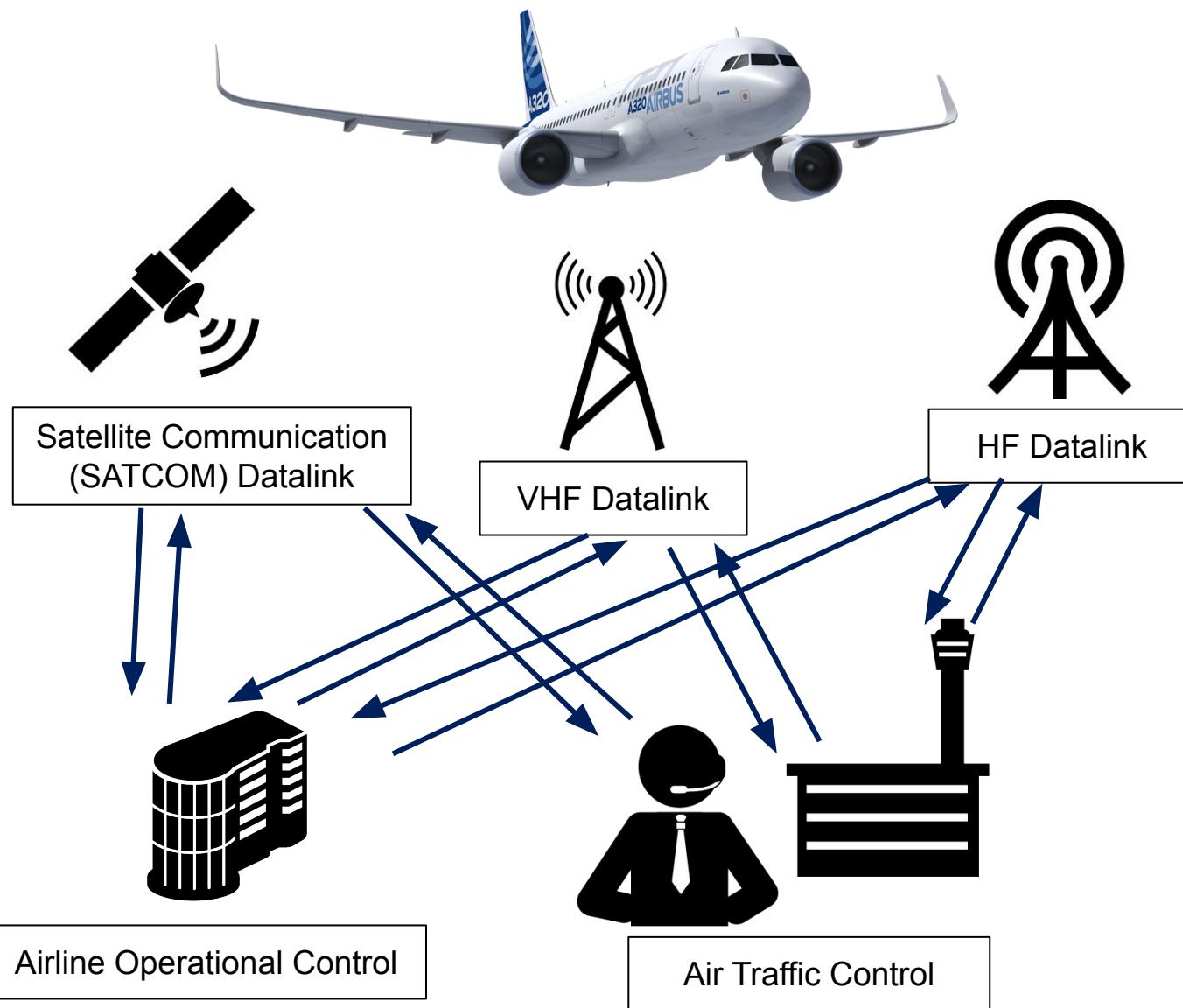
# Commercial Aircraft - Voice communications environment



# Commercial Aircraft - Datalink communications environment



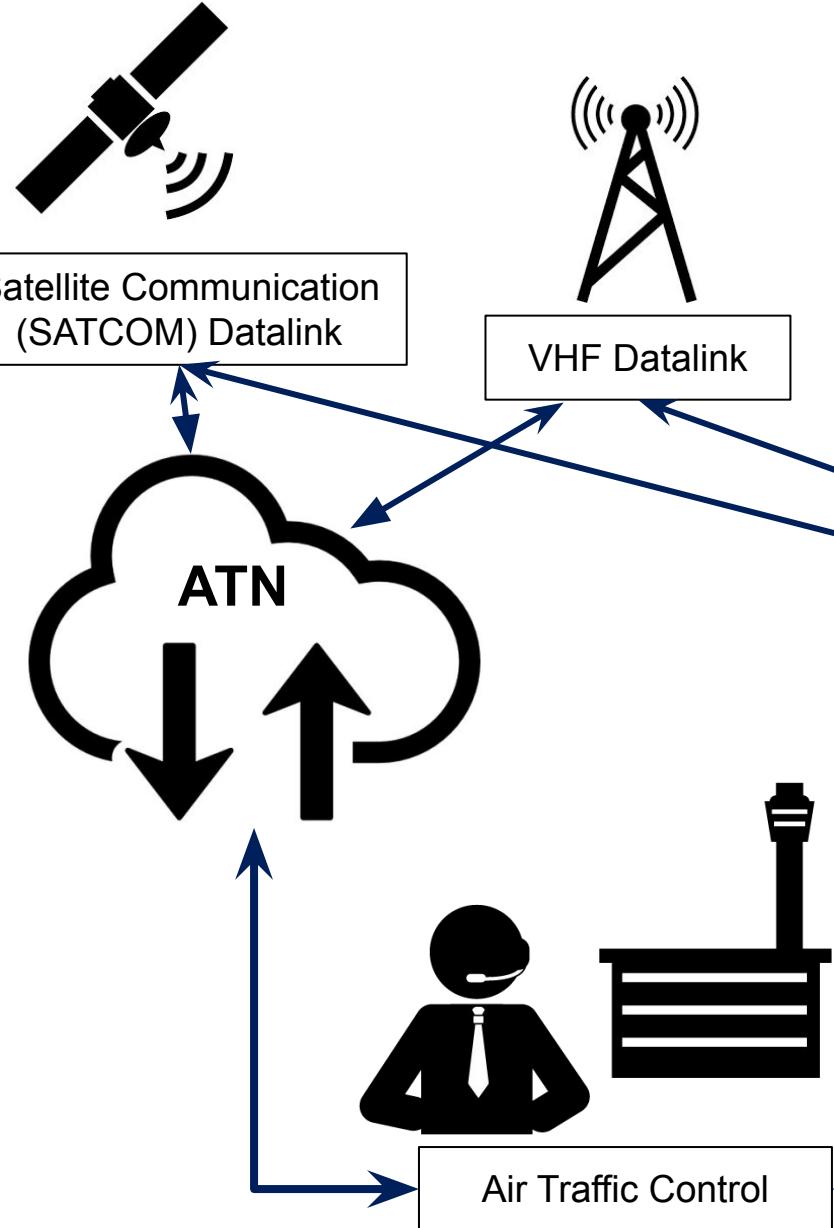
# Commercial Aircraft - Datalink communications environment



**Our focus today:**  
contribution of the Flight Management System to the Aircraft Datalink capacity.  
Air Traffic Control & Airline Operational Control only.

*Maintenance, Electronic Flight Bag, Administrative concepts or Passenger Connectivity do not involve the FMS.*

# Commercial Aircraft - Datalink communications environment



## Aircraft Communications Addressing & Reporting System

- Industry initiated for AOC DTLK purposes
- Used to launch ATC DTLK in the Pacific then Atlantic areas
- Not designed for end-to-end msg assurance

## Aeronautical Telecommunications Network

- ICAO endorsed
- Prerequisite to develop ATC DTLK in high-density EU airspace
- Designed for end-to-end msg assurance

# Some History...

## The inception

The Aircraft Communications Addressing & Reporting System (ACARS) network was born in 1978, driven by a need to digitize exchanges performed over voice communications between Pilots & Airline ground personnel (e.g. dispatchers).

The driving factor at the launch of ACARS was... the need to automatize the logging of block times for flights which are used to determine flight & cabin crew pay checks.

It quickly became apparent that this network could be used for a very wide variety of purposes going well beyond purely administrative topics.

However, it was not before the 1990s that the use of the ACARS network to enable automated exchanges between the Flight Management System and an Airline's ground system was introduced.

The initial aim of this "FMS AOC" capacity was to enable:

- Quicker A/C preparation thanks to the UPLINK of data from the ground system directly to the FMS to reduce crew workload (thus turn-around time)
- Better follow-up of each flight for the dispatcher and post-flight reporting and analysis thanks to DOWNLINK by the FMS of various reports (automated or upon request).



Today, the FMS AOC feature is increasingly used by many/most Airlines (and not just the majors as it used to be the case) thanks to the development of many Commercial Off-The-Shelf (COTS) solutions for ground systems, particularly as turn-around time reduction and flight optimization become even more important (F-PLN & Weather data uplinks are core features).

As the success of the ACARS network for A/L AOC use continued, Air Traffic Control started to investigate the capacity to supplement then replace voice communications by datalink-based communications...

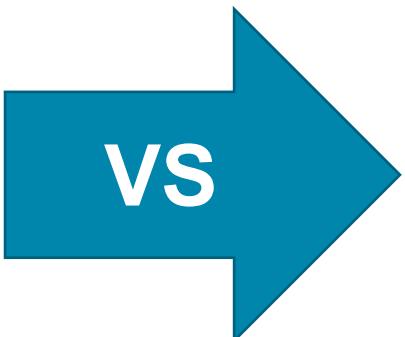
# Why Datalink (Air Traffic Control view)?



HF exchanges (Oceanic)  
Poor quality / availability



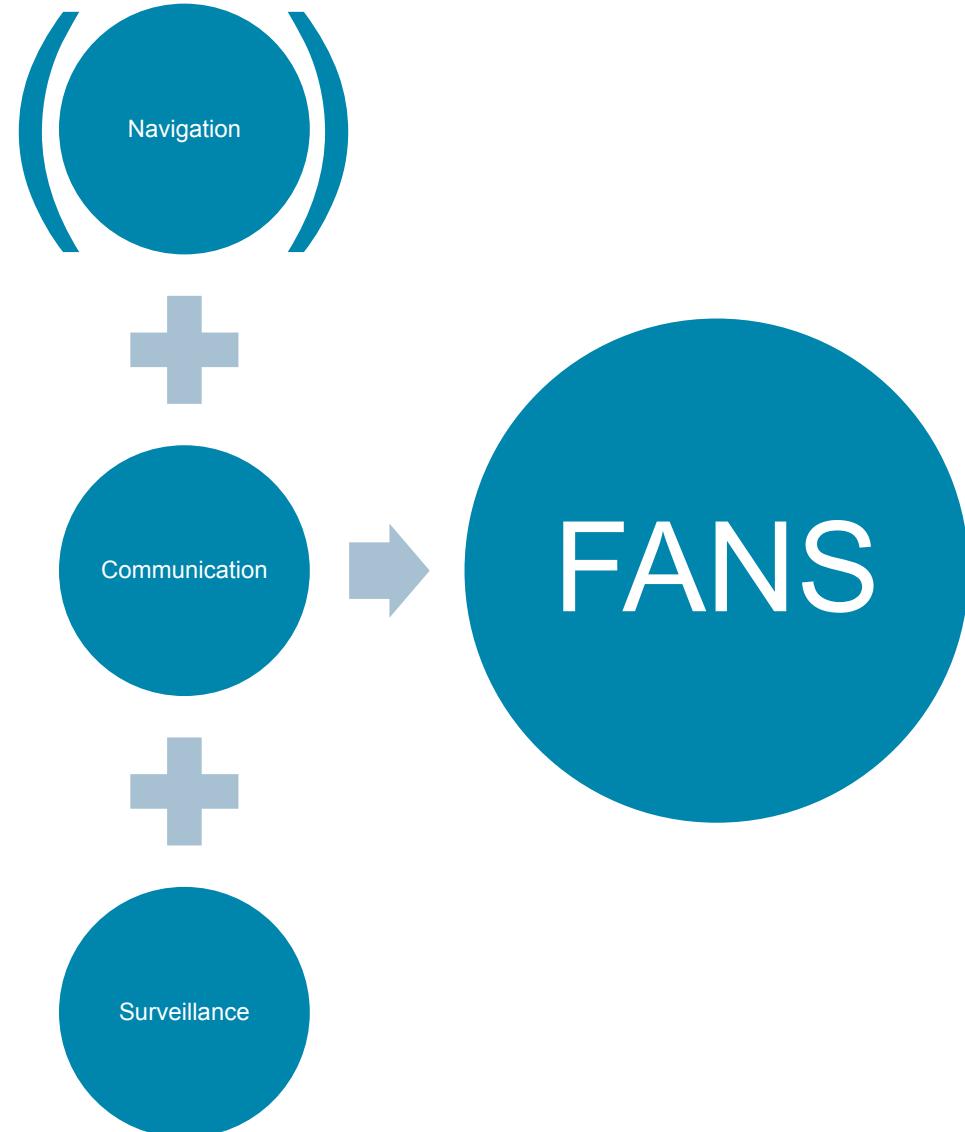
VHF exchanges (JFK)  
Frequency congestion



# FMS contribution to Air Traffic Control Datalink

# What is FANS/ATC Datalink about?

- FANS = “Future” Air Navigation System
- Implementation started back in the 90’s (Future is now)
- Replace or Supplement Voice exchanges between ATC & flight crews by Datalink exchanges (depending on airspaces)
  - **Reduce frequency congestion**
  - Mitigate clearance interpretation errors
  - Mitigate clearance readback errors
  - **Reduce crew workload** via automatic loading of route clearances in the Flight Management System
  - Increase Controller awareness of A/C status (reliability of traffic flow leading to increased airspace throughput thanks to **reduced separation minima**)
  - ...



# Applications

## CPDLC

Controller-Pilot Datalink Communications

Exchanges of messages (clearances, requests, negotiations, information) between Controllers & Pilots in text format



## ADS-C

Automatic Dependent Surveillance – Contract

Automatic downlink of reports (position & predicted route) by the A/C to the Controller: no pilot intervention

```
Flight ID: VIR29N Aircraft Registration: G-VMIK
ACARS BATAP serial numbe: 897
message: ACK: Request for contract 1
ADS basic report:
Pos = 470012N0173922W
Alt = 37900 ft
Time = 12:27:14
Redundant NAV units
Accuracy < 0.25 NM
TCAS is ON
Air Reference:
Heading = 226.7 degree
Speed = 0.801 mach
Vertical rate = 496 ft/min

Predicted route:
Pos = 450041N0200102W
Alt = 38000 ft
ETA = 12:47:05 UTC
Pos = 370045N0300050W
Alt = 38000 ft
```

# ADS-B, where the A/C position (& other parameters) are Broadcast by the XPDR around the A/C to anyone who can "hear it" on the 1090MHz frequency (e.g. FlightRadar24)

## ATS623

Air Traffic Services over ARINC623

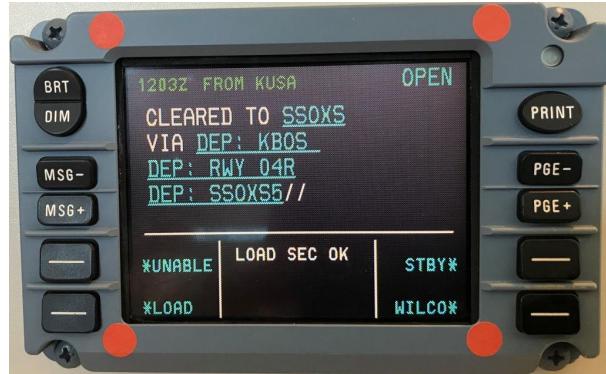
Specific services (where implemented): Digital ATIS, Departure Clearances, Oceanic Clearances (may soon disappear)



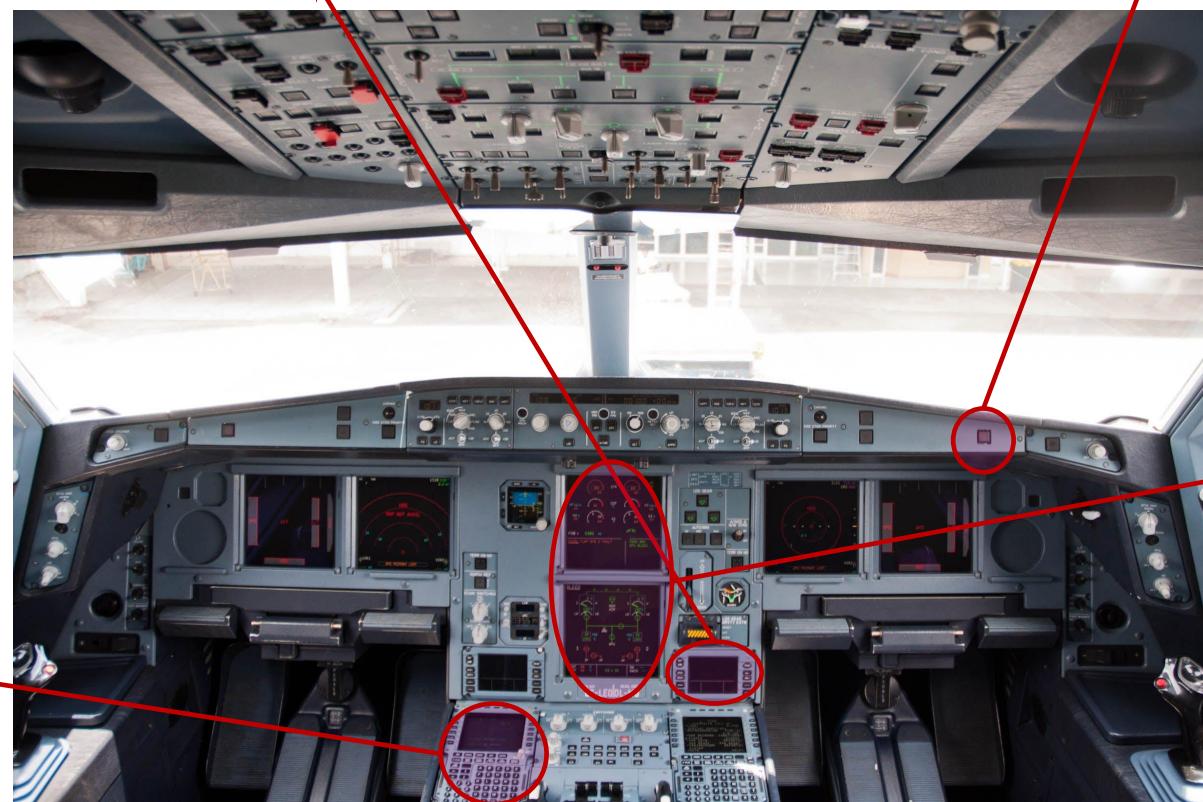
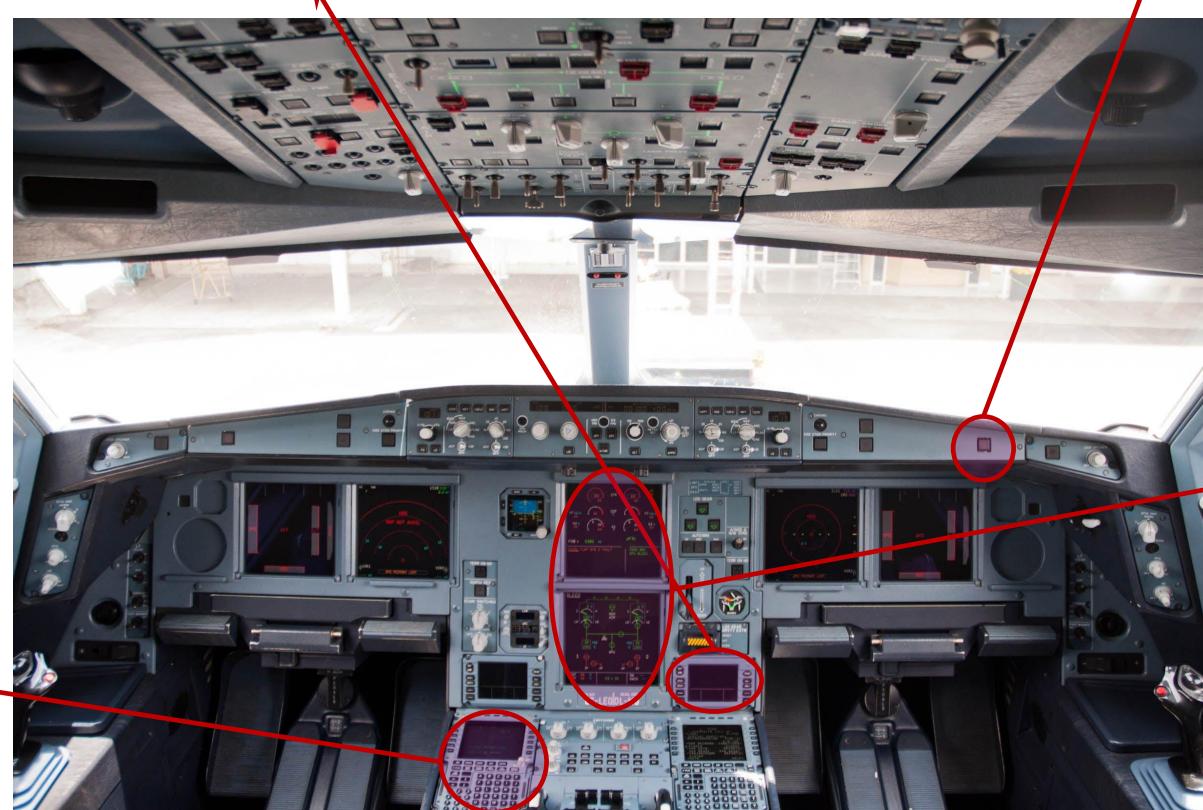
# Cockpit layout – The ATC basics



Multipurpose Control & Display Units (MCDUs)



Datalink Control & Display Units (DCDUs)



ATC MSG P/B  
(aural & visual alerts)

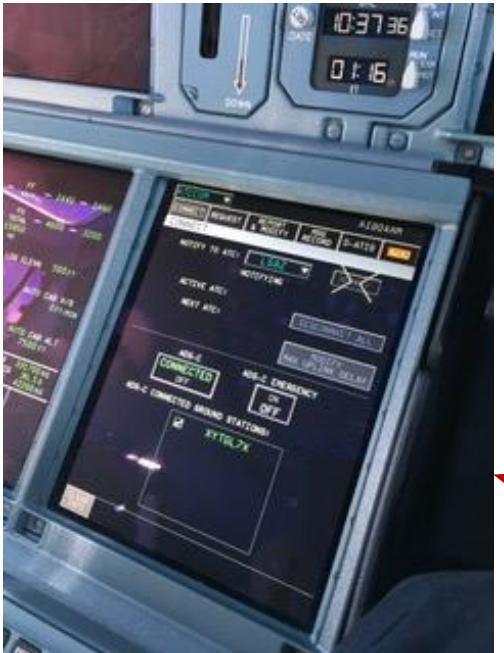
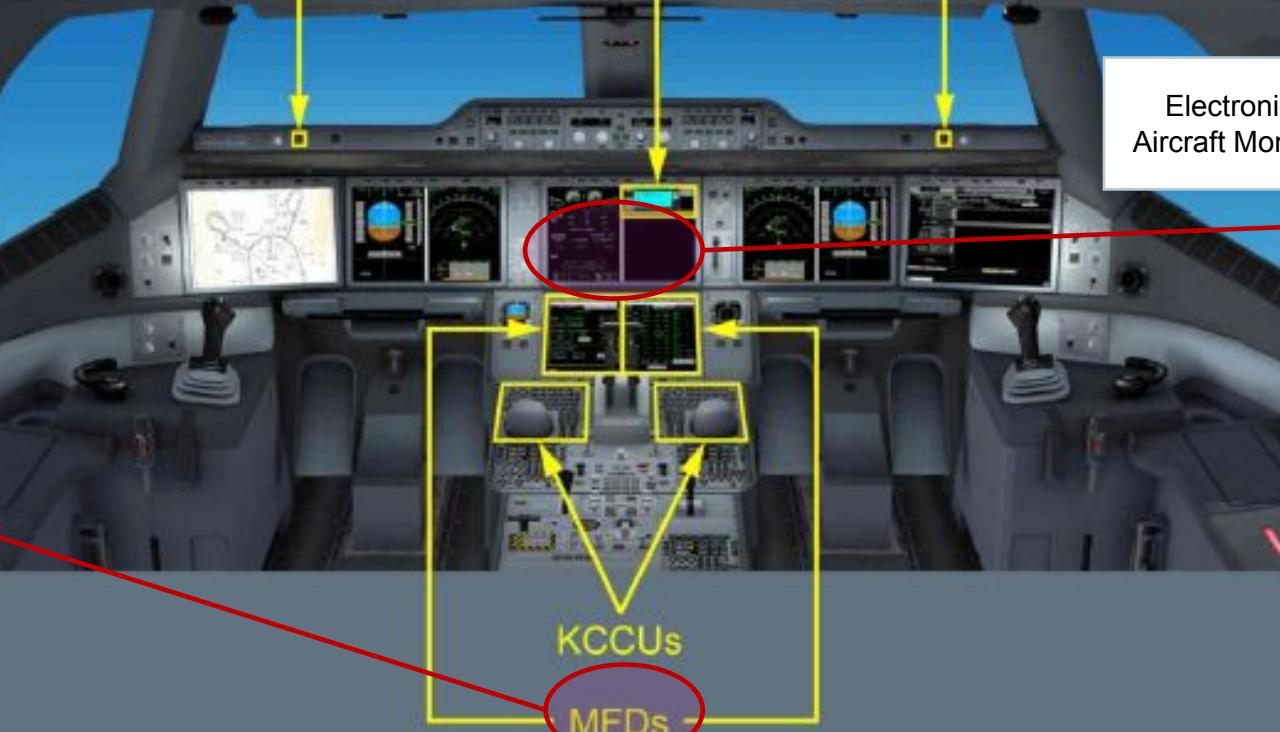
Electronic Centralized  
Aircraft Monitoring (ECAM)

# Cockpit layout – The ATC basics

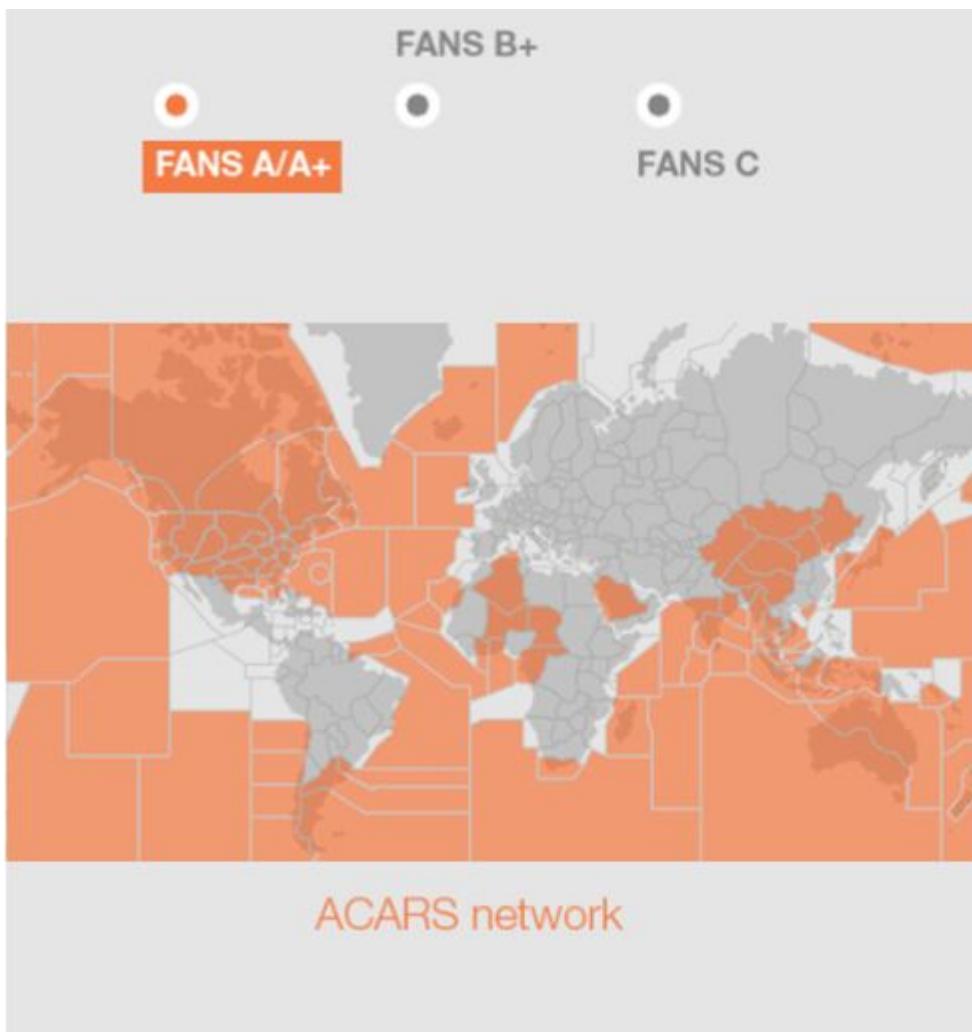
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Electronic Centralized Aircraft Monitoring (ECAM)



# Who uses FANS/ATC Datalink? – FANS 1/A+



## FANS A/A+

For operations in oceanic and remote areas and US continental.



### COMMUNICATION

Replace voice control by ATC datalink communication over the ACARS network



### SURVEILLANCE

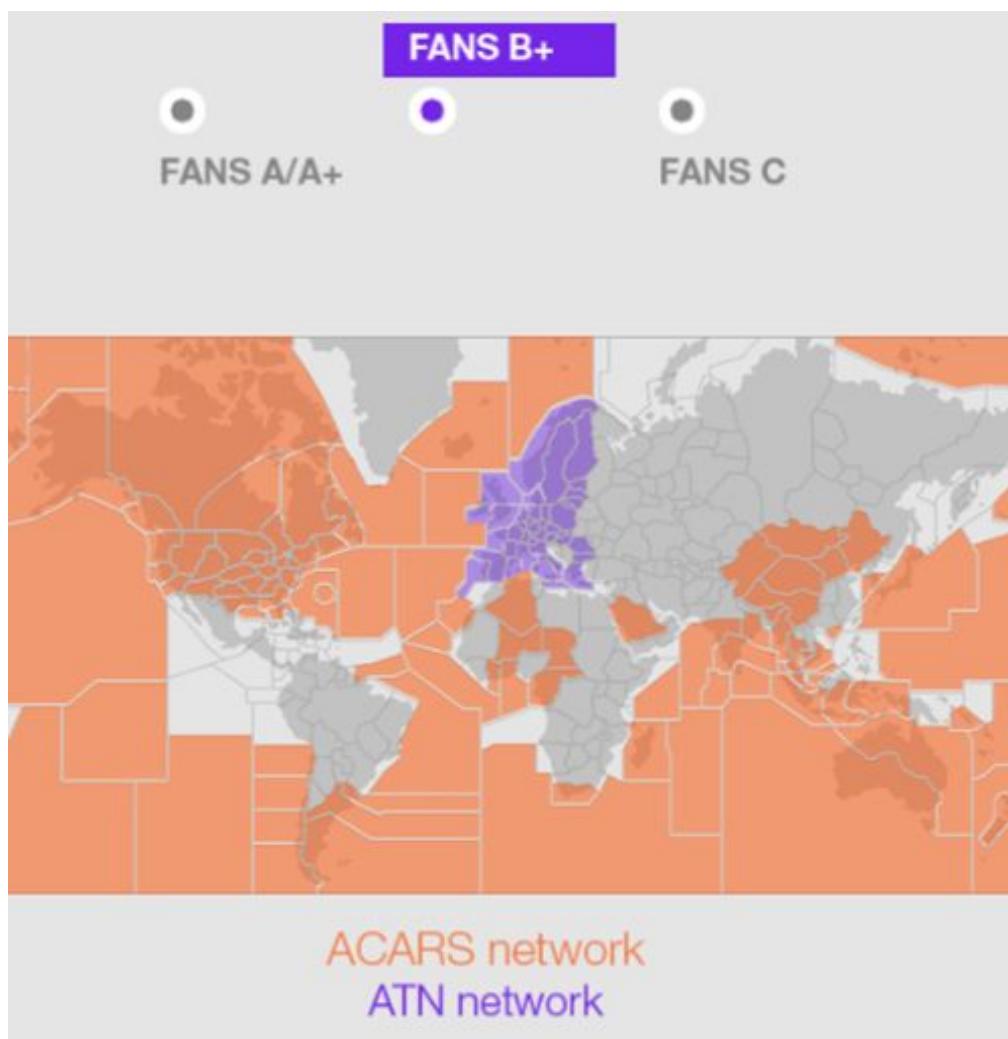
Offer ground surveillance means in area out of radar coverage: ADS-C

### FANS A+

- Datalink recording in the CVR
- RMP frequency loading (option)
- HMI improvements
- Max Uplink Delay
- ATS623 (option)

FANS A/A+ mandated in the NAT, currently FL290-FL410

# Who uses FANS/ATC Datalink? – ATN B1/FANS B+



## FANS B+

For operations in continental high-density area.



### COMMUNICATION

Replace voice control by ATC datalink communication over the ATN network

### FANS B+

- Fully compliant with LINK 2000+
- European Mandate
- Protected Mode to replace the Voice Read-Back procedure
- Datalink recording in the CVR
- RMP frequency loading (option)
- HMI improvements
- ATS623 (option) over the ACARS network

FANS B+ mandated in Europe, above FL285

# Who uses FANS/ATC Datalink? – FANS 1/A+, ATN B1, ATN B2

## FANS 1/A+

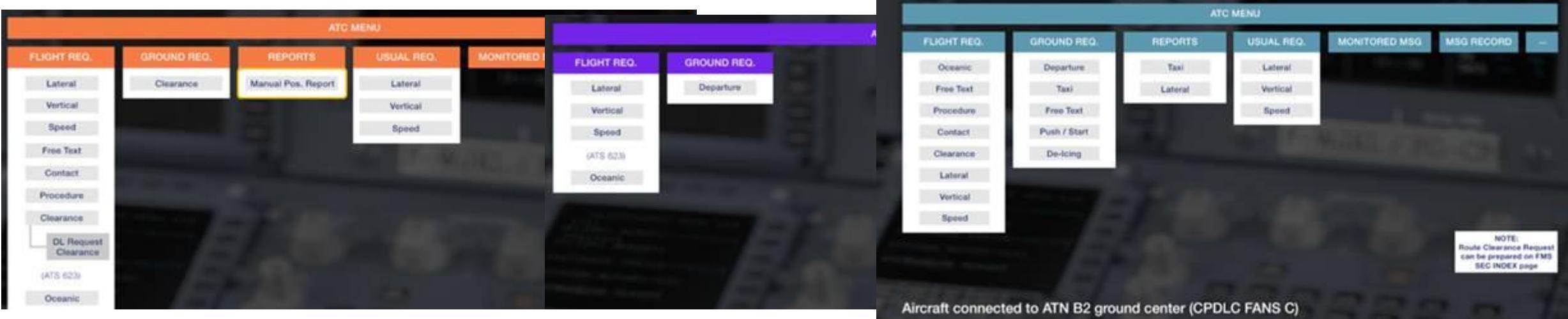
- Wide CPDLC messages set
- Supporting Oceanic & Remote operations
- Where CPDLC may be the primary means of communication between ATC & Pilots
- ADS-C for route conformance & short term predictions (NEXT / NEXT+1)

## ATN B1 (“FANS B+”)

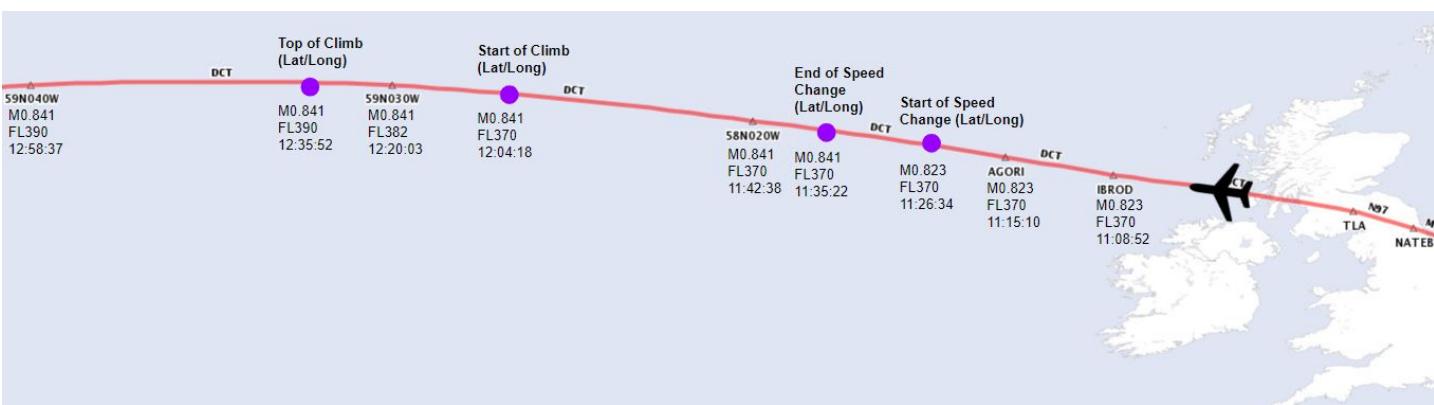
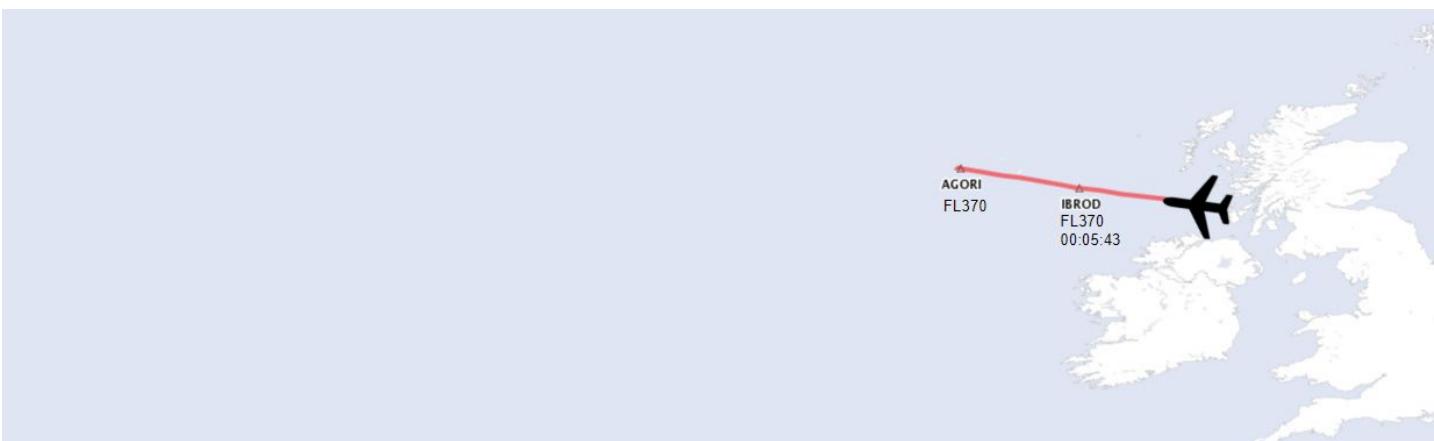
- Limited CPDLC messages set
- Supporting high-density European continental operations
- Voice remains primary

## ATN B2 (~“FANS C”)

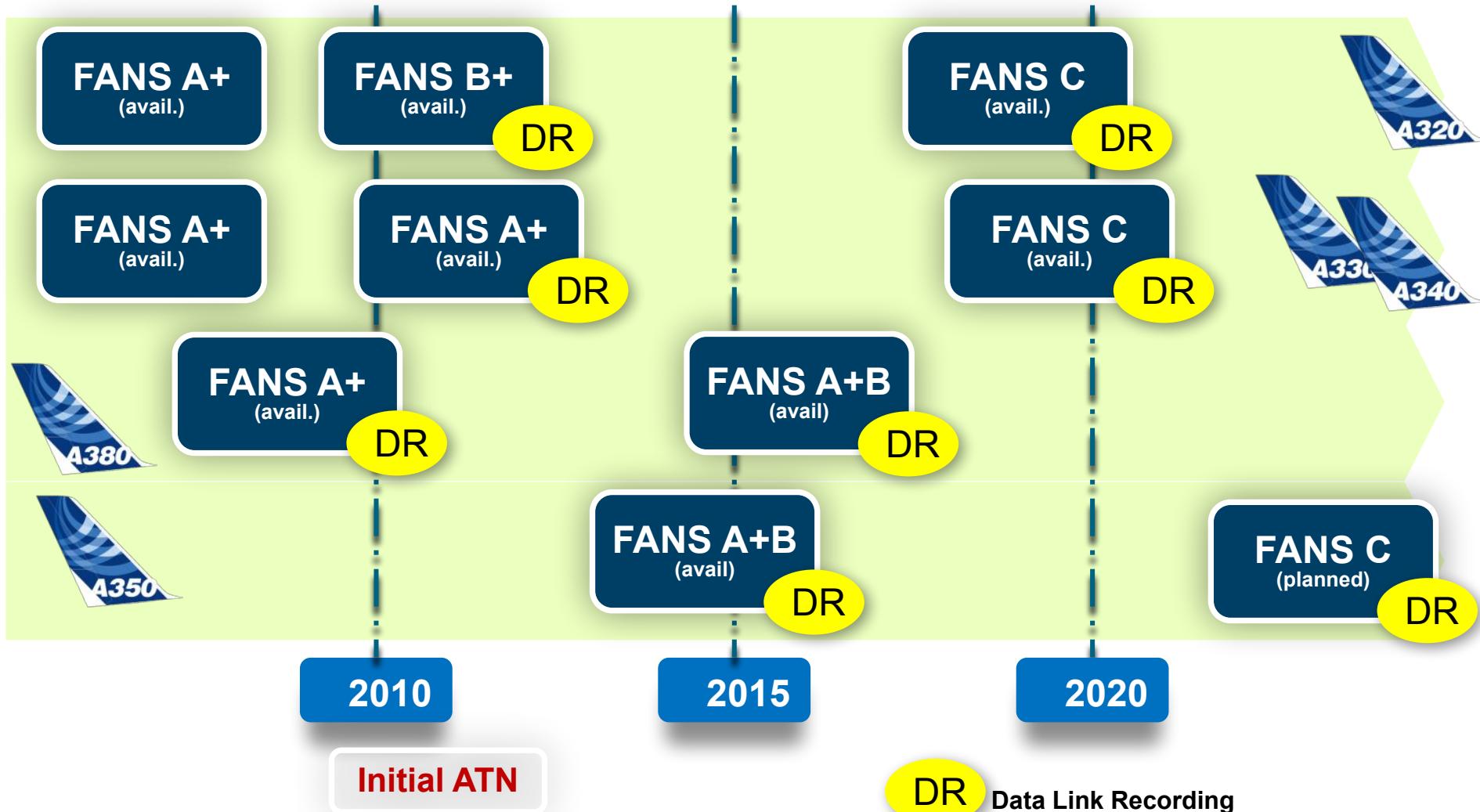
- Very wide CPDLC messages set
- To support ALL future ATM operations across the World
- From Preflight to Taxi-In
- ADS-C for full route conformance monitoring and future Trajectory-Based Operations (4D)



# Transitioning from FANS A to FANS C...



# The Airbus products & roadmap



# Mandates & Operations – PBCS

Performance-Based Communication & Surveillance is the COM & SURV cousin of Performance-Based Navigation (based on the RNP concept).

It is endorsed in ICAO doc 9869.

Its use is spreading as it allows, when RCP & RSP capabilities are associated to an RNP4 capability, for reduced separation minima application in Oceanic/Remote airspaces (typically 23NM lateral/5 minutes longitudinal)

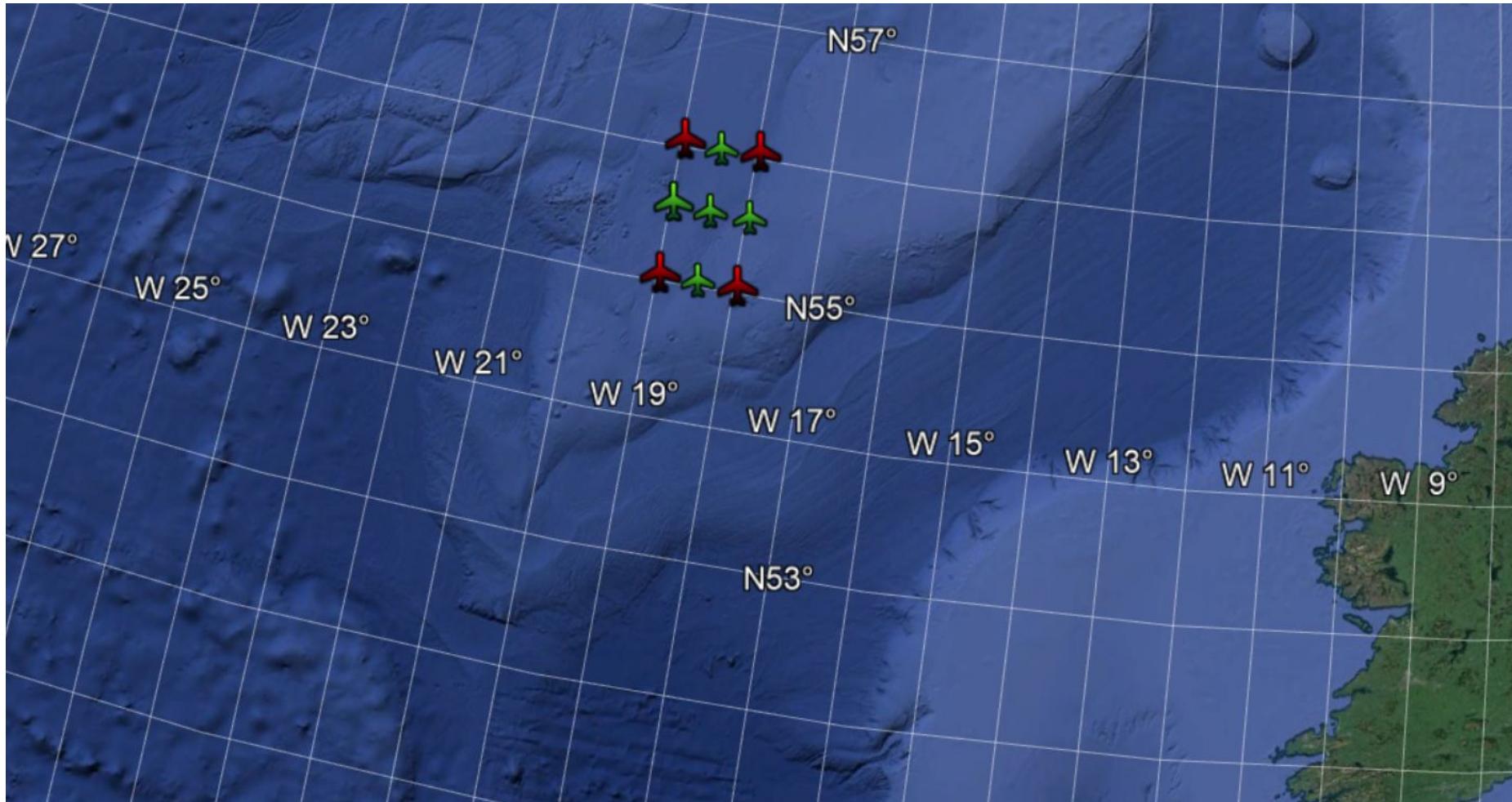
## Concept

- PBCS aims at specifying acceptable performance (transmission time, availability...) for Communication & Surveillance exchanges between A/C & Air Traffic Control
- Current PBCS use is based on FANS A+ Datalink, and the RCP240 & RSP180 specifications
  - 240 refers to a max delay of 240 seconds between ATC CPDLC uplink initiation & flight crew answer reception by ATC
    - **For RCP240, the allocated Pilot Operational Response Time is 60 SECONDS (max)**
  - 180 refers to a max delay of 180 seconds between the generation of a report (ADS-C) and its reception on ground
- Basically, all FANS A+ (incl. also FANS A+B & FANS C) Airbus A/C are RCP240 and RSP180 capable (certified in the AFM)

## Use

- At this date, only a limited set of NAT tracks are currently restricted to PBCS capable A/C (usually offer the best route/winds)
- Other airspaces also use reduced separations between PBCS-capable A/C but more on a tactical basis
- Filing the P2 & SUR/RSP180 codes is critical to ensure the best possible route of flight (reduced separation applied by ATC)

# Mandates & Operations – PBCS



Theoretical throughput increase when going from 60/60NM separation minimum (red icons) to 23/23NM separation (reg+green icons)

# Context: the NAT HLA

*Previously known as MNPS for Minimum Navigation Performance Specification*

No VHF coverage\*

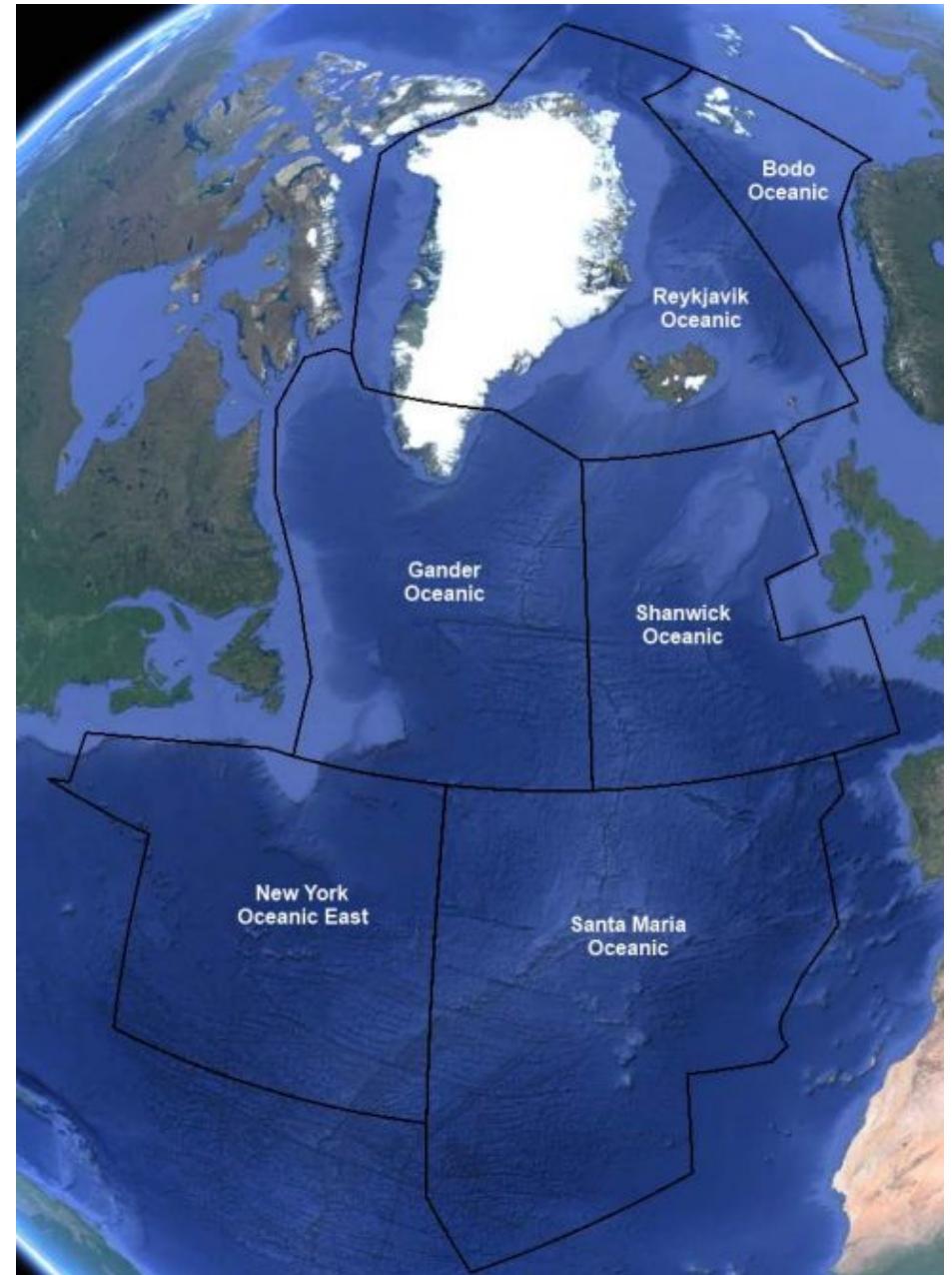
No Radar coverage\*

NO Direct Controller Pilot Communication (DCPC)\*

NO Secondary Surveillance Radar (SSR)\*

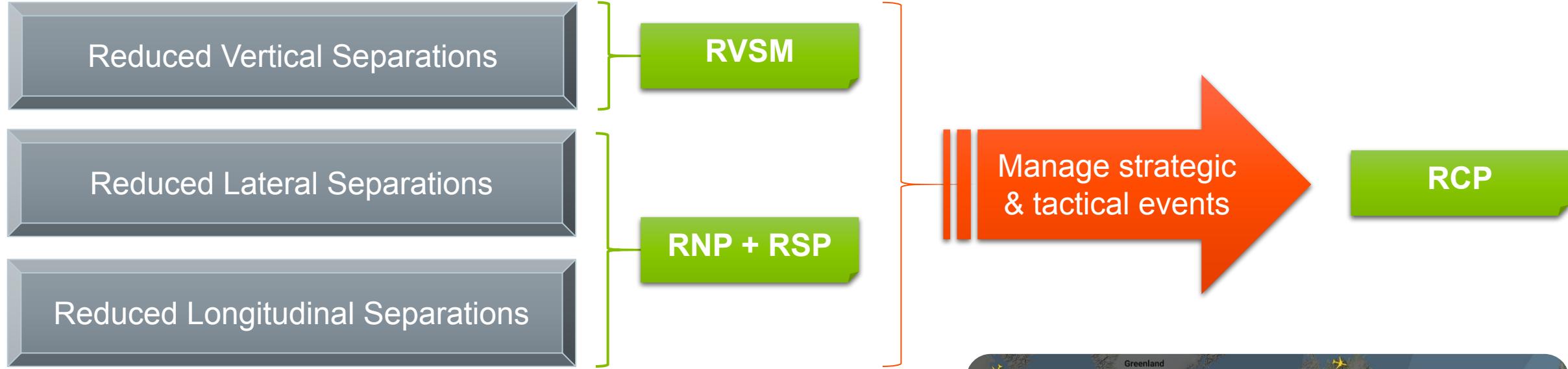
PROCEDURAL Airspace

\* Except on very specific routes (e.g. Blue Spruce routes)

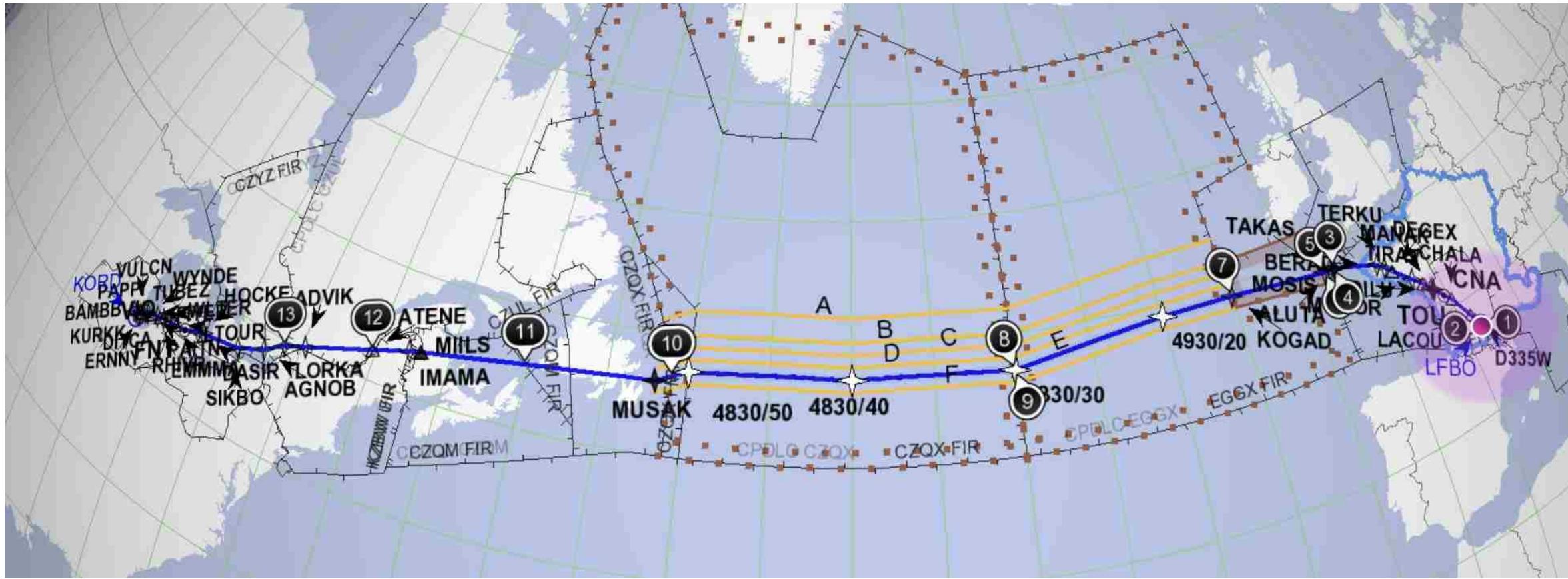


# Context: the NAT HLA

**The busiest intercontinental airspace:** 2,000 crossing flights/day in 2017



# From Toulouse to Chicago, via NAT Track Echo – A350 F-WXWB



LFBO LACOU5B LACOU UM184 CNA UN863 MANAK UT183 DEGEX UN490 MOSIS  
N491 TAKAS DCT KOGAD NATE MUSAK N264A MIILS Q907 SIKBO Q905 HOCKE  
Q824 FNT WYNDE1 KORD

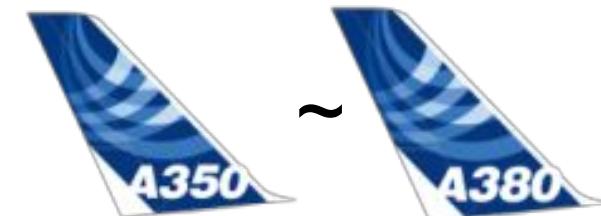
LFBO/FL380 TAKAS/FL400 MUSAK/FL430

Flying the NAT Organized Track System (OTS) is NOT mandatory, you can file a FPL that does not use a NAT Track. However, NAT Tracks are designed everyday by Gander & Shanwick ATC to provide the “best routes” in terms of forecast weather.

# Push-to-load Function (management of a route clearance 1/3)



ATC  
MSG



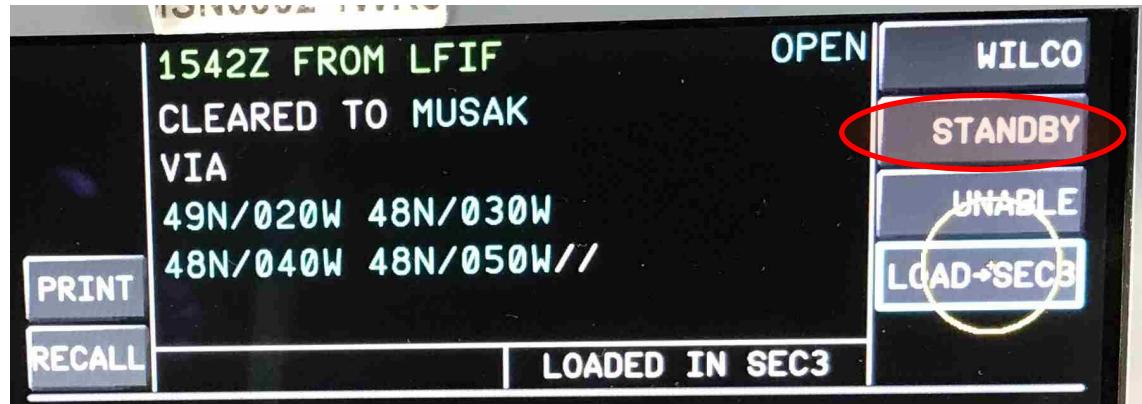
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AIRBUS suggested 1<sup>st</sup> step: LOAD the clearance into the SECondary F-PLN to check for an immediate LOAD FAILED or LOAD PARTIAL

# Push-to-load Function (management of a route clearance 2/3)

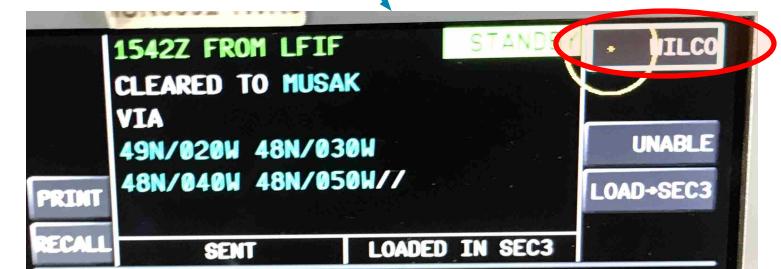
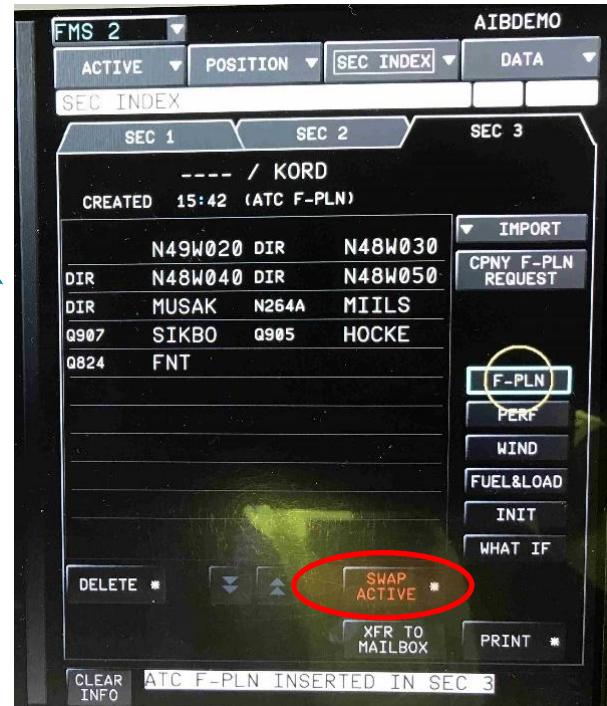
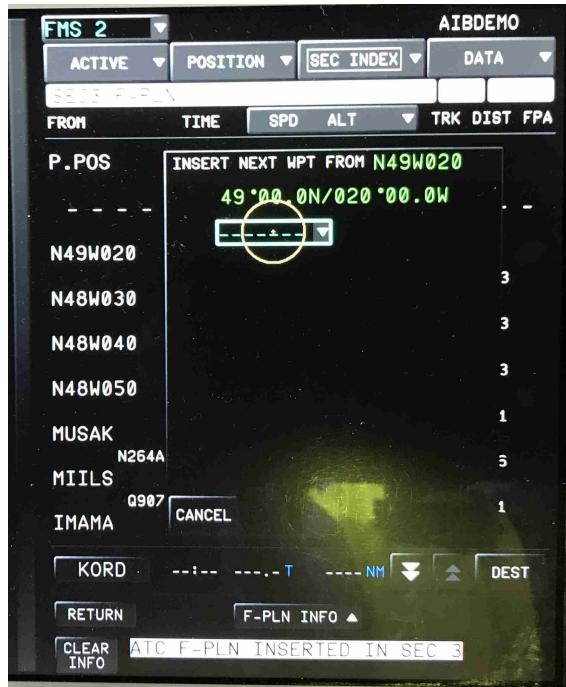
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AIRBUS suggested 2<sup>nd</sup> step: Quickly thereafter, send a STANDBY answer to ATC to take the appropriate time to review & analyse the new route

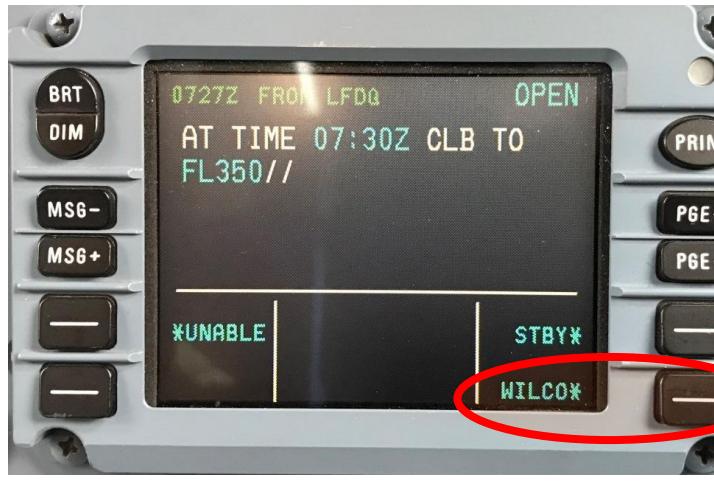
# Push-to-load Function (management of a route clearance 3/3)

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AIRBUS suggested 3<sup>rd</sup> step: After the route has been carefully checked and reviewed, send the appropriate answer to ATC (WILCO or UNABLE)

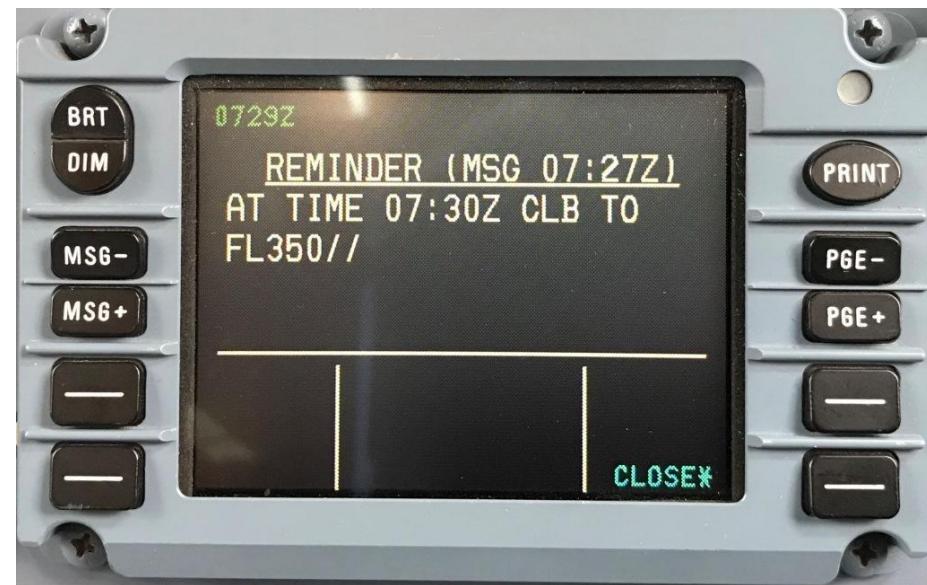
# Monitoring Function (management of a Deferred Clearance)



# Monitoring Function (management of a Deferred Clearance)



**30 seconds before the condition (position, altitude, time) is reached, the REMINDER is triggered on the DCDU (with the ATC MSG visual + aural)**



*Note: Some Reminders may also provide the LOAD key if the message is loadable*

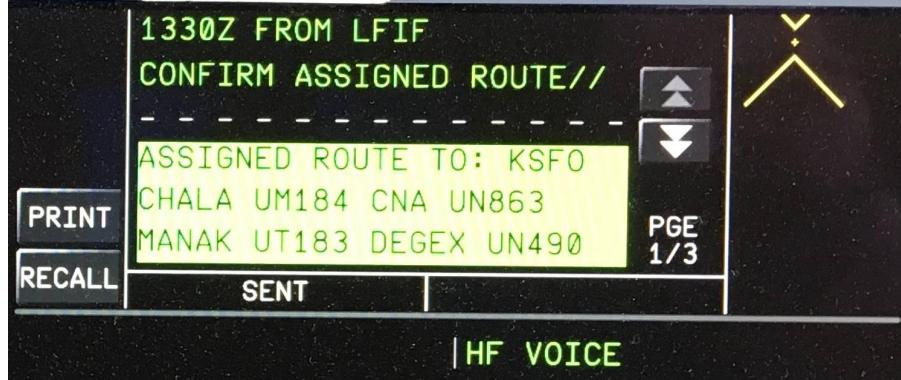
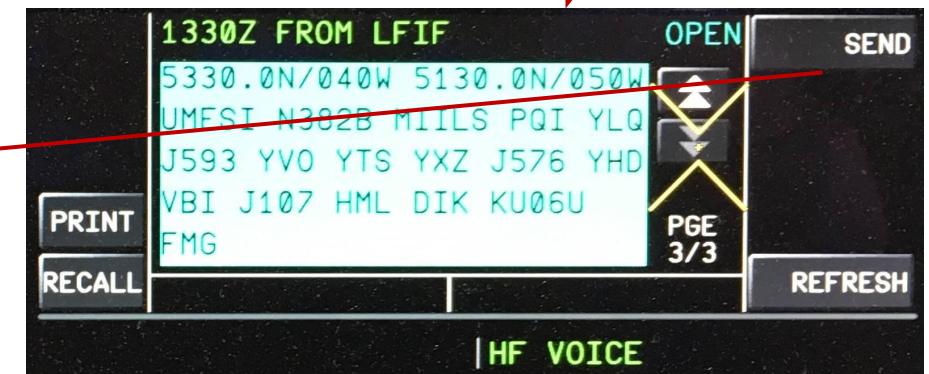
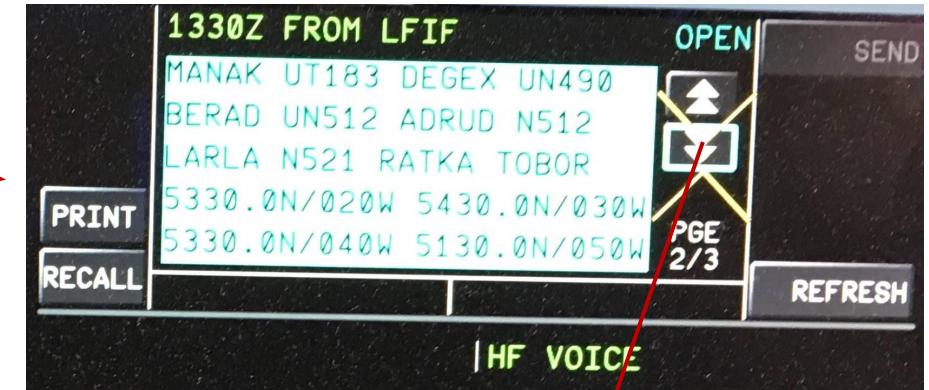
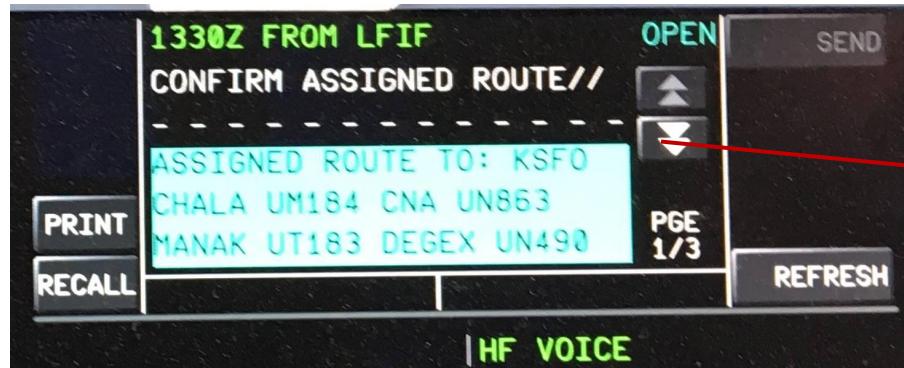
# Prefilled data Function (management of a Confirm instruction)

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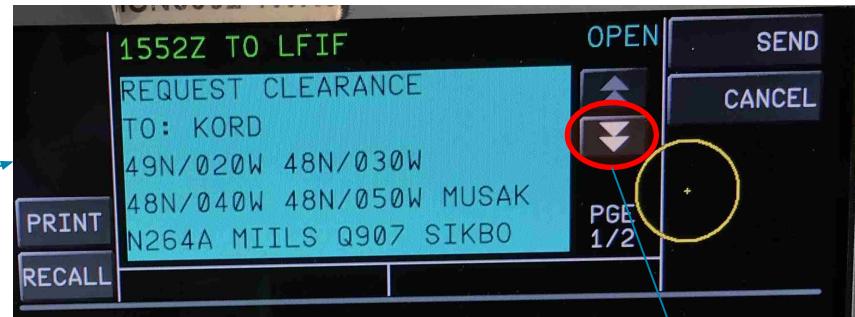
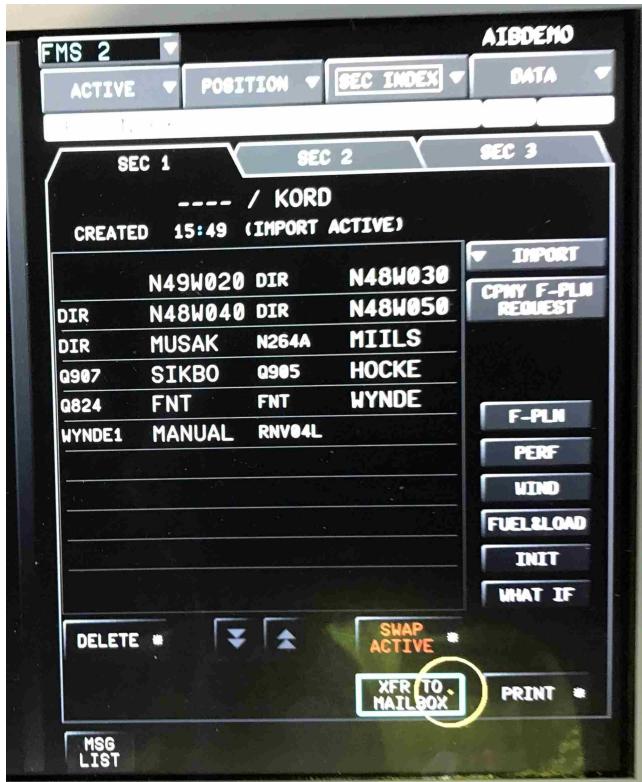
# Prefilled data Function (management of a Confirm instruction)

~



# Prefilled data Function (management of a Route Request)

~



Flight Plan (route) request preparation  
in the FMS SEcondary F-PLN can  
come from the Airline AOC, or be a  
**manual modification by the flight  
crew** of their current active route



# FMS contribution to Airline Operational Control Datalink

# FMS AOC Datalink capacity

## Uplinks from the ground to the FMS

- Main intent is to **save time during flight preparation** (turn-around time reduction, flight crew workload alleviation)
- Replace manual entries (risk of error) by automated data transmission from the ground (dispatcher)
- Flight Plan data
- Wind & Temperature data
- Miscellaneous Performance data (Fuel & Load, etc)
- Take-Off Performance data

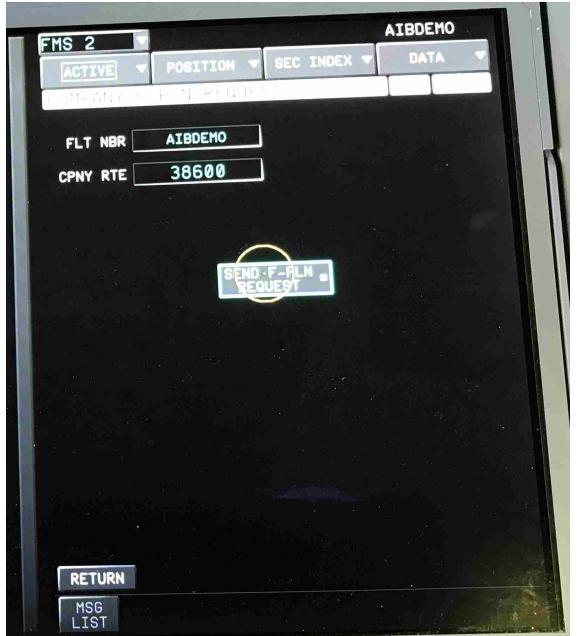
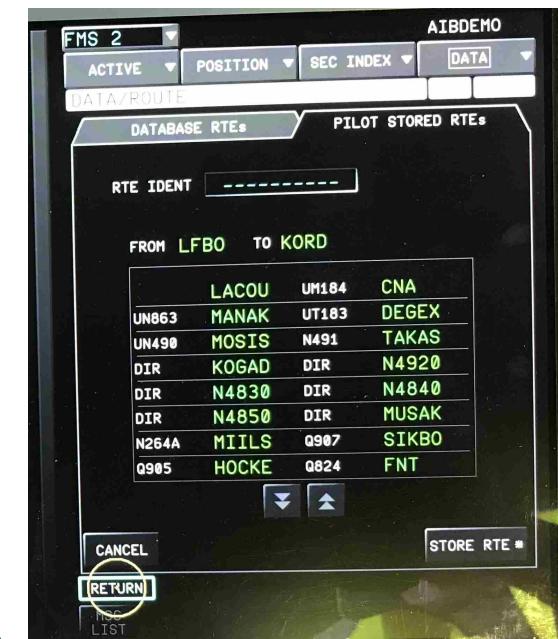
## Downlinks from the FMS to the ground

- Main intent is to **automate reporting tasks after the flight** and increase dispatcher awareness of flight status
- Typically upon request from the ground or FMS triggers (no pilot involvement)
- Current Position Report (with FMS data such as Fuel on Board...)
- Progress Report (Estimated Time of Arrival...)
- Flight Plan Report (full route of flight, but without predictions)
- Performance Report (additional FMS contextual data)

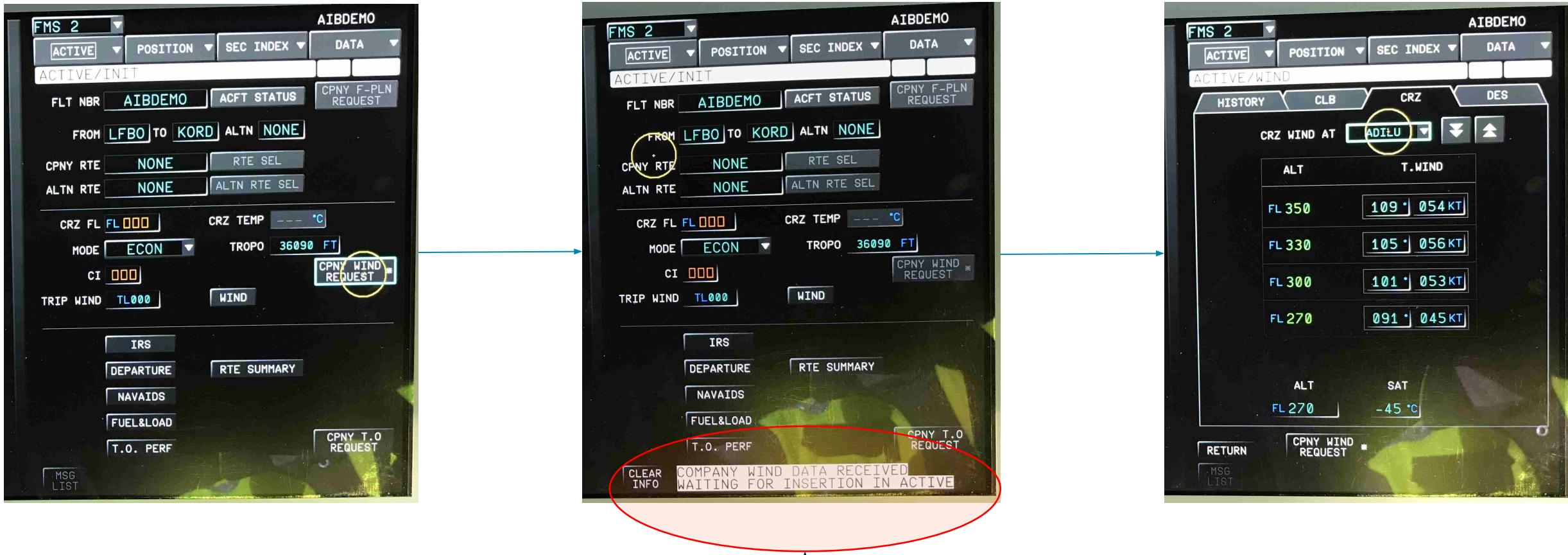
# Cockpit Preparation: Flight Plan uplink

LFBO LACOU5B LACOU UM184 CNA UN863 MANAK UT183 DEGEX UN490 MOSIS  
N491 TAKAS DCT KOGAD NATE MUSAK N264A MIILS Q907 SIKBO Q905 HOCKE  
Q824 FNT WYNDE1 KORD

LFBO/FL380 TAKAS/FL400 MUSAK/FL430



# Cockpit Preparation: Wind & Temperature uplink



ENROUTE FORECAST WINDS									
FIX	CRZ FL		FL240	FL300	FL340	FL390			
	TROP	SAT	TAT	SAT	TAT	SAT	TAT	SAT	TAT
ETREK	36	30080	31052	30065	30077	30080			
	39	-57 -28	-32 000	-48 -18	-54 -25	-59 -30			
LUXAN	36	30080	31052	30065	30077	30080			
	39	-57 -28	-32 000	-48 -18	-54 -25	-59 -30			
LTP	36	30080	31052	30065	30077	30080			
	39	-57 -28	-32 000	-48 -18	-54 -25	-59 -30			
SOPLO	36	30070	31057	30059	30061	30083			
	37	-59 -30	-33 -01	-48 -18	-57 -28	-60 -31			
OMASI	February 20270	Flight Management System Data Link							
	37	-59 -30	-33 -01	-48 -18	-57 -28	-60 -31			

# Cockpit Preparation: FMS Performance data uplink

A321-271  
ENG  
**PW1133G**  
ACTIVE NAV DATA BASE  
05NOV-03DEC ABV2012001  
SECOND NAV DATA BASE  
← 08OCT2020 - 05NOV2020

CHG CODE  
[ ]  
IDLE / PERFDL + 0.0 / + 0.0 SOFTWARE STATUS/XLOAD>

INIT CO RTE ← → FROM / TO  
ALTN / CO RTE EGSS / EDDW  
NONE  
FLT NBR AIBJRF1 IRS INIT>  
PAX NBR 12 WIND / TEMP>  
COST INDEX TROPO  
39 34000  
CRZ FL / TEMP GND TEMP  
FL290 / -48 ° + 14 °  
PERF DATA UPLINK

INIT FUEL PRED ← →  
TAXI ZFW / ZFWCG  
0.2 74.0 / 25.0  
TRIP / TIME BLOCK  
3.2 / 0058 32.0  
RTE RSV / %  
0.1 / 2.8  
ALTN / TIME TOW / LW  
--- / --- 105.8 / 102.5  
FINAL / TIME TRIP WIND  
1.5 / 0030 -----  
MIN DEST FOB EXTRA / TIME  
1.5 21.1 / 0650  
PERF DATA UPLINK

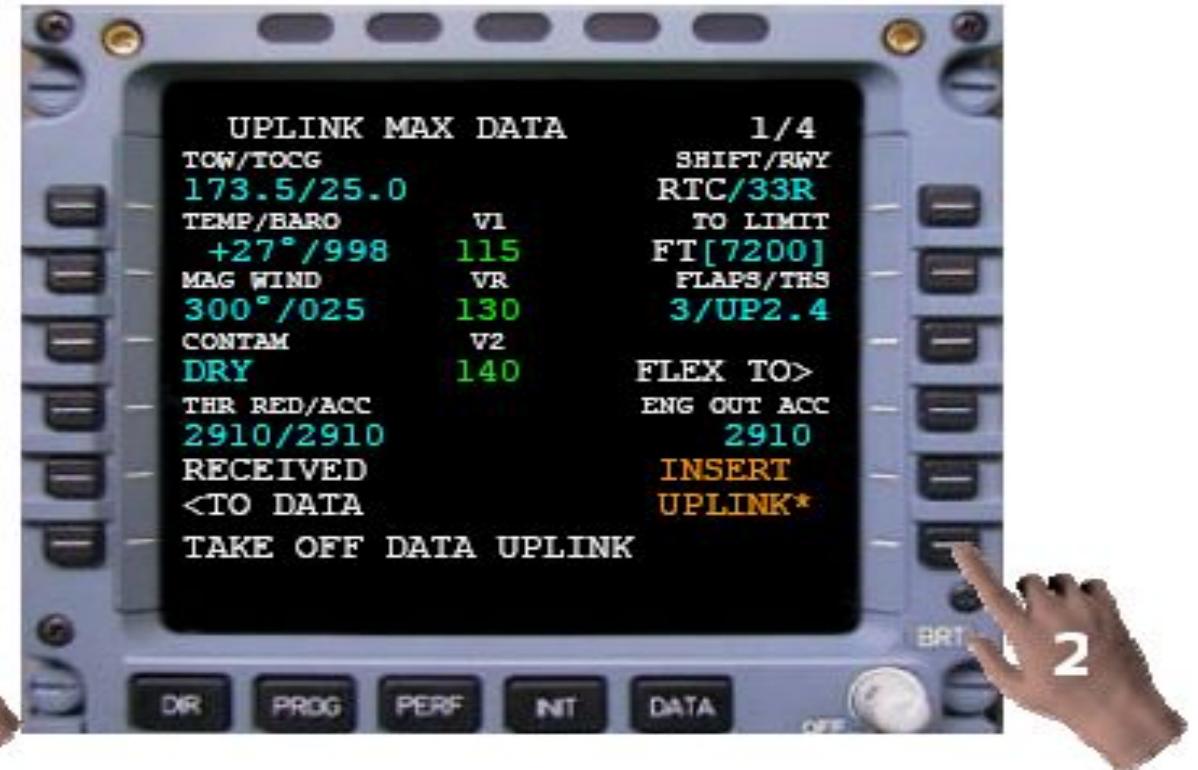
TAKE OFF RWY 04  
V1 FLP RETR  
□□□ F = 180 NOISE>  
VR SLT RETR TO SHIFT  
□□□ S = 232 [M] [ ] \*  
V2 CLEAN FLAPS / THS  
□□□ O = 250 [ ] / [ ]  
TRANS ALT DRT TO - FLX TO  
6000 [ ]  
THR RED / ACC ENG OUT ACC  
1830 / 1830 1830  
UPLINK NEXT  
<TO DATA PHASE>  
PERF DATA UPLINK

# Cockpit Preparation: FMS Take-Off Performance data uplink

Request for TO DATA



Insertion of TO DATA



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Thank you

# Glossary

●ACARS	Aircraft Communication Addressing and Reporting System	●FMS	Flight Management System
●ADS	Automatic Dependent Surveillance	●GNSS	Global Navigation Satellite System
●ADS-B	ADS - Broadcast	●GPS	Global Positioning System
●ADS-C	ADS - Contract	●HF	High Frequency
●AFN	ATS Facilities Notification	●ICAO	International Civil Aviation Organization
●AMI	Airline Modifiable Information	●MCDU	Multipurpose Control and Display Unit
●AOC	Airline Operational Communication	●NAT	North Atlantic
●ARINC	Aeronautical Radio Inc.	●OCL	Oceanic Clearance
●A623	Standard for ATIS, DCL and OCL	●RNP	Required Navigation Performance
●ATC	Air Traffic Control	●SATCOM	Satellite Communication
●ATIS	Air Traffic Information Services	●VHF	Very-High Frequency
●ATM	Air Traffic Management		
●ATN	Aeronautical Telecommunication Network		
●ATS	Air Traffic Services		
●ATSU	Air Traffic Services Unit		
●CNS	Communication, Navigation and Surveillance		
●CNS/ATM	CNS / Air Traffic Management		
●CPDLC	Controller-Pilot DataLink Communication		
●DCDU	Datalink Control and Display Unit		
●DCL	Departure Clearance		
●EFIS	Electronic Flight Instrument System		
●FANS	Future Air Navigation System		