FMS Datalink Domain

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Reminder: Flight Management System main functions

- **Flight planning:**
  - flight plan construction
  - flight plan modification
- **Navigation:**
  - aircraft position computation
  - radio tuning
- **Guidance:**

  Capability to automatically follow the flight plan:
  - along lateral trajectory
  - along vertical trajectory
- **Optimization / Performance:**
  - costs, speeds, altitude
  - predictions

- **Communication** with the ground (AOC and ATC)

- **Display management** on EFIS

Agenda

1. Presentation of Datalink function
2. AOC
3. ATC

Agenda

1. **Presentation of Datalink function**
2. AOC
3. ATC

Legacy aeronautical communications

- Voice-based
- Specific phraseology (pilots = radio operators)
- Language dependent
- Poor quality – sometimes very noisy

- High workload to process instructions into flight actions (e.g. insert a clearance onto FMS)

Datalink definition

- Bi-directional data exchanges between aircraft and ground stations (airline and/or ATC)
- Designed to reduce crew workload, minimize errors and improve efficiency of flight

Within the navigation function (FMS):

- Uplink of data to the FMS for review and acceptance by the crew
- Downlink of FMS data for report and monitoring

Datalink definition

FMS Datalink – 2 domains:

- **Airline Operational Control (AOC)** communications involving data transfer between the aircraft and the Airline Operational centers: flight preparation, take-off data, FOB…

- **Air Traffic Control (ATC)** communications involving data transfer between the aircraft and the ATC centers: CPDLC (including departure clearance) , ADS-C…

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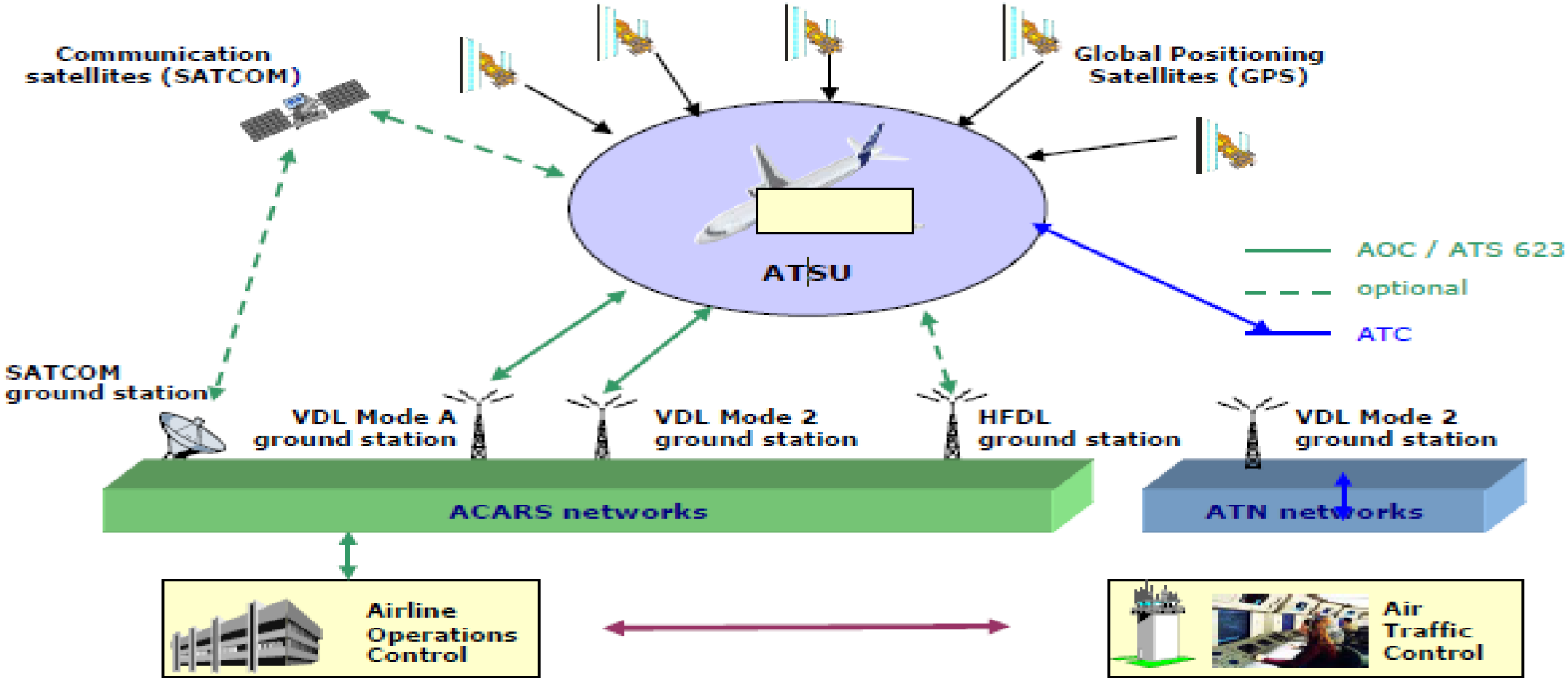
Datalink networks



Datalink networks

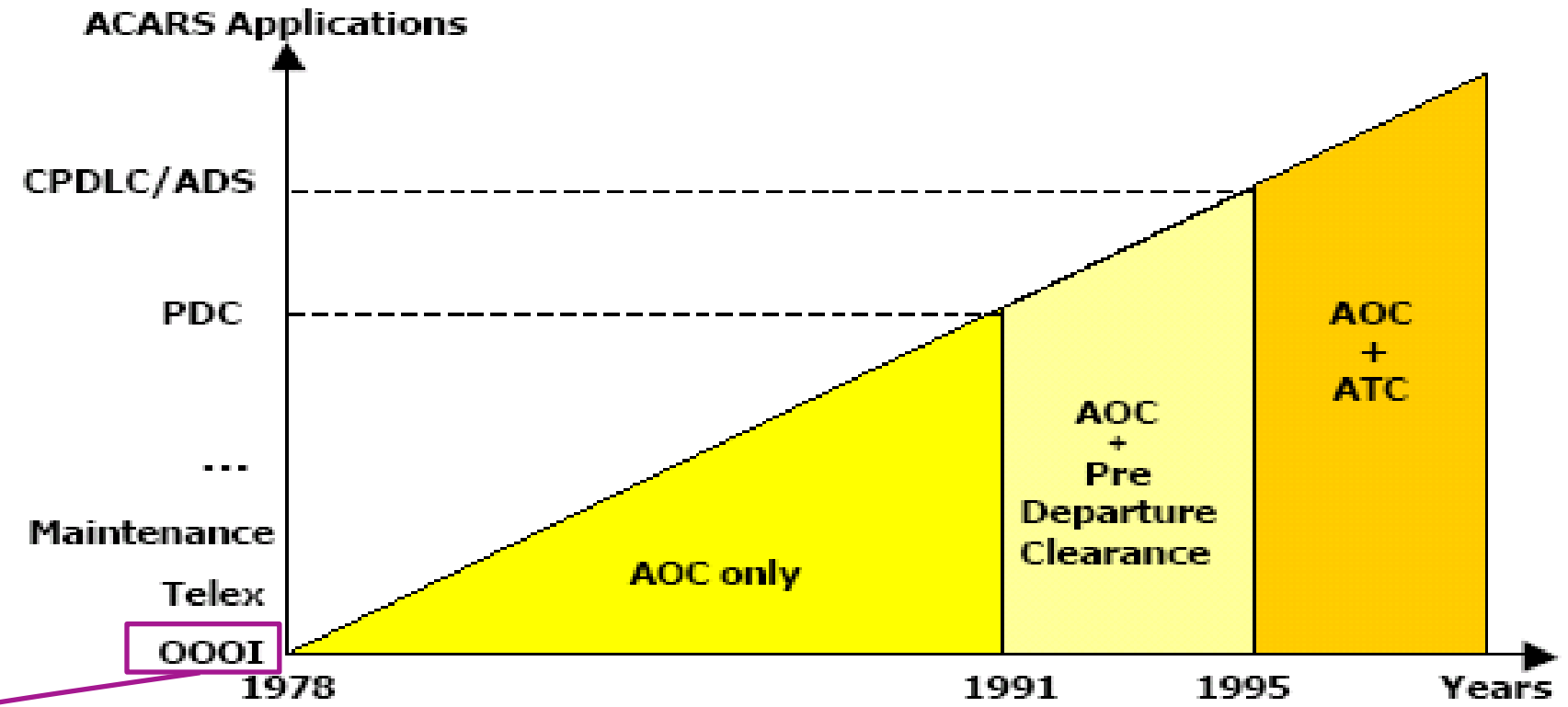
- Datalink currently communicates through **two networks** using a variety of Air/Ground means (VHF, HF, Satcom…) as well as operations centers and terrestrial Ground-Ground networks:

ACARS:
- AOC
- FANS A (Oceanic and remote)

ATN:
- FANS B (Continental)
- FANS C (Worldwide but limited to EU for first implementation)

- Compared to ACARS, ATN is a global standard providing high data rate, high integrity, more reliable and robust means for implementing current and future intensive datalink applications.

Datalink evolution



OOOI: Precursor of AOC datalink through ACARS

« Out – Off – On – In »

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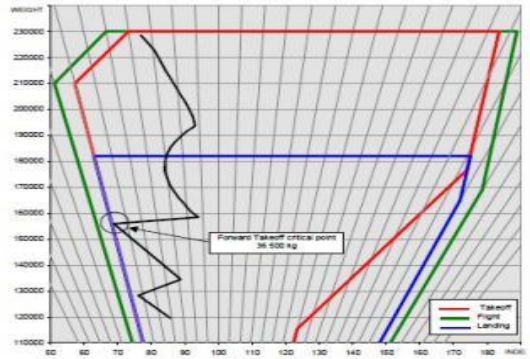
FMS Datalink function

The objective of the function is to uplink and downlink relevant data:

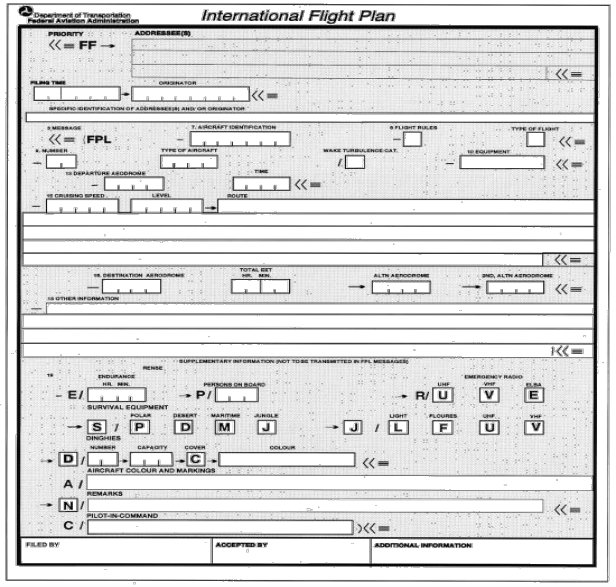


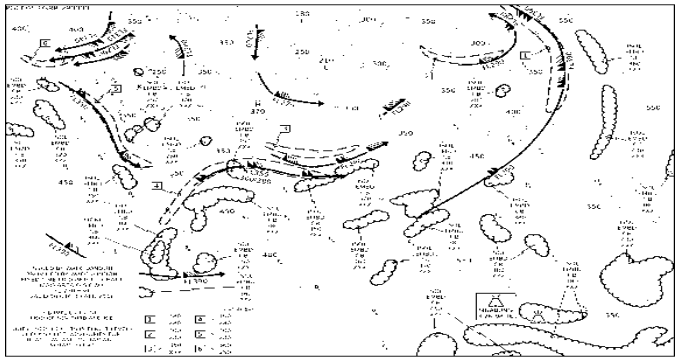
On ground

→ loading information:	AOC flight plan and perfos
→ meteo analysis:	AOC winds
→ clearances:	ATC flight plan

In flight

→ meteo analysis :	AOC winds
→ trajectory modification:	AOC flight plan ATC clearance
→ surveillance:	ADS-C (ATC)
→ report:	AOC and ATC reports





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1. Presentation of Datalink function

2. **AOC**

3. ATC

Introduction: AOC functions in Airbus aircraft

FLIGHT OPERATION AOC

Information relating to flight: Estimated Time of Arrival (ETA), Weather reports, Fuel…

AOC FMS

- e.g: Progress report, Flight plan report, Flight plan initialization, wind data

AOC application

- Customized application which enables flight crew to exchange with airline operations

Out of scope

MAINTENANCE OPERATION

Enable real or reactive time follow-up of Aircraft maintenance status (CMS and ACMS reports).

ACMS (Aircraft Condition Monitoring System)

- e.g: ACMS reports, set of parameters

CMS (Central Maintenance System)

- e.g: PFR/CFR

Out of scope

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AOC presentation

- The FMS-AOC datalink allows data exchange over the ACARS network **with the airline.**

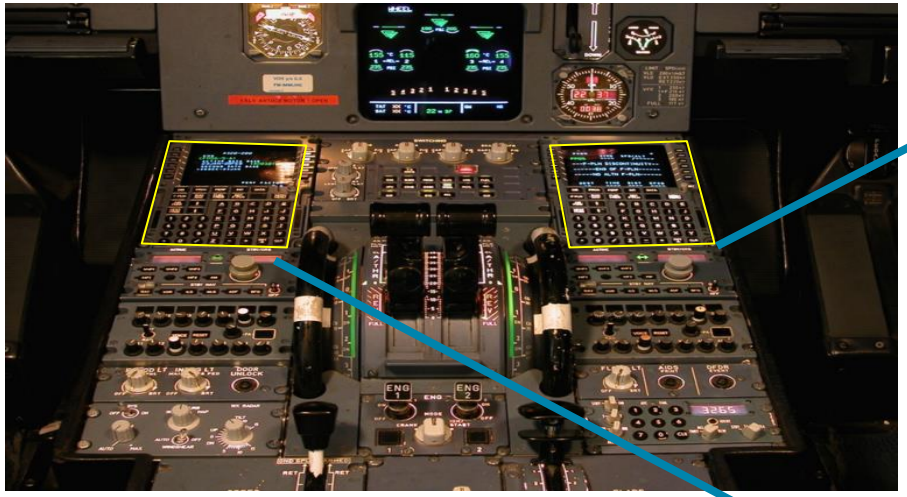
- 2 categories:

  – **uplink** messages: reception of data (unsollicited or in response to manual request) or requests sent by the ground station

  – **downlink** messages: sending of reports or requests to the ground station

AOC presentation

- Specific dedicated prompts are available in **FMS MCDU** pages for AOC requests (not arranged in a single page)



AOC presentation

- A variety of functions:
  - **F-PLN initialization:** uplink message containing a flight plan and associated performance data
  - **Take-off data:** uplink message containing TO speeds and conditions
  - **Wind data:** uplink message containing climb, cruise, descent and alternate wind data
  - **Temperature data**
  - **Flight reports:**
    - Position or progress reports: information on a/c current position and progress
    - Flight plan or performance reports: active route information

Flight Plan initialization

When the a/c is **on ground**, the ground station can send a **flight plan** and optional associated **performance data** automatically or following crew “Init request” .

“Init request” informs the airline ground systems that the aircraft is being prepared for departure and can trigger the uplink of many initialization data

FMS Initialization Request Page

FMS Received INIT page

Advantage: the pilot does not have to manually enter these data through MCDU:

Major workload reduction

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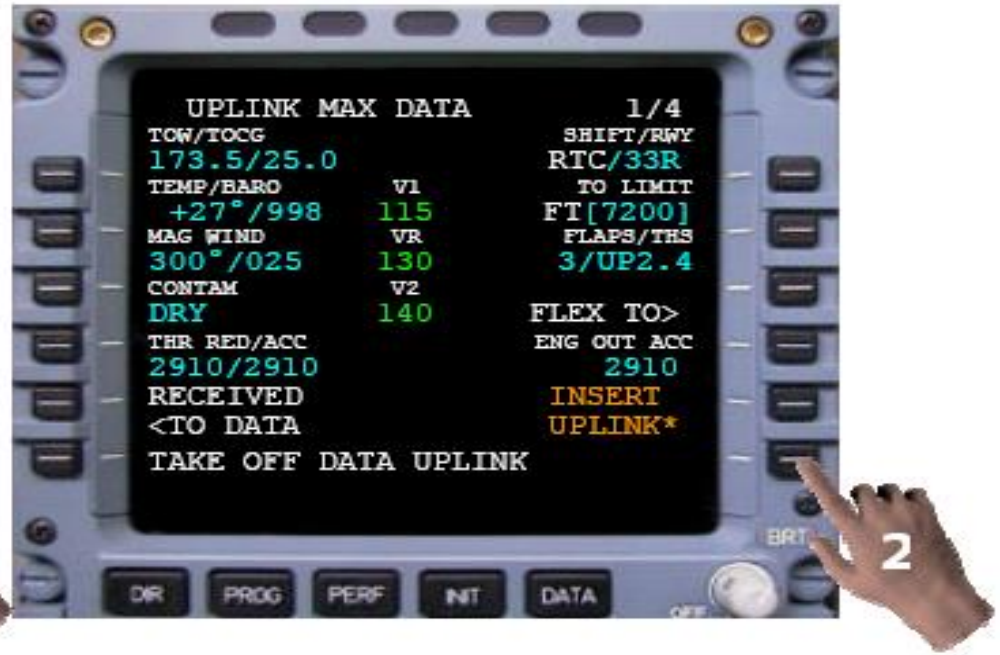
Take-off data

The crew can **uplink performance initialization data** to the FMS. Message features:

- only processed prior to first engine start
- may be received as an automatic uplink or as a response to a crew request
- contains **runways data** (ident, take-off speeds, flap settings, CG…) at the origin airport

Request for TO DATA

Insertion of TO DATA



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Wind data

The crew can **request** and **uplink winds updates** for:

- climb (altitude / wind direction / wind magnitude)
- cruise waypoint (altitude followed by a list of waypoints with associated wind data)
- descent (/ wind direction / wind magnitude/ (temperature) + optional ISA, QNH, transition altitude)

Flight plan reports

Flight reports provide real time information to the ground concerning the aircraft's current situation and position:

- **Position report**
  provides current a/c position information to the ground

- **Progress report**
  provides data relative to the destination (arrival time, EFOB)

- **Flight plan report**
  provides data relative to the active lateral flight plan

- **Performance data report**
  provides the active performance data currently used by the FMS

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1. Presentation of Datalink function
2. AOC
3. **ATC**

ATM – ATC datalink Communication

- Over the oceans and remote areas, need for communication more reliable than HF voice radio. The improvement of communications means coupled with enhanced navigation and surveillance capacity enables to reduce separation minimas.

=> Increase of airspace capacity, flexibility for flight level change (fuel saving)

- Over the continents, reduce radio channels congestion

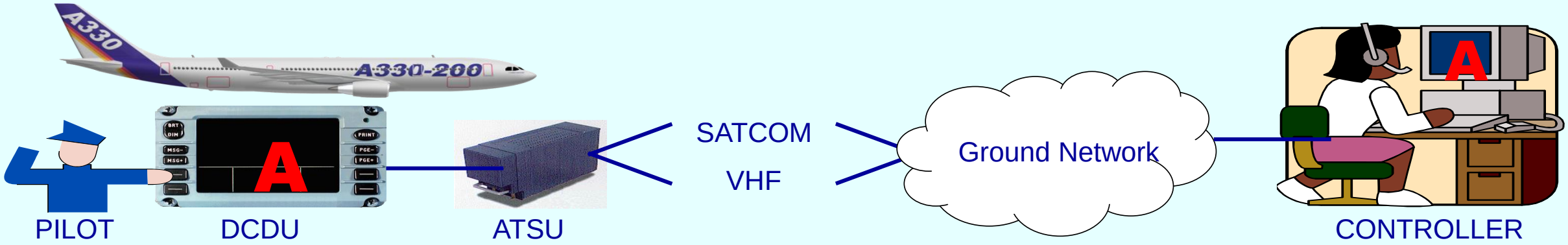
=> Introduction of ATC Datalink communication : FANS (Future Air Navigation System) to support:

- Requests, clearance, and instructions.
- Position reporting.
- Routine controller-pilot communication.

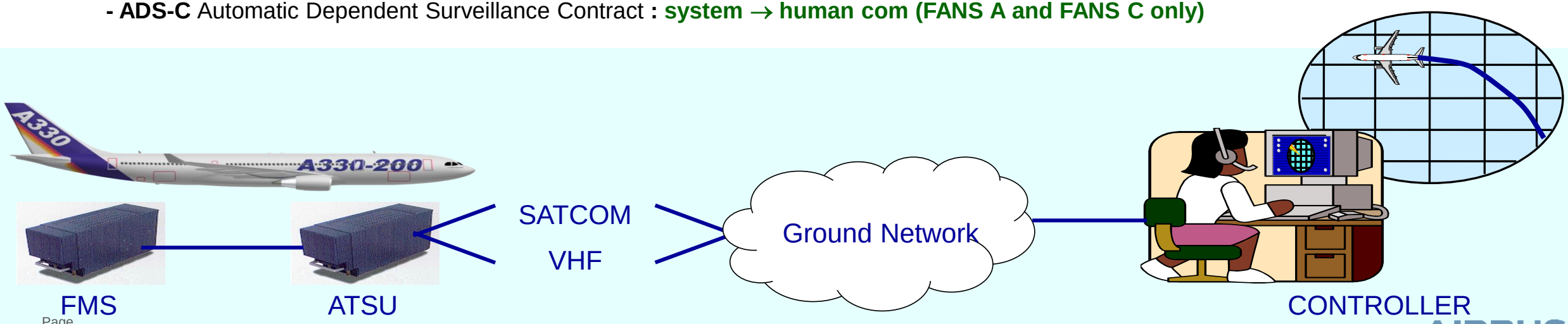
Better **C**ommunication coupled with more precise **N**avigation and a richer **S**urveillance for a better **A**ir **T**raffic **M**anagement.

What is FANS?

- CPDLC Controller Pilot Datalink Communication **: human ↔ human com**

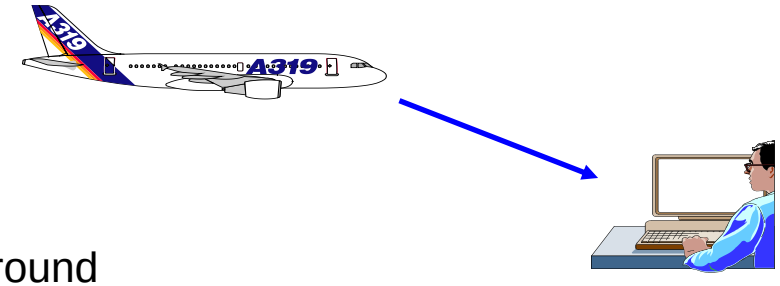


- ADS-C Automatic Dependent Surveillance Contract **: system → human com (FANS A and FANS C only)**



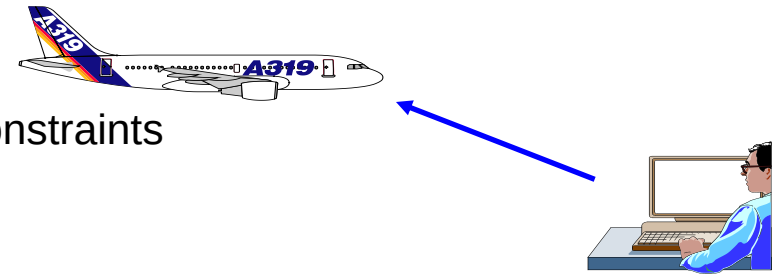
CPDLC

- Datalink communications between pilot and the controller of the relevant flight region
- Adapted to areas where voice communications are difficult (e.g. HF voice over oceans) or to reduce voice congestion in high density continental area FANS B in Europe)
- Consists in the exchange of individual or combined elements chosen within a set of internationally normalized preformatted ATC elements (clearances, requests, reports…)



• **Air-Ground communication** “route requests”:

- preparation on secondary f-pln
- sent to the ATC embedded system then to the ground



• **Ground-Air communication** “route clearances”:

- integration in the secondary f-pln
- type of messages: route clearances / crossing constraints
- NDB and compatibility checks
- computation of predictions
- acknowledgement or rejection

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FANS Operational Benefits

CPDLC Main Benefits

- Reduction of voice frequency congestion
- Reduction of communication errors
- Decreasing of workload for ATC controller and flight crew
- Historical recording of exchanged messages

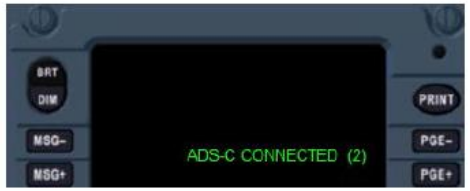
ADS-C

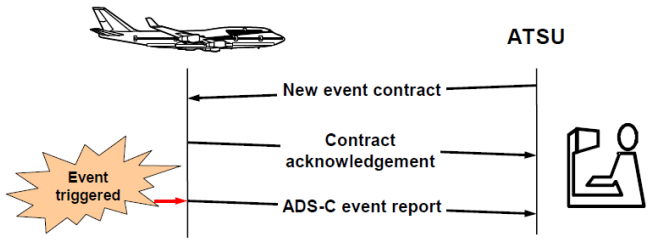
ADS-C enables the aircraft to automatically send position and F-PLN intentions to ATC centers.

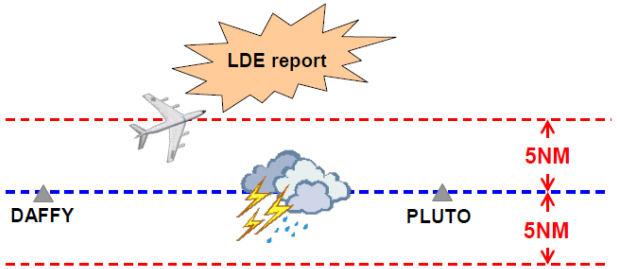
ATC controllers can select the rate and mode of reporting (at specified time intervals or on the occurrence of a special event such as a lateral deviation or attitude change),

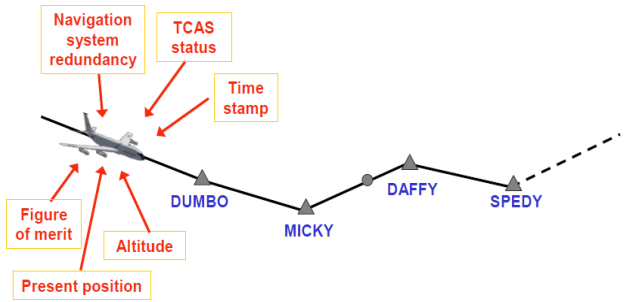
ADS-C enables to reduce lateral and longitudinal separation.

Lateral deviation example (On event Report):









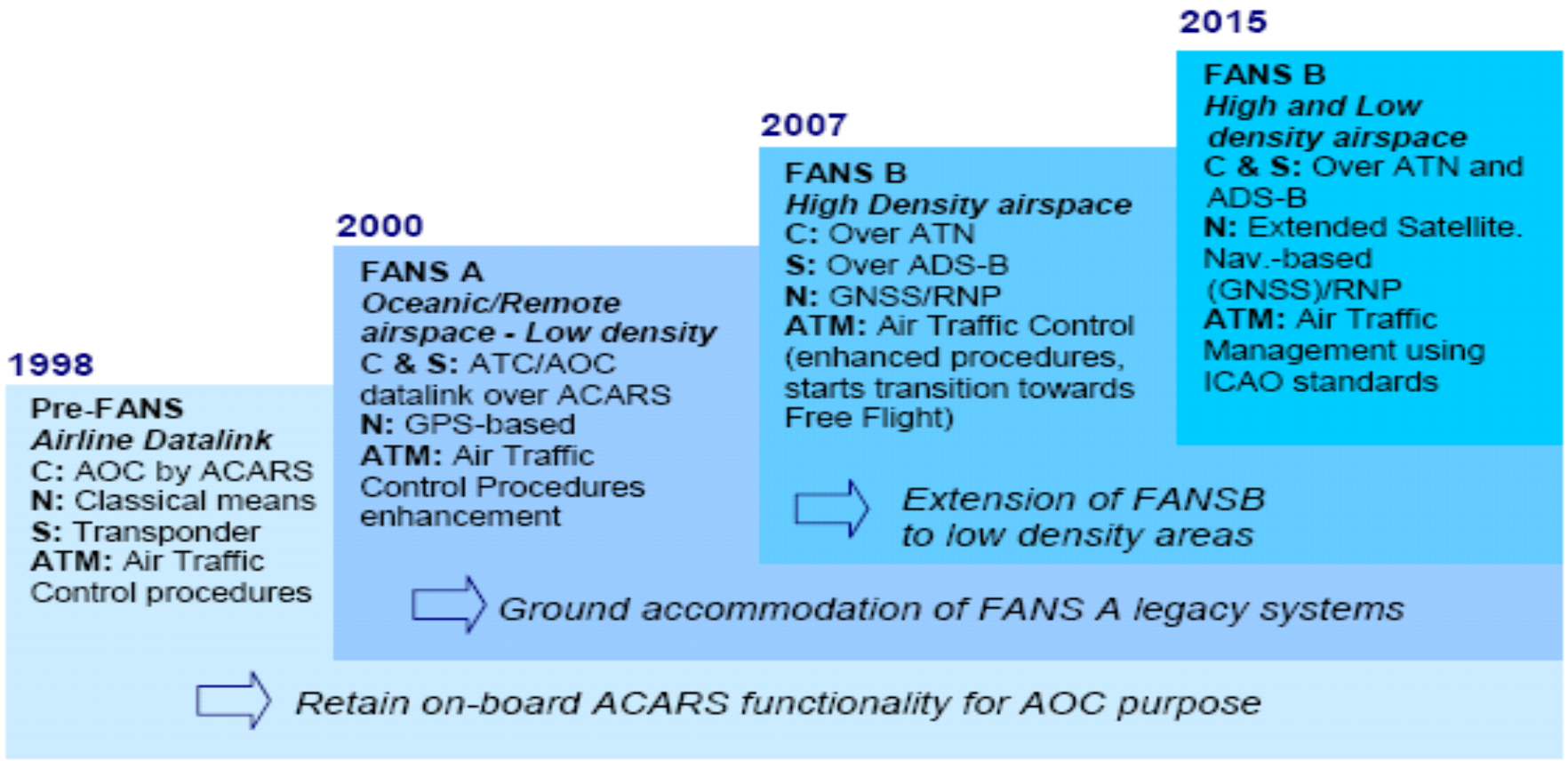
FANS Operational Benefits

ADS–C Main Benefits

- Automatic position reporting
- Decreasing workload for flight crew
- Automatic ADS-C report to ATC when aircraft deviates from cleared profile
- Aircraft eligible to reduced separation operations (50/50 – RNP10, 30/30 – RNP4)

Airbus Implementation of CNS/ATM

CNS/ATM (Communication, Navigation and Surveillance for Air Traffic Management) or FANS is based on global navigation, communications and automatic dependent surveillance systems



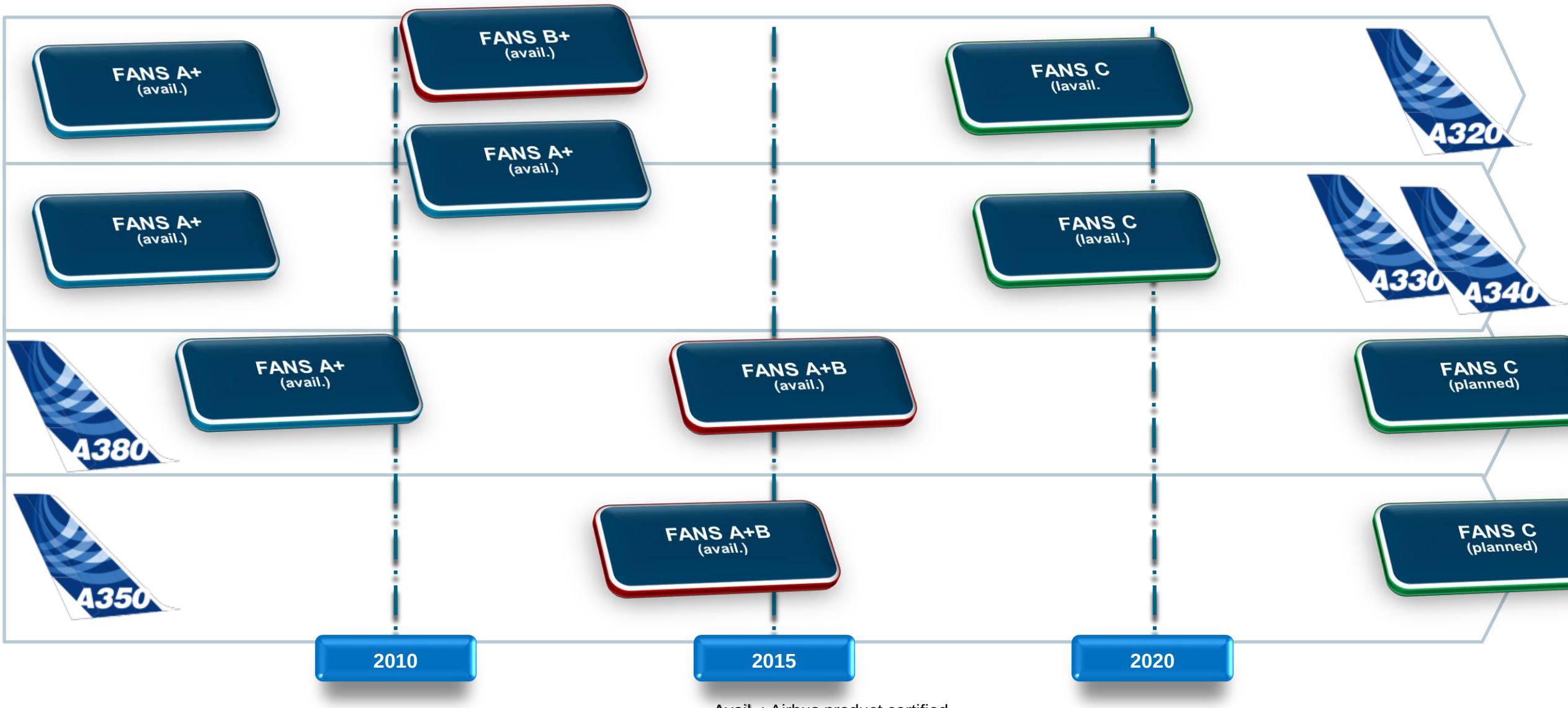
Airbus Implementation of CNS/ATM – What is next

- New FANS product : FANS C

- FANS C is a single integrated solution, for a worldwide interoperability
  - FANS 1/A+
  - FANS B ATN B1
  - FANS C ATN B2

- First implementation is on A320 family and A330 (entry into service Feb 2019), to support SESAR Large Scale Demonstrations and initial deployment

Airbus Products Roadmap



Avail. : Airbus product certified

Launched : Airbus product development launched

Planned : Airbus product development planned (investment decision not taken yet)

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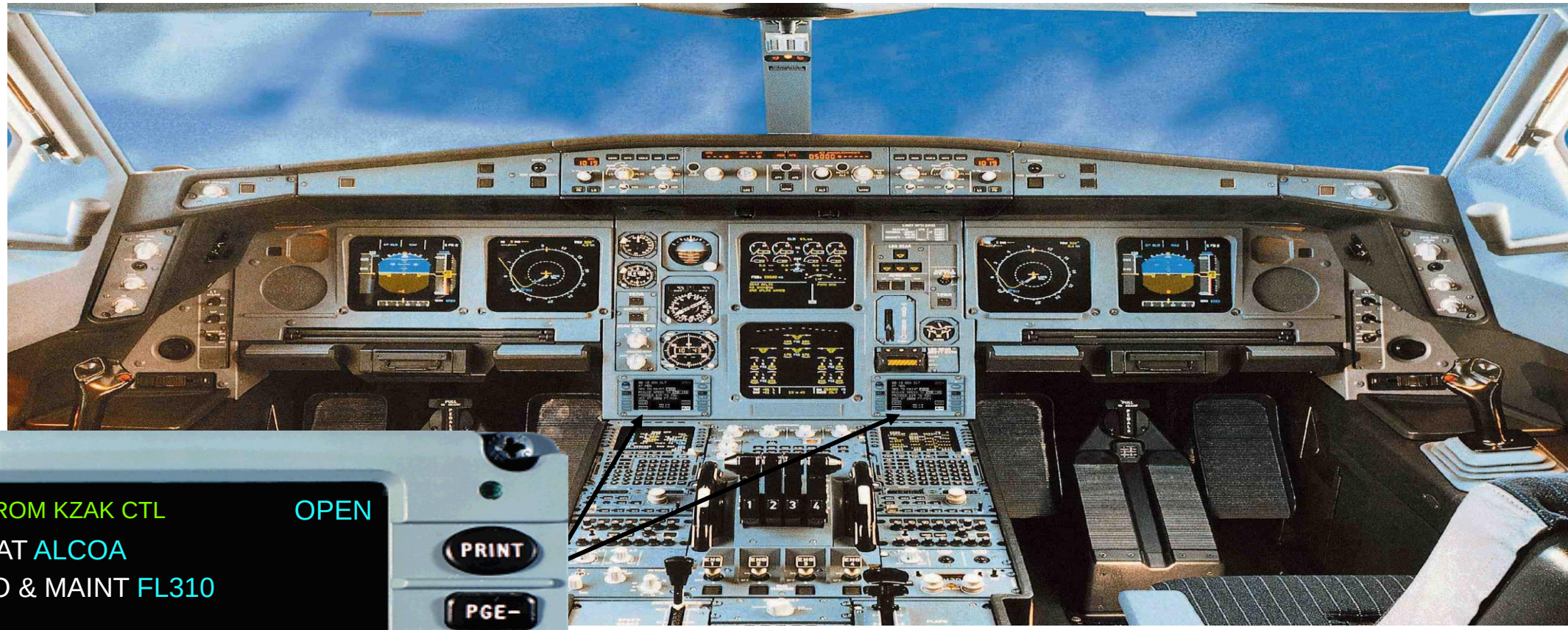
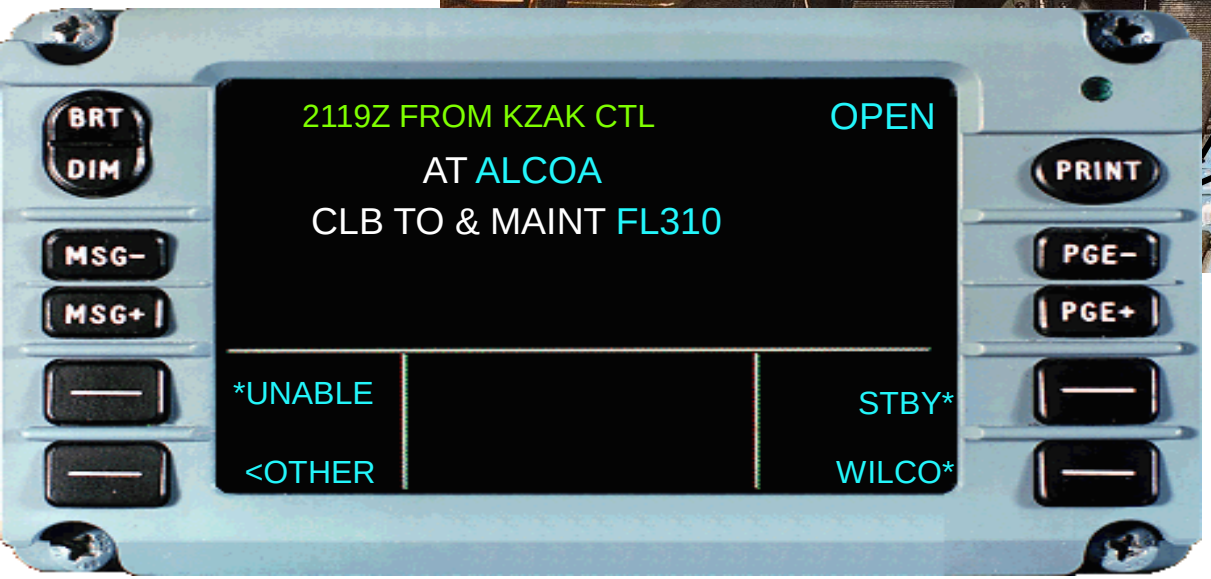
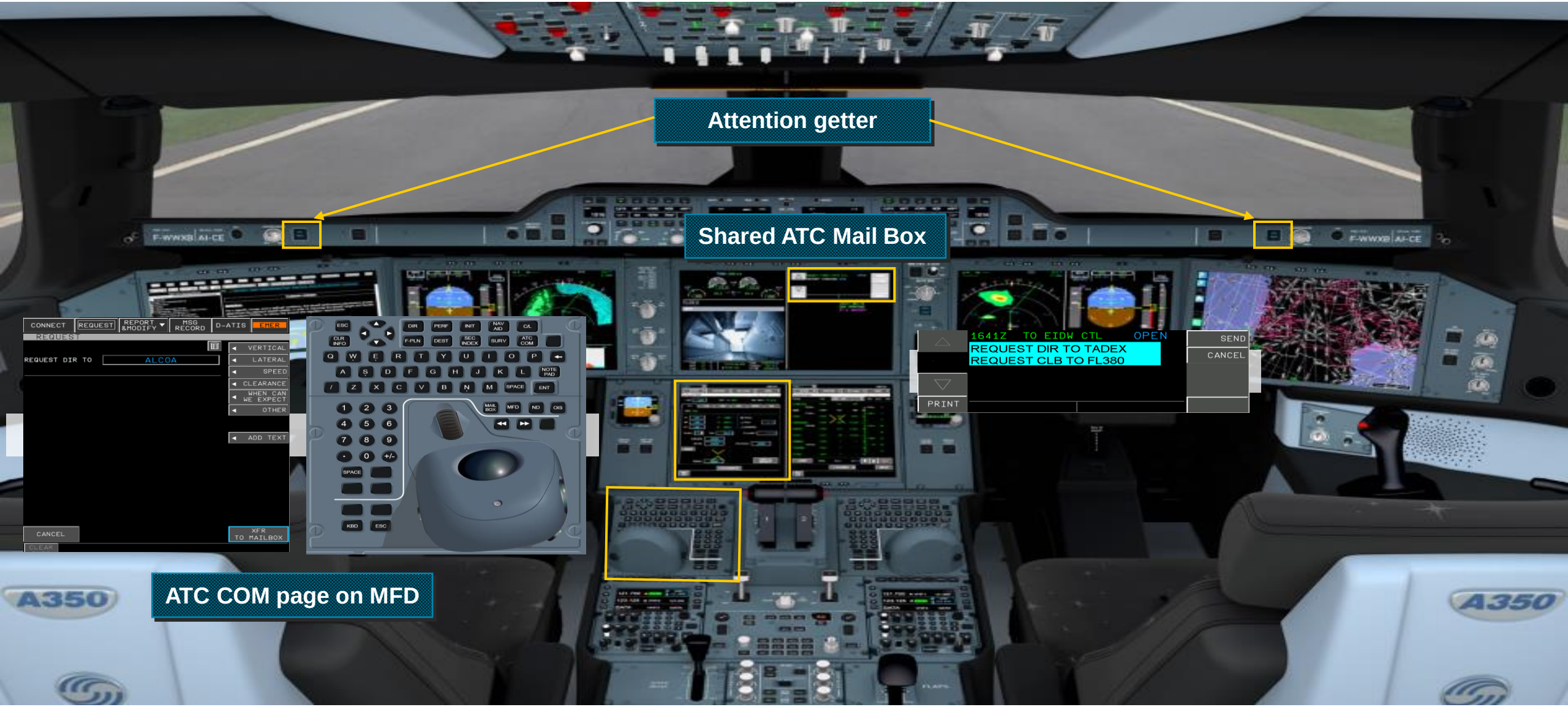
Flight crew interface on SA/LR





Flight crew interface on A350



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Display on mailbox A380

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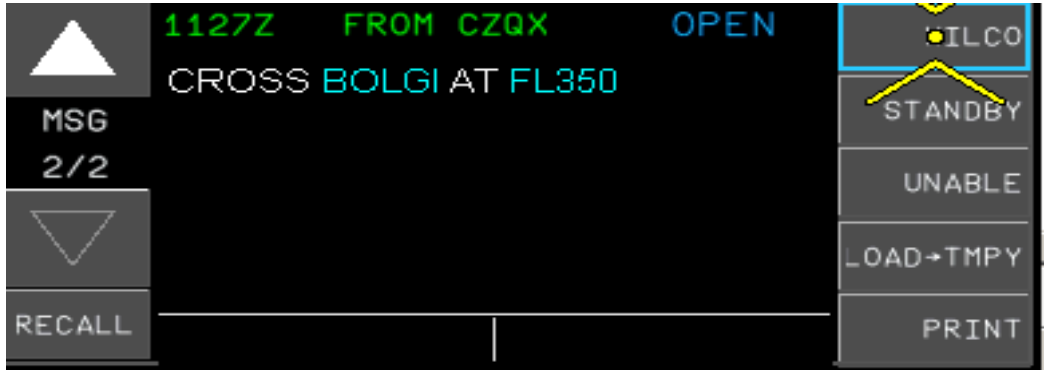
ATC clearances are displayed on mailbox for crew review and acceptance. A short set of these clearances can be loaded into the FMS.



System Architecture of Airbus Commercial Current Solutions

Cockpit Interfaces including FMS

Applications

LRU ATSU

A/G Router

Comm Means

VDR

SDU

HFDR

A320/A330/A340

IMA ATC Applications

ACR

VDR

SDU

HFDR

A380/A350

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FMS role in FANS

• In the frame of ATC communication, the FMS:

- **provides data** concerning the flight status to the ATC D/L Application system
  (ADS-C, CPDLC reports, confirm answers)

- **monitors** some data on request of ATC D/L Application system
  (reports, deferred clearances, confirm messages)

- gives means to the aircrew to **prepare a route request**

- allows the aircrew to **load ATC clearances** (crossing constraints, route clearances…) in the Secondary or Temporary Flight Plan depending on the type of message

• The FMS acts as a **data provider** for:

- CPDLC : Controller Pilot Data Link Communication

- ADS-C : Automatic Dependent Surveillance Contract

We will now study more in detail these two functions….

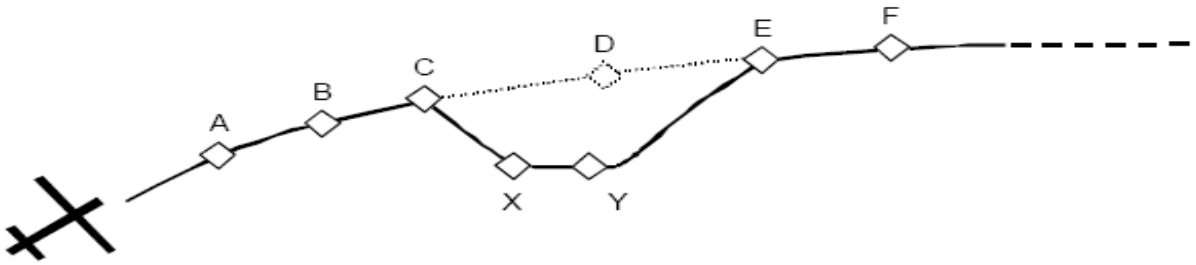
ATC messages - CPDLC

Route clearance

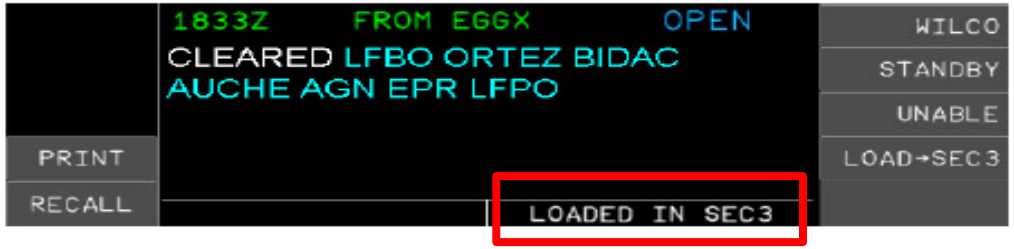
The ATC sends a flight plan initialization or modification displayed on mailbox. Some of them can be loaded in the secondary flight plan of the FMS.

Example : **At [C] cleared [X, Y, E]** received on mailbox

With active flight plan = [FROM, A, B, C, D, E, F, …]



New flight plan = [FROM, A, B, C, X, Y, E, F, …]



A route clearance may be loaded onto the aircraft FMS

ATC messages - CPDLC

Report messages

the ATC requests a report when a certain event is met. The condition is monitored by the FMS which sends a reminder on mailbox when the condition is met.

Example: report leaving [altitude], report passing [position]…

Confirm messages

the ATC requests navigation parameters: these parameters are sent by the FMS to the ATC System which automatically proposes an answer on the mailbox.

Example: confirm altitude, confirm speed, confirm next waypoint…

Deferred clearances

30 s before the clearance condition, the FMS indicates that the monitored condition is met to ATC System.

Example: at [time] climb to and maintain [altitude], at [altitude] proceed dir to [position]

ATC messages - CPDLC exchanges

A few examples (but there are hundreds):

Uplinks (Ground -> A/C)

UL #	Message Element
Reponses/Acknowledgements	
3	ROGER
Crossing Constraints	
51	CROSS [position] AT [time]
52	CROSS [position] AT OR BEFORE [time]
53	CROSS [position] AT OR AFTER [time]
Route Clearances	
79	CLEARED TO [position] VIA [routeclearance]
80	CLEARED [routeclearance]
83	AT [position] CLEARED [routeclearance]
Direct Clearances	
74	PROCEED DIRECT TO [position]
77	AT [position] PROCEED DIRECT TO [position]
Report/Confirmation Requests	
127	REPORT BACK ON ROUTE
128	REPORT LEAVING [altitude]
129	REPORT LEVEL [altitude]

Important! Notice the different nature of the downlink and uplink messages:

Uplinks: often imperative (commands) or rights to perform a procedure (clearances)

Donlinks: Often reports (for information) or requests

Downlinks (A/C -> Ground)

DL #	Message Element
Reponses/Acknowledgements	
0	WILCO
1	UNABLE
3	ROGER
Route Modifications	
24	REQUEST [routeclearance]
Report/Confirmations	
28	LEAVING [altitude]
29	CLIMBING TO [altitude]
30	DESCENDING TO [altitude]
31	PASSING [position]
32	PRESENT ALTITUDE [altitude]
33	PRESENT POSITION [position]
34	PRESENT SPEED [speed]
35	PRESENT HEADING [degrees]
36	PRESENT GROUND TRACK [degrees]
37	LEVEL [altitude]
38	ASSIGNED ALTITUDE [altitude]
39	ASSIGNED SPEED [speed]
40	ASSIGNED ROUTE [routeclearance]
41	BACK ON ROUTE
42	NEXT WAYPOINT [position]
43	NEXT WAYPOINT [time]

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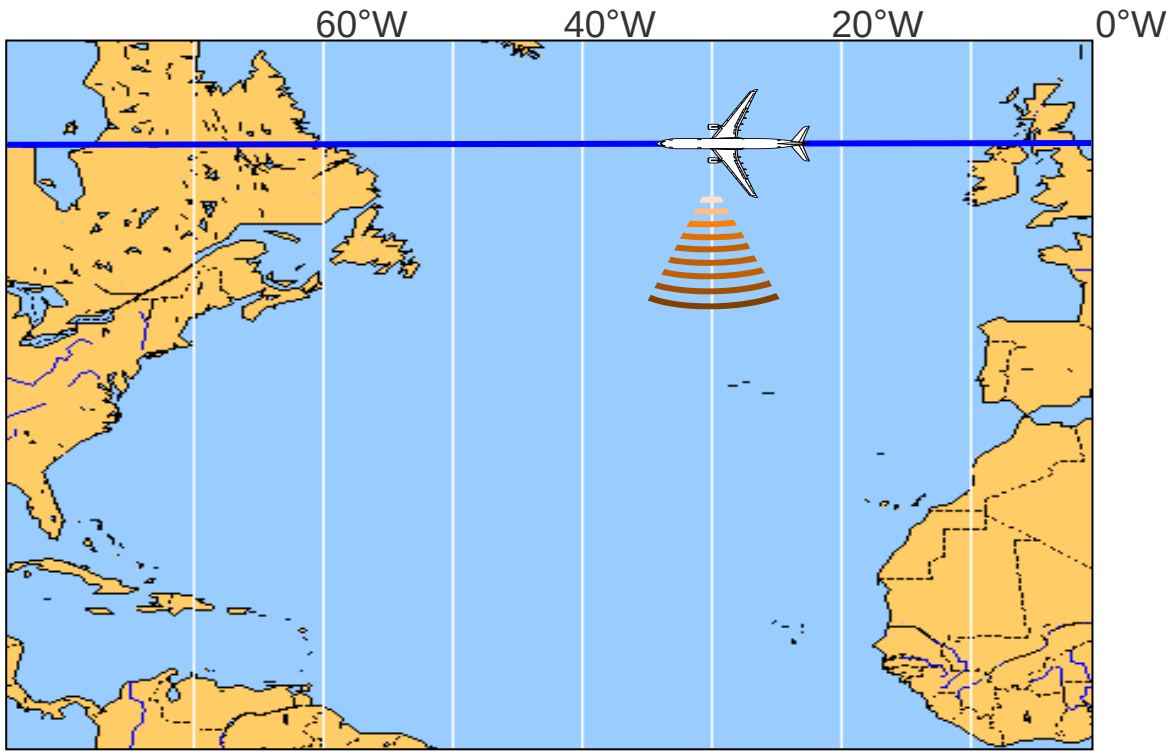
FANS A ADS-C



ADS-C consists in automatic sending of A/C parameters used by the connected ATC center:

- periodic
- on event
- on-demand reports

For FANS A ADS-C these **A/C parameters**:

- gives present position and altitude of the A/C, short and long term intent, local weather data and occurrence of certain events.
- are helpful for ground ATC controllers to monitor more precisely A/C position and trajectory in order to maintain separations minima.

Waypoint event report

Current position/time		
Position	UTC	Altitude
56N30W	05:34	F390

Predicted group		
TO position	TO ETA	TO Altitude
56N040W	05:55	F390
NEXT position	NEXT Altitude	
56N050W	F390	

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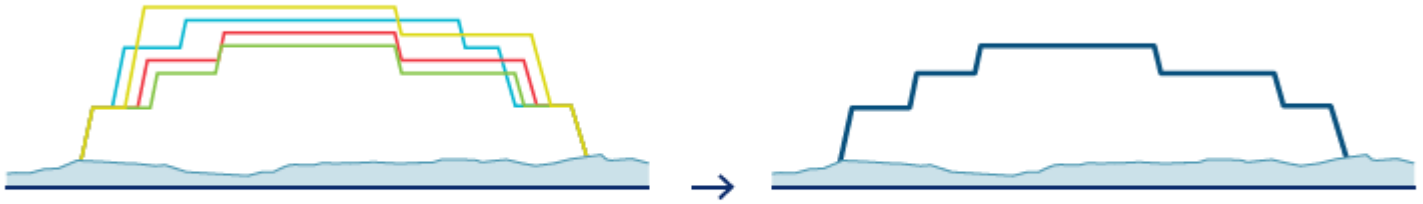
4D Trajectory Based Operations



CURRENT SITUATION

Airspace based, tactical control, airspace congestion.

4D TRAJECTORY OPERATIONS

Trajectory based, strategic & monitoring control.

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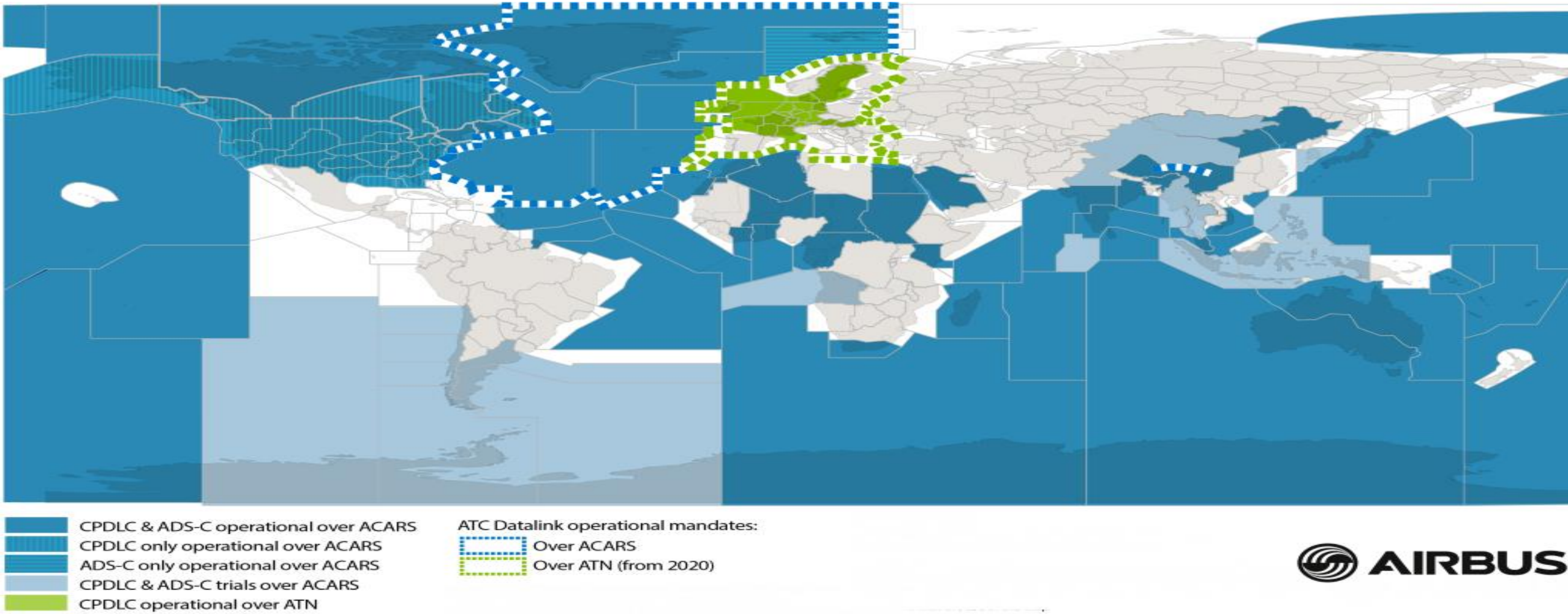
4D concept

The future…. (video)

CPDLC & ADS-C in the World



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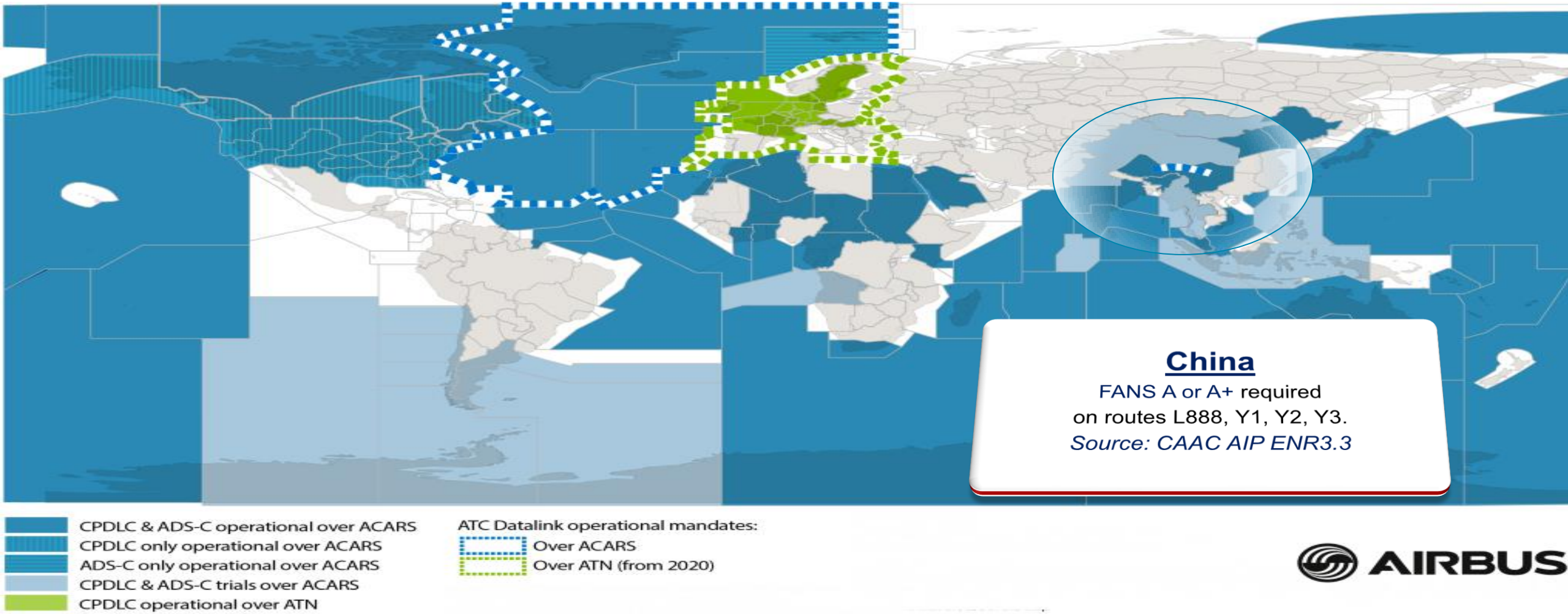
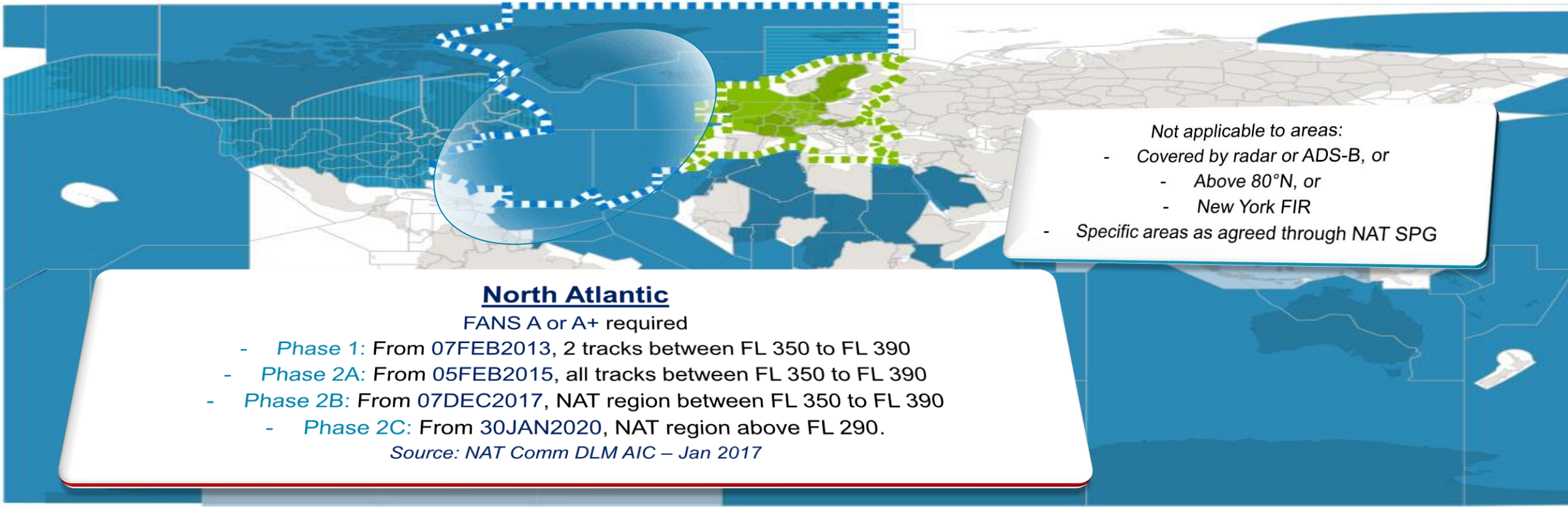
CPDLC & ADS-C in the World



CPDLC & ADS-C in the World



Not applicable to areas:
- *Covered by radar or ADS-B, or*
- *Above 80°N, or*
- *New York FIR*
- *Specific areas as agreed through NAT SPG*

North Atlantic

FANS A or A+ required

- *Phase 1:* From 07FEB2013, 2 tracks between FL 350 to FL 390
- *Phase 2A:* From 05FEB2015, all tracks between FL 350 to FL 390
- *Phase 2B:* From 07DEC2017, NAT region between FL 350 to FL 390
- *Phase 2C:* From 30JAN2020, NAT region above FL 290.

Source: NAT Comm DLM AIC – Jan 2017

CPDLC & ADS-C operational over ACARS
CPDLC only operational over ACARS
ADS-C only operational over ACARS
CPDLC & ADS-C trials over ACARS
CPDLC operational over ATN

ATC Datalink operational mandates:
Over ACARS
Over ATN (from 2020)

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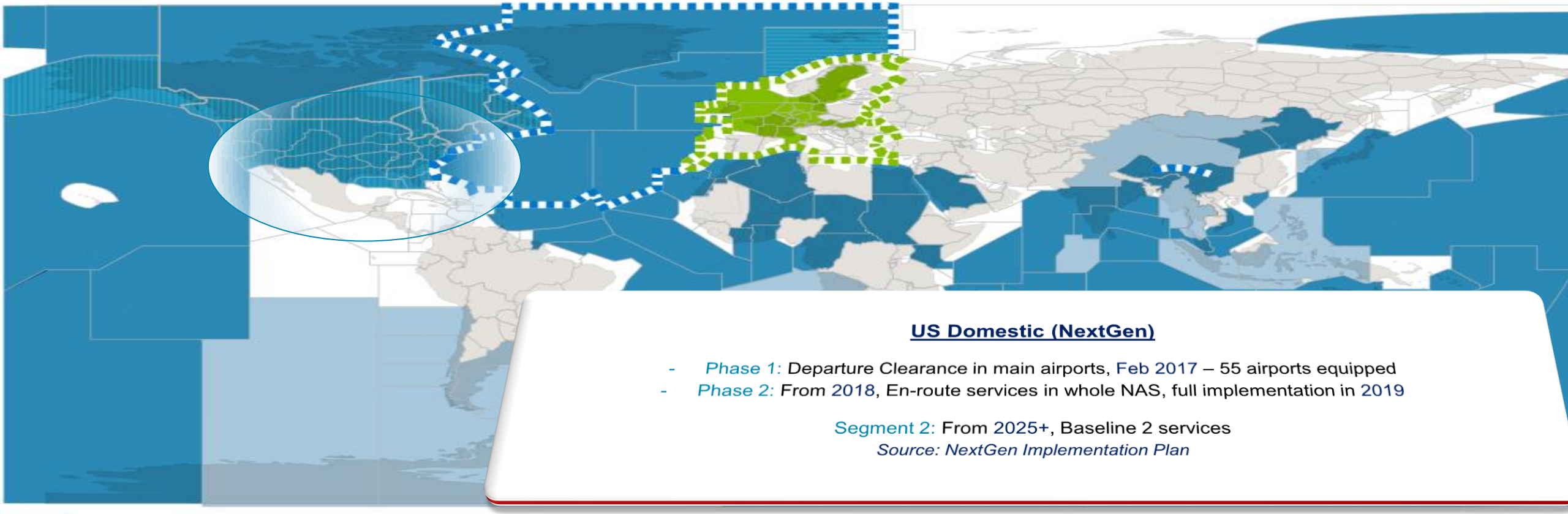
CPDLC & ADS-C in the World



US Domestic (NextGen)

- *Phase 1:* Departure Clearance in main airports, Feb 2017 – 55 airports equipped
- *Phase 2:* From 2018, En-route services in whole NAS, full implementation in 2019

Segment 2: From 2025+, Baseline 2 services

Source: NextGen Implementation Plan

CPDLC & ADS-C operational over ACARS
CPDLC only operational over ACARS
ADS-C only operational over ACARS
CPDLC & ADS-C trials over ACARS
CPDLC operational over ATN

ATC Datalink operational mandates:
Over ACARS
Over ATN (from 2020)

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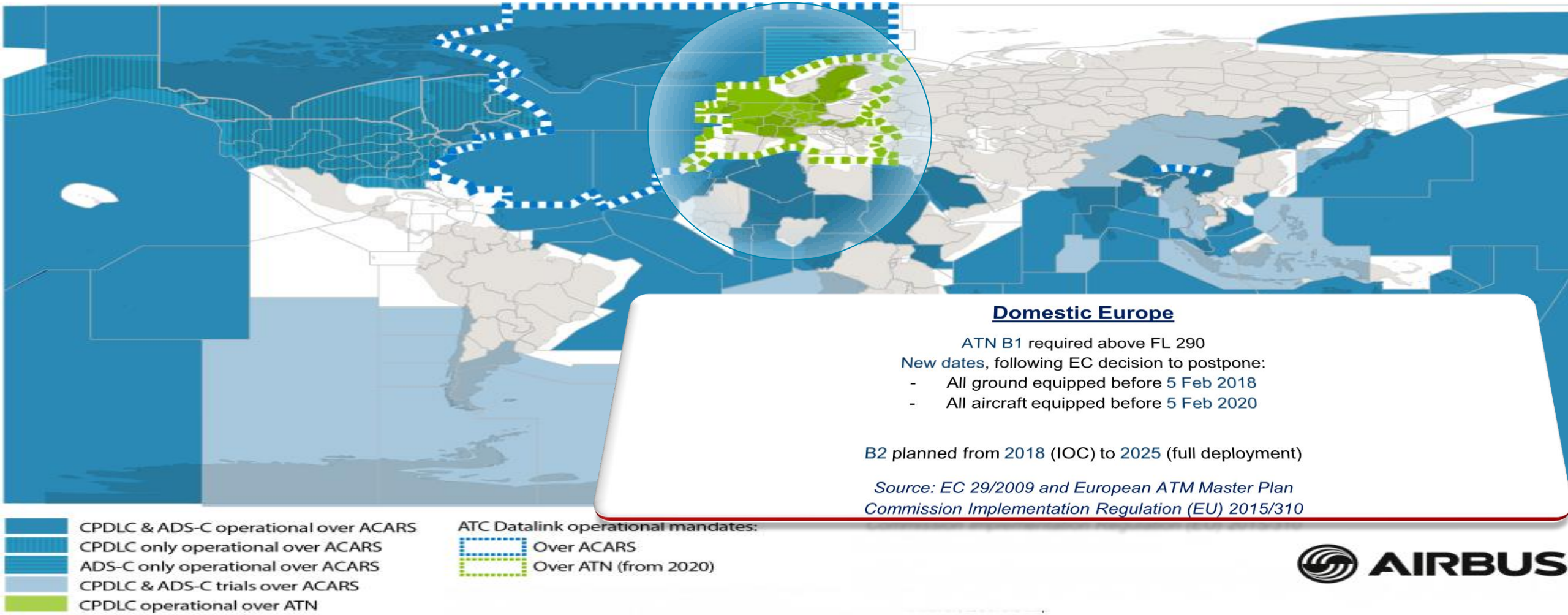
CPDLC & ADS-C in the World



Domestic Europe

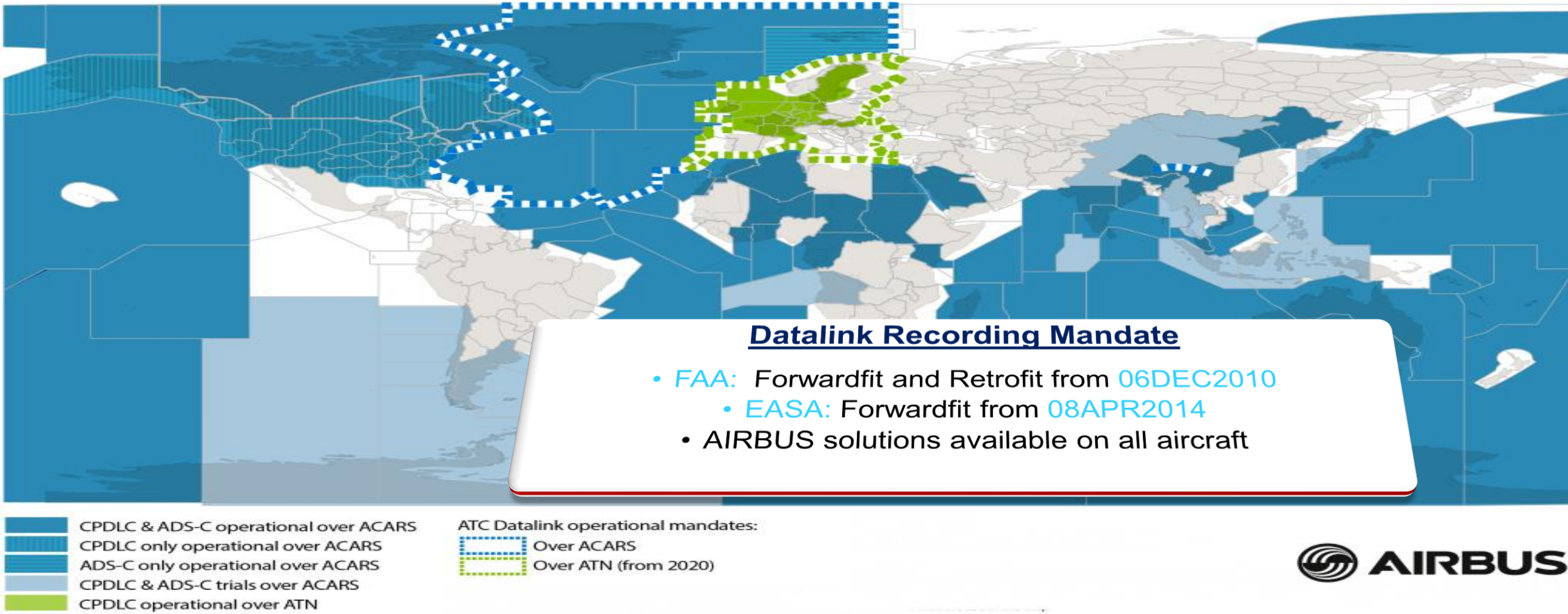
ATN B1 required above FL 290
New dates, following EC decision to postpone:
- All ground equipped before 5 Feb 2018
- All aircraft equipped before 5 Feb 2020

B2 planned from 2018 (IOC) to 2025 (full deployment)

Source: EC 29/2009 and European ATM Master Plan
Commission Implementation Regulation (EU) 2015/310

AIRBUS

CPDLC & ADS-C in the World



Thank you

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Glossary

ACARS	Aircraft Communication Addressing and Reporting System
ADS	Automatic Dependent Surveillance
ADS-B	ADS-Broadcast
AFN	ATS Facilities Notification
AMI	Airline Modifiable Information
AOC	Airline Operational Communication
ARINC	Aeronautical Radio Inc.
ARINC623	Standard for ATIS, DCL and OCL
ATC	Air Traffic Control
ATIS	Air Traffic Information Services
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
EFIS	Electronic Flight Instrument System
FANS	Future Air Navigation System
FMS	Flight Management System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HF	High Frequency
ICAO	International Civil Aviation Organization
MCDU	Multipurpose Control and Display Unit
NAT	North Atlantic
RNP	Required Navigation Performance
SATCOM	Satellite Communication