Introduction
Fly By Wire Aircraft & New Technology

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Your safety is our mission.

An agency of the European Union
Airbus cockpit

Airbus Fly-by-Wire Aircraft
Airbus cockpit

Airbus Fly-by-Wire Aircraft
Fly-by-Wire Concept

Non Fly-by-Wire Aircraft

Flight Controls characteristics

The mechanical transmission of pilot controller deflection to servo controls implies

- A large control column with large deflections
- Mechanically coupled control columns
- Autopilot back drive of control column

Handling characteristics are specific to each aircraft
Fly-by-Wire Aircraft

The relationship between the pilot input on the stick and the aircraft response is called the **control law**

- Provide similar aircraft handling characteristics
- Minimize the transition training time
- Provide efficient mixed fleet flying capability
Fly-by-Wire Concept

Fly-by-Wire Cockpit

Main operational benefits of a side-mounted stick:

- It fits **comfortably** into the hand with a properly adjusted armrest
- It is adapted for **emergency situations** such as incapacitation, stick jamming, control failures...
- It allows an **unobstructed view** of the main instrument panel
- It makes the **sliding table installation** possible for maps, meals, documents...
Fly-by-Wire Cockpit

Main operational benefits of Engine Thrust levers:

- Less weight & greater reliability
- No risk of spurious runaway
- No risk of mechanical jam or freezing
- Symmetrical engines power setting

The autothrust (A/THR) manages the engine thrust. The A/THR is either armed, active, or disconnected.
Fly-by-Wire Cockpit

Arrangement of Panels

- Cockpit Layout corresponding to pilots’ needs

Location of the main controls take into account:

- The relative **importance** of each system
- The **frequency** of operation by the pilots
- The **ease** with which controls can be reached
- The **shape** of the control
Fly-by-Wire Cockpit

- Glareshield

- Short term tactical controls for auto flight system

- Operation can be achieved ‘heads up’ and within easy reach of both pilots
Fly-by-Wire Cockpit

- **Instruments panel**

- Display units are located in the full view of both pilots.

- Display units to:
  - **fly** (PFD)...........(Primary Flight Display)
  - **navigate** (ND)...........(Navigation Display)
  - **monitor** the various aircraft systems (ECAM)
Fly-by-Wire Cockpit

Controls:

- Engine thrust
- Configuration
- Navigation
- Communication
Fly-by-Wire Cockpit • Automation

Automation assists pilots in their tasks:

• For safe and accurate aircraft operation

• For fast and complex computations

• For the enhancement of pilot awareness through data management

Pilots can always takeover
Fly-by-Wire Cockpit • Automation

3 levels of assistance are provided:

**First level:** Flight control loop

**Second level:** Autopilot loop

**Third level:** Flight management loop
Unexpected events cause an alert:

- Alerts are ranked by **severity** and **priority**
- Some alerts are **inhibited** during a given flight phase
- Alerts trigger **visual** and/or **aural** warnings
Fly-by-Wire Design

Fly-by-Wire Cockpit • Alerts

**ECAM E/WD** (Engine Warning Display)

**ECAM SD** (System Display)

Relevant push button lights
Fly-by-Wire Design

Fly-by-Wire Cockpit

- Displays color coding

<table>
<thead>
<tr>
<th>Color</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RED</td>
<td>For configurations, or failures, that require immediate action</td>
</tr>
<tr>
<td>AMBER</td>
<td>For configurations, or failures, that the flight crew should be aware of, but that do not require immediate action</td>
</tr>
<tr>
<td>GREEN</td>
<td>For information in the procedure or checklist items completed</td>
</tr>
<tr>
<td>WHITE</td>
<td>For information in the procedure or checklist items completed</td>
</tr>
</tbody>
</table>
Fly-by-Wire Cockpit

• Displays color coding

**BLUE**
For actions to be completed, limitations to be followed, checklist items to be checked

**MAGENTA**
For a specific memo (e.g. TO or LDG inhibition)

**GREY**
For an action not yet validated by the flight crew (e.g. condition items or a not-sensed procedure that are not activated)
Fly-by-Wire Cockpit

• Dark cockpit concept

No white lights

Systems are set

Ready to fly
Fly-by-Wire System

Technology Evolution on Airbus Aircraft

FANS-B

ADS-B and ATSAW

AP/FD TCAS

OANS

ROPS and RAA

FANS Future Air Navigation System
ADS Automatic Dependent Surveillance
ATSAW Airborne Traffic Situation Awareness
OANS On-board Navigation System
TCAS Traffic Collision Avoidance System
ROPS Runway Overrun Protection System
RAA Runway Approaching Advisory
ATN Air Traffic Network
ACARS A/C Communication Addressing & Reporting System
ATSU Air Traffic Service Unit

AOC Aircraft Operational Communication
ATC Air Traffic Control
FANS B

FANS Brochure is available in AirbusWorld
FANS Brochure is available in AirbusWorld
FANS Brochure is available in AirbusWorld
**ADS-B**

**Surveillance with ADS-B Mode S**

**Automatic:** no pilot action, no need of external interrogation

**Dependent:** aircraft position processed by aircraft

**Surveillance:** performing real time surrounding traffic surveillance

**Broadcast:** refresh rate 0.5 sec

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**Current surveillance ADS-A, -C Mode S**

**Interrogation** 1030 MHz

**Reply** 1090 MHz

**SSR: Secondary Surveillance Radar**

- Elementary Mode S: ELS
- Enhanced Mode S: EHS

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**ADS-B vs ADS-C**

- ADS-B hosted by Transponder, refresh rate: 0.5 sec
- ADS-C hosted by ATSU, Contract: periodic, on demand or on event

**ATSU** Air Traffic Service Unit
<table>
<thead>
<tr>
<th></th>
<th>ADS-B</th>
<th>ADS-C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission Mode</td>
<td>Broadcast</td>
<td>Point to Point</td>
</tr>
<tr>
<td>Acknowledgement</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Data-link</td>
<td>1090ES, UAT, VHF (VDL 4)</td>
<td>VHF (VDL1, 2 &amp; 4), HF, SATCOM</td>
</tr>
<tr>
<td>Periodicity</td>
<td>0.5 s</td>
<td>1 to few minutes</td>
</tr>
<tr>
<td>Air-Ground communication cost</td>
<td>No</td>
<td>Yes (SITA, ARINC)</td>
</tr>
<tr>
<td>Geographic areas</td>
<td>Continental</td>
<td>Oceanic, remote, Continental</td>
</tr>
<tr>
<td>Air-Air applications</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

1090ES  1090 MHz Extended Squitter

UAT  Universal Access Transceiver
**ADS-B**

**ADS-B IN**
A/C information received IN the aircraft

**ADS-B OUT**
A/C information broadcast OUT side the aircraft

**ATSAW**
Display of other a/c information in the cockpit

For ground use
Non Radar Airspace NRA

**ATC**
Air Traffic Control

**ATSAW Airborne Traffic Situation Awareness**
ATSAW in cockpit

Traffic Selector Switch

ADS-B Traffic on Navigation display

Additional information on MCDU

Fully integrated solution
Traffic displayed on the primary field of view
Limited impact (no new equipment)
By default

- Position
- Orientation
- Relative Altitude
- Vertical Tendency

Correlation with TCAS information

AFR6512
ATSAW Navigation Display

The aircraft is highlighted using a traffic selector switch located in the cockpit.

Default position information:
- A/C ident
- Ground Speed
- Wake Vortex category
- Traffic pages on Multipurpose Control and Display Unit (MCDU)
- Additional information during Cruise
AP/FD TCAS

Concept

- TCAS provides a V/S target to follow on the Vertical Speed Indicator (VSI) on the PFD
- The **Auto Flight System** (AFS) provides a V/S guidance through AP/FD orders

The **AP/FD TCAS** combines AFS guidance with TCAS orders to provide an automatic V/S guidance in accordance with TCAS target
Concept

- Provide a TCAS guidance through Auto-Flight System
  - **FD** guidance if **AP OFF**
  - **Automatic** maneuver if **AP ON**
    - In all cases of TCAS RAs
    - In addition to Vertical Speed Scale indications

- Design this guidance to
  - **Minimize deviation** from initial trajectory/*Avoid excessive* load factors
  - Let the aircraft in a safe configuration after Clear of Conflict
Concept

- Operate the TCAS RA with a simple procedure
  - No FCU action
  - No change of AP/FD engagement status
On A320 Family aircraft, the minimum equipment package

- TCAS interface with FMGC
- EIS2 S8.2 or EIS1 V70.1
- FMGC with FG “C13” or “I12” std
- FCU std 4
- FWC F5-D
- DFDR/FDIMU for TCAS mode recording
On A330/A340 aircraft, the minimum equipment package

- TCAS interface with FMGEC
- EIS1 V513 (A330), V112 (A340) or EIS2 L7-1
- FMGEC with new FG (availability 2015)
- FWC L12, or T3 for system ECAM failure message
- DFDR/FDIMU for TCAS mode recording
• Video #1: RA “Climb” followed by “Increase Climb” in turn and in NAV mode

• Video #2: RA “Descend” followed by ”Increase Descend” in HDG mode

• Video #3: RA “Monitor vertical Speed” in LOC and G/S
Reflection in the rain at night

Dazzling & Flash of the sun

Abundance of marking, lights & signs

External correlation
View: NAV
Range: 2 Nm

View: ARC
Range: 0.5 Nm
ROPS and RAA
Preventing Runway Overruns and Incursions: First Line of Safety = SOPs

Continuous Innovations developed by Airbus Available on most of the Airbus Fleet To Enhance Safety
ROPS

ROW = ROP

Runway end Overrun Warning
Go-around

Transition Point

Runway end Overrun Protection
Stop

The Airbus solution to prevent runway overrun during landing phases

HELPS CREW DECISION MAKING FOR GO-AROUND

WARNS THE CREW IF RUNWAY IS TOO SHORT + REQUIREMENT OF BRAKING ACTIONS
### PFD (Below 500 ft)

<table>
<thead>
<tr>
<th>Aural</th>
<th>Pilot Action (Below 500 ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Go-around decision if runway condition is not DRY</td>
</tr>
</tbody>
</table>

**IF WET: RWY TOO SHORT**

- 10
- 10

**Runway end Overrun Warning**

- Go around
- Transition Point
- 500 ft
ROPS

PFD (Below 500 ft) | Aural (Below 200 ft) | Pilot Action (Below 500 ft)
--- | --- | ---
"RWY TOO SHORT" | Go-around decision regardless of runway condition

Runway end Overrun Warning
Go around

Transition Point

500 ft
<table>
<thead>
<tr>
<th>PFD (On ground)</th>
<th>Aural (On ground)</th>
<th>Pilot Action (On ground)</th>
</tr>
</thead>
</table>
|                 | “BRAKE...MAX BRAKING
...MAX BRAKING” | Max Braking Max Reverse |
|                 | If Max Braking applied and Max Reverse not selected, "MAX REVERSE" | |
|                 | If there is still a risk of runway excursion at 80 kt | |
|                 | "KEEP MAX REVERSE" | |
RUNWAY OVERRUN WARNING

ROW-ROP

RUNWAY OVERRUN PROTECTION
Taxiing at night

Taxiing with low visibility
- Fog
- Heavy rain

Heavy traffic

Complex airport network

Taxiing during sunset/sunrise
OBJECTIVES

Improve the flight crew awareness when the aircraft approaches:

- a runway when taxiing on a taxiway
- a runway intersection, when taxiing on a runway
Preventing Runway Incursion: RAA Illustration (1/2)

60 m

7 s
ARC or ROSE NAV mode + ZOOM
✅ Evolution Technology for Safety Enhancement

✅ Optimized integration in all Airbus cockpits

End slide

Your safety is our mission.