A330
Flight deck and systems briefing for pilots

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FOR TECHNICAL DATA OR OPERATIONAL PROCEDURES, PLEASE REFER TO THE RELEVANT AIRBUS DOCUMENTATION
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11. Environmental control system
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13. Radio management and communication
1. General
A330 General

A330 general arrangement

A330-200

A330-300

Typical cabin layout

A330-200

256 seats

18 sleeperette
(62 in pitch)

42 Business
(40 in pitch)

196 Economy
(32 in pitch)

A330-300

295 seats

18 sleeperette
(62 in pitch)

49 Business
(40 in pitch)

228 Economy
(32 in pitch)

A330 fuselage cross-section

Passenger cabin

- True widebody spaciousness and adaptability

Lower cargo holds

- Large, efficient, fully compatible with existing worldwide air cargo system
**A330 General**

**Introduction**

- The medium to long-range A330 is an all-new, wide-body, twin-engine, twin-aisle aircraft.

- The design combines high technology developed for the A320 and A340 with the wide experience gained from the A300 and A310 aircraft currently in worldwide service.

As with the A319, A320, A321 and A340, it will incorporate all of the following features:
  - two-man crew operation with CRT displays
  - electrically signalled flight controls
  - sidestick controllers
  - full authority digital engine control (FADEC)
  - centralized maintenance system.

- Since its introduction in December 1993 the aircraft is the most advanced medium to long-range airliner offering a major stride forward in airline profitability.

- Certification basis includes:
  - JAR 25 at change 13
  - JAR AWO at change 1 for CAT II and CAT III and autoland.
  - ICAO annex 16 chapter 3 for noise.

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**Basic data**

<table>
<thead>
<tr>
<th></th>
<th>A330-200</th>
<th>A330-300</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MTOW</strong></td>
<td>230 000 kg</td>
<td>217 000 kg</td>
</tr>
<tr>
<td><strong>MLW</strong></td>
<td>180 000 kg</td>
<td>179 000 kg</td>
</tr>
<tr>
<td><strong>MZFW</strong></td>
<td>168 000 kg</td>
<td>169 000 kg</td>
</tr>
<tr>
<td><strong>Max fuel capacity</strong></td>
<td>139 090 lit</td>
<td>97 170 lit</td>
</tr>
<tr>
<td><strong>Max operating altitude</strong></td>
<td>41 100 ft</td>
<td>41 100 ft</td>
</tr>
<tr>
<td><strong>Powerplants</strong></td>
<td>GE CF6-80E1A4 70 000 lb</td>
<td>GE CF6-80E1A2 67 500 lb</td>
</tr>
<tr>
<td></td>
<td>RR Trent 772 71 100 lb</td>
<td>RR Trent 768 / 772 67 500 lb / 71 100 lb</td>
</tr>
<tr>
<td></td>
<td>PW 4168 68 000 lb</td>
<td>PW 4164 / 4168 64 000 lb / 68 000 lb</td>
</tr>
<tr>
<td><strong>Design speeds</strong></td>
<td>330 kt CAS/0.86</td>
<td>330 kt CAS/0.86</td>
</tr>
<tr>
<td><strong>Vmo/Mmo</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Underfloor cargo</strong></td>
<td>From 27LD3 to 3LD3 + 8 pallets + bulk 19.7 m³</td>
<td>32/33LD3/11 pallets + bulk 19.7 m³</td>
</tr>
</tbody>
</table>

* Max ramp weight 900 kg higher than MTOW
A330 General

Aircraft design specifications

1. Design weights (see page 1.3)

2. Design speeds

- $V_{MO} = 330$ kt CAS
- $M_{MO} = 0.86$
- $V_D = 365$ kt CAS
- $M_D = 0.93$
- $V_B = 260$ kt CAS
- $M_B = 0.78$
- $V_{LO}$ (landing gear extension)
- $V_{LE}$ (landing gear retraction)

3. Slat and flap design speeds

<table>
<thead>
<tr>
<th>Lever position</th>
<th>Function</th>
<th>Config. No.</th>
<th>Design speed $V_{FE}$ (CAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Climb/cruise/holding</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>Holding</td>
<td>1</td>
<td>240</td>
</tr>
<tr>
<td></td>
<td>Take-off</td>
<td>1 + F</td>
<td>215</td>
</tr>
<tr>
<td>2</td>
<td>Approach</td>
<td>1*</td>
<td>205</td>
</tr>
<tr>
<td></td>
<td>Take-off</td>
<td>2</td>
<td>196</td>
</tr>
<tr>
<td>3</td>
<td>Take-off/approach</td>
<td>3</td>
<td>186</td>
</tr>
<tr>
<td>Full</td>
<td>Landing</td>
<td>Full</td>
<td>180</td>
</tr>
</tbody>
</table>

4. Structural life (design aims)
The objectives for primary structure fatigue life are as follows based on average block time of 4 hours:
- design life goal .................................. 20000 flights
- threshold for initial inspection ............ 8750 flights

5. Landing gear
The design aim is 25000 cycles safe life operation in accordance with FAR and JAR.

6. Cabin pressure

<table>
<thead>
<tr>
<th></th>
<th>Max nominal operational differential pressure</th>
<th>574 mb ± 7 mb</th>
<th>8.33 psi ± 0.1 psi</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actuating cabin pressure of discharge valve</td>
<td>610 mb ± 7 mb</td>
<td>8.85 psi ± 0.1 psi</td>
</tr>
<tr>
<td></td>
<td>Max relief valve overpressure</td>
<td>638 mb</td>
<td>9.25 psi</td>
</tr>
<tr>
<td></td>
<td>Max negative differential pressure</td>
<td>- 70 mb</td>
<td>1.00 psi</td>
</tr>
</tbody>
</table>
### A330 General

#### Aircraft design specifications

7. **Fuel capacity**

<table>
<thead>
<tr>
<th></th>
<th>A330-200</th>
<th></th>
<th>A330-300</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Litres</td>
<td>US gallons</td>
<td>Litres</td>
<td>US gallons</td>
<td></td>
</tr>
<tr>
<td>Inner tank LH</td>
<td>42 000</td>
<td>11 095</td>
<td>41 904</td>
<td>11 070</td>
</tr>
<tr>
<td>Inner tank RH</td>
<td>42 000</td>
<td>11 095</td>
<td>41 904</td>
<td>11 070</td>
</tr>
<tr>
<td>Outer tank LH</td>
<td>3 650</td>
<td>964</td>
<td>3 624</td>
<td>957</td>
</tr>
<tr>
<td>Outer tank RH</td>
<td>3 650</td>
<td>964</td>
<td>3 624</td>
<td>957</td>
</tr>
<tr>
<td>Center tank</td>
<td>6 230</td>
<td>1 646</td>
<td>6 230</td>
<td>1 646</td>
</tr>
<tr>
<td>Trim tank</td>
<td>41 560</td>
<td>10 980</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>139 090</td>
<td>36 745</td>
<td>97 286</td>
<td>25 700</td>
</tr>
</tbody>
</table>

8. **Pavement strength**

Max ramp weight and max aft CG.

<table>
<thead>
<tr>
<th></th>
<th>A330-200</th>
<th>A330-300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat A</td>
<td>61</td>
<td>52</td>
</tr>
<tr>
<td>Cat B</td>
<td>66</td>
<td>61</td>
</tr>
<tr>
<td>Cat C</td>
<td>77</td>
<td>73</td>
</tr>
<tr>
<td>Cat D</td>
<td>105</td>
<td>85</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Flexible pavement</th>
<th>Rigid pavement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat A</td>
<td>Cat B</td>
<td>Cat C</td>
</tr>
<tr>
<td>A330-200</td>
<td>61</td>
<td>66</td>
</tr>
<tr>
<td>A330-300</td>
<td>56</td>
<td>61</td>
</tr>
</tbody>
</table>

Tyres radial - main gear 1400 mm x 530 mm x R23
- nose gear 1050 mm x 395 mm x R16
A330 General

Weight and balance

A330-200 CG limits

A330-300 CG limits

Engines:
- R-R TRENT 772
- PW4168
- GE CF6-80 E1A4

Engines:
- R-R TRENT 768
- PW4164
- GE CF6-80 E1A2
# A330 General

## Ground manœuvre capability

### Minimum turning radius

#### Towing

The A330 can be towed or pushed up to a nosewheel angle of 78° from the aircraft centre line at all weights up to maximum ramp weight without disconnecting the steering.

#### Taxiing

Minimum turning radii (with tyre slip) and minimum pavement width for 180° turn are as shown.

### A330-200

<table>
<thead>
<tr>
<th>Type of turn 1</th>
<th>Type of turn 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Effective turn angle</strong></td>
<td><strong>Effective turn angle</strong></td>
</tr>
<tr>
<td>78°</td>
<td>62.3°</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type</th>
<th>X</th>
<th>Y</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>R6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meter</td>
<td>4.72</td>
<td>34.27</td>
<td>23.24</td>
<td>36.29</td>
<td>29.26</td>
<td>32.89</td>
</tr>
<tr>
<td>Feet</td>
<td>15.47</td>
<td>112.4</td>
<td>76.26</td>
<td>119.04</td>
<td>96.07</td>
<td>107.91</td>
</tr>
</tbody>
</table>

**X** = 22.19 m / 72.8 ft

### A330-300

<table>
<thead>
<tr>
<th>Type of turn 1</th>
<th>Type of turn 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Effective turn angle</strong></td>
<td><strong>Effective turn angle</strong></td>
</tr>
<tr>
<td>77.95°</td>
<td>64.5°</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type</th>
<th>X</th>
<th>Y</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>R6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meter</td>
<td>5.342</td>
<td>38.13</td>
<td>26.49</td>
<td>36.96</td>
<td>32.37</td>
<td>34.60</td>
</tr>
<tr>
<td>Feet</td>
<td>15.53</td>
<td>125.1</td>
<td>86.9</td>
<td>120.9</td>
<td>106.2</td>
<td>113.5</td>
</tr>
</tbody>
</table>

**X** = 27.50 m / 90.23 ft

*Type of turn 1: Asymmetric thrust differential braking (pivoting on one main gear)*
*Type of turn 2: Symmetric thrust no braking*
2. Flight deck layout
General provisions

- As the A330 is a medium long-range aircraft the cockpit offers full provision for a 3rd occupant seat as well as a folding 4th occupant seat.
A330 flight deck layout

Forward view

- Overhead outlet
- Assist handle
- Ceiling light
- Sliding tables
- FO boomset stowage
- FO boomset jack panel
- Reading light
- Window control handle
- Loudspeakers
- Nose wheel steering CTL
- Checklist stowage
- Oxygen mask
- Air conditioning outlet
- Waste bin
- Flight documents stowage
- Checklist stowage
- Flash light
- Window outlets
- Normal checklist storage
- Briefcase stowage

Escape rope stowage

Sidestick

Hand microphone

Ashtray

Roller sunblind

Oxygen mask

Waste bin

Flight documents stowage

Checklist stowage

Window outlets

Normal checklist storage

Briefcase stowage
A330 flight deck layout

Rear view: right aft corner

Rear view: left aft corner
A330 flight deck layout

Pilots’ field of vision

Visibility

• Windows are designed to meet or exceed the Aerospace standard.

• Geometry:
  - windshield panels: flat glass
  - lateral windows: curved acrylic.

Pilots’ vision envelope
Pilots’ field of vision

Pilot's eye position

Max. aft vision with head rotated about spinal column

With head moved 5 inches outboard

Pilots' field of vision

111°

135°

115°

135°
A330 flight deck layout

Pilots’ field of vision - landing configuration CAT II DH = 100 ft

- This geometry improves external aircraft monitoring, thereby increasing safety standards.
- Downward visibility in the pilot axis is 20°.
- Wing tips are visible from respective pilot stations.

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>θ</th>
<th>A</th>
<th>V</th>
<th>0</th>
<th>RVR</th>
<th>SVR</th>
</tr>
</thead>
<tbody>
<tr>
<td>A330-200 m (ft)</td>
<td>5°</td>
<td>39.7</td>
<td>120</td>
<td>150</td>
<td>270</td>
<td>273</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(132)</td>
<td>(394)</td>
<td>(493)</td>
<td>(887)</td>
<td>(897)</td>
</tr>
<tr>
<td>A330-300 m (ft)</td>
<td>2.1°</td>
<td>38.2</td>
<td>120</td>
<td>120</td>
<td>240</td>
<td>243</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(127)</td>
<td>(394)</td>
<td>(394)</td>
<td>(788)</td>
<td>(798)</td>
</tr>
</tbody>
</table>

Diagram showing pilot’s field of vision with SVR, RVR, and cockpit cut-off angle.
A330 flight deck layout

Control and indication panels (shaded)
Main features

• The main features are common with those developed for the A320 and A340 families:
  - sidestick controllers which leave the main instrument panel unobstructed
  - six display units (DU) interchangeable, switchable and integrated into the same system architecture (EFIS/ECAM).

• The other features evolve directly from the concepts introduced with the A300/A310 family:
  - ergonomic layout of panels, synoptically arranged according to frequency of use (normal, abnormal, emergency) within easy reach and visibility for both crew members
  - philosophy of panels (e.g., “lights out” philosophy for overhead panel)
  - principles of presentation of information (“need to know” concept)
  - monitoring of systems through an Electronic Centralized Aircraft Monitor (ECAM)
  - coherent system of colour coding for EFIS, ECAM and panel lights.
A330 flight deck layout

Sidestick arrangement

- Sidesicks are installed on the Captain’s and First Officer’s forward lateral consoles.

- A dual pivot adjustable armrest behind each sidestick to facilitate control is fitted on each seat, with position indicators.

The handgrip includes two switches:
- A/P disconnect/sidestick priority push-button
- Push-to-talk button

Position indicator
Pitch adjustment

Neutral
Radio
Take-over PB
(A/P disconnection or take-over from opposite sidestick)
A330 flight deck layout

Sidestick operation

• Moving the sidestick results in “setting the aircraft trajectory” with a certain level of “g” for the requested manoeuvre depending on the amount of sidestick movement.

• Accuracy of movements is very precise since backlash and friction are negligible.

• Control of the flight path is performed by the Electronic Flight Control System (EFCS) which links the trajectory order with aerodynamic data to stabilize the aircraft and protect it from prohibited attitudes.
A330 flight deck layout

Main instrument panels
Captain and First Officer panels

• The CAPT and F/O panels are mirror images of each other:
  both incorporate two side-by-side Display Units (DUs) (7.25 in x 7.25 in):
  • a Primary Flight Display (PFD)
  • a Navigation Display (ND).

• This arrangement provides:
  - better visibility on all DUs in normal configuration and in case of reconfiguration (PFD ND or ECAM ND)
  - the option to install a sliding table and a footrest in front of each pilot.

• The PFD includes the complete Basic T with:
  - attitude
  - airspeed/Mach (with all upper and lower limits)
  - altitude/vertical speed
  - heading
  - AFS status
  - ILS deviation/marker
  - radio altitude.

• The ROSE mode (ILS, VOR or NAV): aircraft symbol in screen centre, with radar availability
  - ARC mode: heading up, horizon limited to a 90° forward sector, with radar availability
  - PLAN mode: north up, display centered on selected waypoint.

• Engine display: in case of a total DMC/ECAM failure, each pilot may display the ENG STBY page on his ND.

Note: In ROSE-NAV, ARC, and PLAN modes, MAP data from FMS is presented.
A330 flight deck layout

E/WD
ENGINE / WARNING DISPLAY
- ENGINE PRIMARY INDICATIONS
- FLAP / SLAT POSITION
- WARNING & CAUTION MESSAGES

SD
SYSTEM DISPLAY
- SYSTEM SYNOPTIC
- STATUS
- PERMANENT DATA

LIMIT SPEED PLACARD
LDG GEAR
UNLK
AUTO / BRK
LO METE
DECEL
DECEL
DECEL
ON
ON
OFF

ECAM SWITCHING
ECAM ND/NORM
OAPF/F1 OAPF/F2

EGPWS
NORTH REF

DCDU

REGISTRATION SELCAL CODE

STL 472.755/92 Issue 4 2.14
Main centre panel

The centre panel groups:

- two DUs, one above the other, which are interchangeable with the CAPT and F/O DUs:

  • **Engine Display** (DU 1), showing:
    - the main engine parameters (N1, EGT, N2 for GE engines;
      EPR, EGT, N1, N2 for PW engines; (EPR, TGT, N1, N3 for RR engines)
    - N1 (EPR) limit, N1 (EPR) command
    - total fuel
    - the flaps and slats position
    - memo and warning

  • **System Display** (DU 2) showing:
    - an aircraft system synoptic diagrams page
    - or the aircraft status (list of all operationally significant items)

- standby instruments
- landing gear control and indications (including brakes)
- clock.
Glareshield

• The Flight Control Unit (FCU) provides short-term interface between the Flight Management and Guidance Computer (FMGC) and crew for:
  - engagement of A/P, A/THR
  - selection of required guidance modes
  - manual selection of flight parameters SPD, MACH, ALT, V/SPD, HDG or track.

• The EFIS control panels for:
  - selection of desired ND modes (ROSE-ILS, -VOR, -NAV, ARC, PLAN, ENG) and ranges
  - selection of baro settings.
• The master warning, master caution, autoland and sidestick priority lights.
A330 flight deck layout

Central pedestal

In addition to the thrust levers and the engine control functions, the main features on the pedestal are:

- the Multipurpose Control and Display Units (MCDU) for flight management functions and various other functions such as data link, maintenance, etc.

- the Radio Management Panels (RMP) for tuning all radio communications and the radio navigation as a back-up to the normal operation through the Flight Management and Guidance Computers (FMGC).

- the electrical rudder trim

- the parking brake control

- the speedbrake and flap control levers.
A330 flight deck layout

Overhead panel

• The overhead panel has a “single slope”.

• All controls on the overhead panel can be reached by either pilot.

• Two main zones are separated by protective padding.
  
  - **Forward zone:**
    - for most frequently used functions
    - for system controls: arranged in three main rows:
      - centre row for engine-related systems arranged in a logical way
      - lateral rows for other systems.

  - **Aft zone,** not used in flight, mainly for a small maintenance panel corresponding to some maintenance controls.

• The push-button philosophy is identical to that already applied on existing Airbus aircraft.
3. Electrical system
A330 electrical system

Electrical power generation

The electrical power generation comprises:

- Two engine-driven AC generators, nominal power 115 kVA
- One auxiliary power unit (APU) AC generator nominal 115 kVA
- One emergency generator (Constant Speed Motor /Generator or CSM/G), nominal power 8.6 kVA, hydraulically driven by the Green system.
- One static inverter fed by two batteries and working either on the ground or when CSM/G inoperative.
- Two ground connectors, power 90 kVA
- DC network supplied via two main Transformer Rectifier Units (200 A) and one essential (100 A).

A fourth TR (100 A) is dedicated to APU start or APU battery charging.

- Three batteries nominal capacity 37 Ah, 28 V each:
  - Two batteries used:
    - in emergency configuration to feed some equipment during RAT deployment or when CSM/G not operating.
    - On ground to provide an autonomous source.
  - One dedicated to APU start
A330 electrical system

Distribution - normal configuration

AC distribution network

• In normal configuration, each engine-driven generator supplies its associated AC BUS.

• The AC ESS BUS is normally supplied from AC BUS 1.

DC distribution network

• In normal configuration, normal DC systems are split into two networks: DC BUS 1 in parallel with DC BAT BUS and DC BUS 2.

• Each DC network is supplied by its own TR.

• More specifically, ESS TR systematically feeds DC ESS BUS, which allows a better segregation between DC 1 and DC 2.

• Two batteries are connected to the DC BAT BUS via the Battery Charge Limiter (BCL).

• Each battery has its own HOT BUS bar (engine/APU fire squib, ADIRS, CIDS, PRIM and SEC computers, slide warnings, parking brake, etc).

• The third battery is dedicated to APU starting.
A330 electrical system

Distribution - abnormal configurations

Generator failure
- If one generator fails, another will automatically take over:
  • If APU operative, APU generator will take over
  • If APU generator not available, the other engine generator will take over.
- In case of total loss of all main generators:
  • The EMER GEN will deliver 8.6 kVA since the Green hydraulic system is still powered by engine-driven pumps

or

- In case of loss of all engines:
  • The EMER GEN will deliver 3.5 kVA since the Green hydraulic system is then powered by the RAT; in this case the batteries take over when slats are extended.

TR failure
- If one TR fails, the other will automatically take over its corresponding DC network via DC BAT BUS,
- In case of double TR failure:
  • TR 1 and 2: DC BUS 1 and DC BUS 2 are lost
  • TR 1 (or 2) and ESS TR: The remaining TR supplies DC BUS 1 + 2 and DC BAT BUS; the DC ESS BUS is lost.
A330 electrical system

Control and display

Overhead panel

ECAM

STL 472.755/92 Issue 4 3.5
A330 electrical system

Circuit - breaker monitoring

- Circuit-breakers are installed in the avionics bay area below the cockpit.
- Circuit-breakers are monitored by the CBMU (Circuit-Breaker Monitoring Units) which output the identification and status of each circuit-breaker.
- A specific C/B page is provided on the ECAM.
- Computer resets can be performed via system controls.
4. Hydraulic system
A330 hydraulic system

Architecture

* PW and RR engines only
A330 hydraulic system

General

• Three fully independent systems: Green, Blue, Yellow (nominal pressure at 3000 psi).

• Normal operation:
  - four engine-driven pumps, two of which are for the Green system
  - three electrical pumps that can act automatically as backup

They are managed by the HSMU (Hydraulic System Monitoring Unit) which ensures all autofunctions (electrical pumps, RAT, monitoring, etc); manual override is available on the overhead panel.

- one handpump on the Yellow system for cargo doors operation when no electrical power is available.

• Abnormal operation:
  - in the event of one engine failure, the Green electrical pump runs automatically for 25 seconds when landing gear lever is selected up.
  - in the event of engine 2 failure, the Yellow electrical pump runs automatically when flaps are not retracted.
  - In the event of both engine failure, RAT deployment will be automatically controlled by the HSMU to pressurize the Green system.
5. Flight controls
Electronic Flight Control System (EFCS)

Surfaces:
• all hydraulically activated
• all electrically controlled
• mechanical back-up control:
  - rudder
  - Trimmable Horizontal Stabilizer
A330 flight controls - EFCS

General

The A330 fly-by-wire system is being designed to make this new aircraft more cost effective, safer and more pleasant to fly, and more comfortable to travel in than conventional aircraft.

Basic principles

• A330 flight control surfaces are all:
  - electrically controlled
  - hydraulically activated

• Stabilizer and rudder can be mechanically controlled.

• Sidesticks are used to fly the aircraft in pitch and roll (and indirectly through turn coordination, in yaw).

• Pilot inputs are interpreted by the EFCS computers for moving the flying controls as necessary to achieve the desired pilot commands.

• Regardless of pilot inputs, the computers will prevent:
  - excessive manoeuvres
  - exceedance of the safe flight envelope.
Computers

Electrical control of the main surfaces is achieved by two types of computers:

- three flight control primary computers (PRIM) which can process all three types of control laws (Normal, Alternate, Direct)

- two flight control secondary computers (SEC) which can process the Direct Control Law.

These computers perform additional functions including:

- speedbrakes and ground spoiler command
- characteristic speed computation (PRIM only).

High-lift devices are commanded by two Slat/Flap Control Computers (SFCC).

The SFCCs also command the aileron droop via the primary or secondary computers.

In order to provide all required monitoring information to the crew and to the Central Maintenance System (CMS), two Flight Control Data Concentrators (FCDC) acquire the outputs from the various computers to be sent to the ECAM and Flight Data Interface Unit (FDIU). These two FCDCs ensure the electrical isolation of the flight control computers from the other systems.
## Power sources

### Electrical power supply
The flight control computers (primary, secondary and Flight Control Data Concentrator) are fed by various DC busbars. This ensures that at least two flight control computers are powered in the event of major electrical power losses such as
- failure of two main systems or
- electrical emergency configuration (CSM-G) or
- battery-only supply.

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>Emergency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AC</td>
<td>DC</td>
</tr>
<tr>
<td>Primary 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary 2</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Primary 3</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Secondary 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FCDC 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FCDC 2</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
Power sources

Hydraulic power supply

Three hydraulic circuits (Green, Yellow, Blue) power the flight controls.

<table>
<thead>
<tr>
<th>System circuit</th>
<th>Power source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>2 engine (N° 1 and 2) - driven pumps</td>
</tr>
<tr>
<td></td>
<td>1 electropump</td>
</tr>
<tr>
<td></td>
<td>1 RAT</td>
</tr>
<tr>
<td>Yellow</td>
<td>1 engine (N° 2) - driven pump</td>
</tr>
<tr>
<td></td>
<td>1 electropump</td>
</tr>
<tr>
<td>Blue</td>
<td>1 engine (N° 1) - driven pump</td>
</tr>
<tr>
<td></td>
<td>1 electropump</td>
</tr>
</tbody>
</table>

The distribution to the various control surfaces is designed to cover multiple failure cases.
Safety objectives

Safeguards were designed for protection against:

Loss of pitch control - extremely improbable ($<10^{-9}$)
Loss of elevators - extremely remote ($< 10^{-7}$)

Loss of roll control - extremely improbable
Permanent loss of THS - extremely improbable
Rudder loss or runaway - extremely improbable

In order to satisfy these objectives, the following architecture applies:

- electrical signalling for spoilers, elevators and ailerons
- electrical and mechanical signalling in parallel for rudder and THS.
Dispatch objectives

The basic objective is to allow dispatch of the aircraft with at least one peripheral or computer failed in order to increase the dispatch reliability without impairing flight safety.

<table>
<thead>
<tr>
<th>Systems</th>
<th>Dispatch situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 IRS</td>
<td>Maximum 1 inoperative or “off”</td>
</tr>
<tr>
<td>2 yaw rate gyros</td>
<td>Maximum 1 inoperative or “off”</td>
</tr>
<tr>
<td>3 PRIM</td>
<td>Maximum 1 inoperative or “off”</td>
</tr>
<tr>
<td>2 SEC</td>
<td>Maximum 1 inoperative or “off”</td>
</tr>
<tr>
<td>3 ADR</td>
<td>Maximum 1 inoperative or “off”</td>
</tr>
<tr>
<td>3 IR - 2 N\textsubscript{2} accelerometers</td>
<td>Maximum 1 inoperative or “off”</td>
</tr>
<tr>
<td>2 FCDC</td>
<td>Maximum 1 inoperative or “off”</td>
</tr>
<tr>
<td>3 PRIM/2 SEC Electro hydraulic and electro actuators</td>
<td>Maximum 1 inoperative or “off” maximum 1 inoperative if it is not connected to 2 computers No-go items are inboard aileron, elevator and yaw damper actuators.</td>
</tr>
</tbody>
</table>
Design principles

Two types of flight control computers:

• **PRIM** (two channels with different software for control/monitoring).
  - **SEC** (two channels with different software for control/monitoring).

Each one of these computers can perform two tasks:

- process orders to be sent to other computers as a function of various inputs (sidestick, autopilot…)
- execute orders received from other computers so as to control their own servo-loop.

The three primary or main computers (PRIM):

- process all control laws (Normal, Alternate, Direct) as the flight control orders.

  One of the three PRIM is selected to be the master; it processes the orders and outputs them to the other computers PRIM 1, 2 and 3, SEC 1 and 2) which will then execute them on their related servo-loop.

  The master checks that its orders are fulfilled by comparing them with feedback received; this allows self-monitoring of the master which can detect a malfunction and cascade control to the next computer.

  Each PRIM is able to control up to eight servo-loops simultaneously; each can provide complete aircraft control under normal laws.

The two secondary computers (SEC):

- are able to process direct laws only
- either SEC can be the master in case of loss of all primary computers
- each SEC can control up to 10 servo-loops simultaneously; each can provide complete aircraft control.

Electrically controlled hydraulic servo-jacks can operate in one of three control modes depending upon computer status and type of control surface:

- **Active**: the servo-jack position is electrically controlled
- **Damping**: the servo-jack position follows the surface movement
- **Centering**: the servo-jack position is maintained neutral.
A330 flight controls - EFCS

Schematic diagram
Pitch control

A330 flight controls - EFCS

Mechanical trim

Autopilot commands

Sidestick commands

PRIM (1)

Norm

3 Prim fail

SEC (1)

Norm

Prim 1+2 fail

Auto trim

Electrical motors

Hydraulic motors

L. elev

R. elev

THS
Pitch control

Pitch control is provided by two elevators and the THS:
- elevator deflections 30° nose up - 15° nose down
- THS deflections 14° nose up - 2° nose down.

Each elevator is actuated by two independent hydraulic servo control units;
L ELEV is driven by Green and Blue hydraulic jacks
R ELEV is driven by Green and Yellow hydraulic jacks
one servo control is in active mode while the other is in damping mode.

In case of a failure on the active servo-jack, it reverts to damping mode while the other becomes active.

In case of electrical supply failure to both servo-jacks of one elevator, these revert to centering mode which commands a 0° position of the related elevator.

Autoflight orders are processed by one of the primary computers.

Sidestick signals, in manual flight, are processed by either one of PRIM 1 and 2 or SEC 1 and 2

The THS is driven by two hydraulic motors supplied by Blue and Yellow systems; these motors are controlled:
- either of the three electrical motors with their associated electronics controlled by one primary computer each
- or by mechanical command from control wheels located on the central pedestal.

The control wheels are used in case of major failure (Direct Law or mechanical back-up) and have priority over any other command.
A330 flight controls - EFCS

Roll control

- Autopilot commands
- Sidestick commands

PRIM (1) (2) (3)
- NORM
- SPLRS 2, 4, 5
- 3 PRIM FAIL

SEC (1) (2)
- SPLRS 3, 6

Ailerons hyd jacks
Spoilers

1 2 3 4 5 6
Roll control

Roll control is provided two ailerons and five spoilers (2 to 6) per wing:
- aileron deflection is ± 25°
- spoiler max deflection is -35°. Deflection is reduced in CONF 2 and 3.

Each aileron is driven by two electrically signalled servo-controls which are connected to:
- two computers for the inboard ailerons (PRIM 1 or 2 and SEC 1 or 2)
- one computer for the outboard ailerons (PRIM 3, SEC 1 or 2)
- one servo-control is in active mode while the other is in damping mode.

In manual mode, above 190 kt the outboard ailerons are centered to prevent any twisting moment.

In AP mode or in certain failure cases the outboard ailerons are used up to 300 Kt. Each spoiler is driven by one electro-hydraulic servo-control which is connected to one specific computer.

In the event of a failure being detected on one spoiler, the opposite spoiler is retracted and maintained in a retracted position.

Autopilot orders are processed by one of the primary computers.

Sidestick signals, in manual flight, are processed by either one of the primary or secondary computers.

Note: If the RAT is deployed to provide Green hydraulic power, the outboard ailerons servo-controls revert to damping mode in order to minimize hydraulic demands.
Yaw control

- NWS ORDER
- TRAVEL LIMITER
- HYDRAULIC JACKS
- RUDDER
- MECHANICAL MIXER

Diagram showing the yaw control system with electrical and mechanical links.
**Yaw control**

Yaw control is provided by one rudder surface:
- rudder deflection ± 31.6°.

The rudder is operated by three independent hydraulic servo-controls, with a common mechanical input. This mechanical input receives three commands:
- rudder pedal input
- rudder trim actuator electrical input
- yaw damper electrical input.

The mechanical input is limited by the Travel Limitation Unit (TLU) as a function of airspeed in order to avoid excessive load transmission to the aircraft. This function is achieved by the secondary computers.

The rudder trim controls the rudder pedal zero load position as a function of pilot manual command on a switch located on the pedestal (artificial feel neutral variation). This function is achieved by the secondary computers.

Yaw damper commands are computed by the primary or secondary computers.

In case of total loss of electrical power or total loss of flight controls computers the back up yaw damper unit (BYDU) becomes active for yaw damping function.

Autoflight orders are processed by the primary computers and are transmitted to the rudder via the yaw damper servo-actuator and the rudder trim actuator.

Note: in the event of loss of both yaw damper actuators the yaw damping function is achieved through roll control surfaces, in which case at least one spoiler pair is required.
Left intentionally blank
A330 flight controls - EFCS

Additional functions devoted to aileron and spoilers

Ailerons
Ailerons receive commands for the following additional functions:

• **manoeuvre load alleviation**: two pairs of ailerons are deflected upwards - 11° max to reduce wing loads in case of high “g” manoeuvre

• **lift augmentation** (aileron droop): two pairs of ailerons are deflected downwards to increase lift when flaps are extended.

Spoilers
Spoilers receive commands for the following additional functions:

• **manoeuvre load alleviation**: spoilers 4, 5 and 6

• **Ground spoiler functions**: spoilers 1 to 6
  • - 35° max for spoiler 1,
  • - 50° max for spoilers 2 to 6

• **Speedbrake functions**: spoilers 1 to 6
  • - 25° max for spoiler 1
  • - 30° max for spoilers 2 to 6

Six spoilers and two pairs of ailerons perform these functions in following priority order:

• the roll demand has priority over the speedbrake function

• the lift augmenting function has priority over the speedbrake function

• if one spoiler surface fails to extend, the symmetrical surface on the other wing is inhibited.
A330 flight controls - EFCS

Slats/flaps controls
Slats/flaps

- High lift control is achieved on each wing by:
  - seven leading edge slats
  - two trailing edge flaps
  - two ailerons (ailerons droop function)

- Slat and flaps are driven through similar hydromechanical systems consisting of:
  - Power Control Units (PCU)
  - differential gearboxes and transverse torque shafts
  - rotary actuators.

- Slats and flaps are electrically signalled through the SFCCs:
  - control lever position is obtained from the Command Sensor Unit (CSU) by the two SFCCs
  - each SFCC controls one hydraulic motor in both of the flap and slat PCUs.

- Aileron droop is achieved through the primary computers, depending on flap position data received from the SFCC.

- The SFCC monitors the slats and flaps drive system through feed-back Position Pick-off Units (FPPU) located at the PCUs and at the outer end of the transmission torque shafts.

- Wing Tip Brakes (WTB) installed within the torque shaft system, controlled by the SFCC, prevent asymmetric operation, blow back or runaway.

- A pressure-off brake provided between each hydraulic motor of the PCU and the differential gearboxes, locks the slat or flap position when there is no drive command from the SFCC.

- Flight Warning Computers (FWC) receive slat and flap position data through dedicated instrumentation Position Pick-off Units (IPPU) for warnings and position indication on ECAM display units.
Controls and displays

- **Overhead panel**
  Pushbutton switches on the overhead panel allow disconnection or reset of the primary and secondary computers. They provide local warnings. Side 1 computer switches on left-hand side are separated from those of side 2 computers on right-hand side.

- **Glareshield**
  Captain and First Officer priority lights, located in the glareshield, provide indication if either has taken the priority for his sidestick orders.

- **Lateral consoles**
  Captain and First Officer sidesticks, located on the lateral consoles, provide the flight controls computers with pitch and roll orders. They are not mechanically coupled. They incorporate a take-over pushbutton switch.

- **Central pedestal**
  - Speedbrake control lever position is processed by the primary computers for speedbrake control. A “ground spoiler” position commands ground deceleration (spoilers and ailerons).
  - Rudder trim switch and reset pushbutton switch are processed by the secondary computers. The local rudder trim position indication is repeated on the ECAM FLT/CTL system page.
  - Flap control lever position is processed by the SFCC. It allows selection of high-lift configurations for slats and flaps. Lever position indication is repeated in the “flap section” of the ECAM engine and warning display.
  - Pitch trim wheels allow the setting of the THS position for take-off. They permit manual pitch trim control.

- **Main instrument panel**
  ECAM display units and PFDs present warnings and status information on the Flight control system. Permanent indication of slat and flap positions are given on the ECAM engine/warning display. Remaining flight control surface positions are given on the FLT/CTL system page which is presented on the ECAM system/status display.

- **Rudder pedals**
  Interconnected pedals on each crew member’s side allow mechanical yaw control through the rudder.
A330 flight controls - EFCS

ECAM system page

Diagram of flight control system with labels and indicators.
Control law introduction

- **Flight through computers**
  Depending upon the EFCS status, the control law is:
  - **Normal Law** (normal conditions even after single failure of sensors, electrical system, hydraulic system or flight control computer).

According to number and nature of subsequent failures, it automatically reverts to:
- Alternate Law, or
- Direct Law.

- **Mechanical back-up**
  During a complete loss of electrical power the aircraft is controlled by:
  - longitudinal control through trim wheel
  - lateral control from pedals.

Overall Normal LAW schematic
Normal Law - flight mode

Basic principle

- No direct relationship between sidestick and control surface deflection.
- The sidestick serve to provide overall command objectives in all three axes.
- Computers command surface deflections to achieve Normal Law objectives (if compatible with protections).

• Highlights
Normal Law - flight mode

Objectives

• Pitch axis:

Sidestick deflection results in a change of vertical load factor.
The normal law elaborates elevator and THS orders so that:
- a stick movement leads to a flight path variation
- when stick is released, flight path is maintained without any pilot action, the aircraft being automatically trimmed.

• Lateral axis: Sidestick deflection results in initiating roll rate.

Roll rate demand is converted into a bank angle demand.
The Normal Law signals roll and yaw surfaces to achieve bank angle demand and maintain it - if less than 33° - when the stick is released.

Pedal deflection results in sideslip and bank angle (with a given relationship).

Pedal input - stick free - results in stabilized sideslip and bank angle (facilitates de-crabbing in crosswind).

• Adaptation of objectives to:

- Ground phase: ground mode
  . Direct relationship between stick and elevator available before lift-off and after touch-down.
  . Direct relationship between stick and roll control surfaces.
  . Rudder: mechanical from pedals + yaw damper function.
  . For smooth transition, blend of ground phase law and load factor (Nz) command law at take off.

- Flight phase: flight mode
  The pitch normal law flight mode is a load factor demand law with auto trim and full flight envelope protection. The roll normal law provides combined control of the ailerons, spoilers 2 to 6 and rudder.

- Landing phase: flare mode
  . To allow conventional flare.
  . Stick input commands a pitch attitude increment to a reference pitch attitude adjusted as a function of radio altitude to provide artificial ground effect.
Normal Law - flight mode

Engine failure or aircraft asymmetry

- By virtue of fly-by-wire controls and associated laws, handling characteristics are unique in the engine failure case:
  - with no corrective action:
    - stabilized sideslip and bank angle
    - slowly diverging heading
    - safe flight
  - short-term recommended action:
    - zero sideslip or sideslip target (take-off) with pedals
    - then stabilize heading with stick input
    - steady flight with stick free and no pedal force (rudder trim).

No corrective action

- This feature is made possible since roll controls can be fully deflected with sidestick neutral.

Corrective action

The optimal pilot rudder application results in optimum climb performance.
A330 flight controls - EFCS

Normal Law - flight mode

Main operational aspects and benefits

- Automatic pitch trim
- Automatic elevator to compensate turns up to 33° bank
- Aircraft response almost unaffected by speed, weight or center of gravity location
- Bank angle resistance to disturbance stick free
- Precise piloting
- Turn coordination
- Dutch roll damping
- Sideslip minimization
- Passenger comfort
- Reduced pilot, workload
- Increased safety

Normal Law - protections

- Protection does not mean limitation of pilot authority. Full pilot authority prevails within the normal flight envelope.
- Whatever the sidestick deflection is, computers have scheduled protections which overcome pilot inputs to prevent:
  - excessive load factors (no structural overstressing)
  - significant flight envelope exceedances:
    - speed overshoot above operational limits
    - stall
    - extreme pitch attitude
    - extreme bank angle.

Load factor protection

- Design aim
  To minimize the probability of hazardous events when high manoeuvrability is needed.

- Load factor limitation at:
  + 2.5 g, -1 g for clean configuration
  + 2 g, 0 g when slats are extended.

  Rapid pull-up to 2.5 g is immediately possible.
High speed protection

- **Design aims**
  To protect the aircraft against speed overshoot above $V_{MO}/M_{MO}$.
  Non-interference with flight at $V_{MO}/M_{MO}$.

- **Principle**
  When speed or Mach number is exceeded ($V_{MO} + 6 \text{ kt}/M_{MO} + 0.01$):
  - automatic, progressive, up elevator is applied (0.1 g max)
  - pilot nose-down authority is reduced.

- **Results**
  Maximum stabilized speed, nosed-down stick:
  $V_{MO} + 15 \text{ kt}$
  $M_{MO} + 0.04$

---

High angle-of-attack protection

- **Design aims**
  - Protection against stall
  - Ability to reach and hold a high CL (sidestick fully back), without exceeding stall angle (typically 3°/5° below stall angle): good roll manoeuvrability and innocuous flight characteristics.
  - Elimination of risk of stall in high dynamic manoeuvres or gusts.
  - Non-interference with normal operating speeds and manoeuvres.
  - Load factor limitation maintained.
  - Bank angle limited.
  - Available from lift-off to landing.

- **Windshear protection**
  Windshear protection is ensured by
  - SRS mode
  - speed trend indication
  - wind indication (speed and direction)
  - flight path vector
  - Windshear warning
  - predictive windshear function of weather radar (optional).
**High angle-of-attack protection**

- **Principle**
  When the AOA*) is greater than AOA prot, the basic objective defined by sidestick input reverts from vertical load factor to AOA demand.

- **Result**
  - AOA protection is maintained if sidestick is left neutral.
  - AOA floor results in GA power with an ensuing reduction of AOA.
  - AOA max is maintained if sidestick is deflected fully aft.

  Return to normal basic objective is achieved if the sidestick is pushed forward.

---

**Pitch attitude protection**

- **Design aim**
  To enhance the effectiveness of AOA and high-speed protection in extreme conditions and in windshear encounter.

- **Principle**
  Pilot authority is reduced at extreme attitude.

- **Result**
  Pitch attitude limited:
  - nose-down 15°
  - nose-up 30°, to 25° at low speed

---

**Bank angle protection**

- When stick is released above 33° the aircraft automatically rolls back to 33°.
- If stick is maintained, bank angle greater than 33° will be maintained but limited to 67°.
- When overspeed protection is triggered:
  - Spiral stability is introduced regardless of bank angle
  - Max bank angle is limited to 45°.
- When angle-of-attack protection is triggered, max bank angle is limited to 45°.

---

**Low energy warning**

A low energy aural warning “SPEED SPEED SPEED” is triggered to inform the pilot that the aircraft energy becomes lower than a threshold under which, to recover a positive flight path angle through pitch control, the thrust must be increased.

*) $\alpha$ = AOA

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Reconfiguration control laws

No loss of Normal Law after a single failure.

*Automatic reversion from Normal Law to Alternate or Direct Law* according to the number and nature of subsequent failures.

- **Normal Control Law**
  - **Failures** (at least two failures detected)
  - **Alternate Control Law**
    - **Failures** (at least two failures - second not self-detected)
      - **Pitch Direct Law**
      - **Mechanical back-up**
    - **Crew action** (failure detection confirmation)
### Alternate Law

- **Probability objective**: $10^{-5}$/flight hour ($10^{-3}$ under MMEL).

- No change for **ground, take-off and flare** mode compared to Normal Law.

- **Flight mode**:
  - **Pitch axis**: as per Normal Law with limited pitch rate and gains depending on speed and CONF.
  - **Roll/yaw axes**: Depending on failure:
    1. The lateral control is similar to normal law (no positive spiral stability is introduced).
    2. Characterized by a direct stick-to-roll surface relationship which is configuration dependent.

- **Protections**:
  - pitch attitude: lost
  - high speed: replaced by static stability
  - high angle of attack: replaced by static stability (Vc prot. Law) $\alpha > \alpha_{sw}$
  - low energy: lost

### Direct Law

- **Probability objective**: $10^{-7}$/flight hour ($10^{-5}$ under MMEL).

- No change for **ground mode** and **take-off mode** compared to Normal Law.

- **Flight mode**: Maintained down to the ground
  - in all three axes, direct relationship between stick and elevator/roll control surfaces which is center of gravity and configuration dependent.

- **All protections are lost**
  Conventional aural stall and overspeed warnings are provided as for Alternate Law.

- **Main operational aspect**:
  - **manual trimming** through trim wheel.
Control law reconfiguration summary

<table>
<thead>
<tr>
<th>Control law</th>
<th>Pitch</th>
<th>Lateral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Type A</td>
<td>Type A</td>
</tr>
<tr>
<td>Alternate</td>
<td>Type A</td>
<td>Type A/B</td>
</tr>
<tr>
<td>Direct</td>
<td>Type B</td>
<td>Type B</td>
</tr>
</tbody>
</table>
A330 flight controls - EFCS

Mechanical back-up

- To sustain the aircraft during a temporary complete loss of electrical power.

- Longitudinal control of the aircraft through trim wheel. Elevators kept at zero deflection.

- Lateral control from pedals. Roll damping is provided by the Back up Yaw Dumper Unit (BYDU).

- Message on PFD MAN PITCH TRIM ONLY (red).
Control law status information

Besides ECAM messages, the pilot is permanently informed of control law status on PFD.

**Normal Law**
- Normal FMA indications
- Pitch attitude protection
- Bank angle protection

**Alternate Law**
- Normal FMA indications
- + Audio warning
- + ECAM messages with limitations, if any

**Direct Law**
- Normal FMA indications + USE MAN PITCH TRIM
- + Audio warning
- + ECAM messages with limitations, if any
Control law status information
Crew information : PFD speed scale

F / CTL IN PITCH
NORMAL LAW

F / CTL IN PITCH
ALTN & DIRECT LAW
# A330 flight controls - EFCS

## Priority display logic

<table>
<thead>
<tr>
<th>Captain's side</th>
<th>First Officer's side</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sidestick</strong></td>
<td><strong>Annunciation</strong></td>
</tr>
<tr>
<td>Take-over button depressed</td>
<td>CPT Green</td>
</tr>
<tr>
<td>Take-over button depressed</td>
<td>“Light off”</td>
</tr>
<tr>
<td>Sidestick deflected</td>
<td>F/O Green</td>
</tr>
<tr>
<td>Sidestick in neutral</td>
<td>Red</td>
</tr>
</tbody>
</table>
Priority logic

- Normal operation: Captain and First Officer inputs are algebraically summed.

- Autopilot disconnect pushbutton is used at take-over button.

- Last pilot who depressed and holds take-over button has priority; other pilot’s inputs ignored.

- Priority annunciation:
  - in front of each pilot on glareshield
  - ECAM message
  - audio warning.

- Normal control restored when both buttons are released.

- Jammed sidestick:
  - priority automatically latched after 30 seconds
  - priority reset by depressing take-over button on previously jammed sidestick.
6. Landing gear
A330 landing gear

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A330 landing gear

Main features

- Conventional landing gear with single bogie nose gear and double bogie main landing gear with direct-action shock absorbers.

- The main landing gear is also provided with a shock absorber extension/retraction system.

- The main gears retract laterally; nose gear retracts forward into the fuselage.

- Electrically controlled by two Landing Gear Control/Interface Units (LGCIU).

- Hydraulically actuated (Green system) with alternative free-fall/spring downlock mode.

- Alternating use of both LGCIUs for each retraction/extension cycle. Resetting the landing gear control lever results in transition to the other LGCIU.

- Elimination of gear lever neutral position through automatic depressurization of landing gear hydraulic supply at speeds above 280 kt.

- Elimination of microswitches by use trouble-free proximity detectors for position sensing.
A330 landing gear

<table>
<thead>
<tr>
<th>AUTO/BRK</th>
<th>LO</th>
<th>MED</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>DECEL</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A/SKID &amp; N/W STRG</th>
<th>ON</th>
<th>OFF</th>
</tr>
</thead>
</table>

BLUE LO PR DISTRIBUTION LINE

PEDALS

TO OTHER DUAL VALVE

PULL & TURN

TO OTHER GEAR

TO GEARS

CONTROL VALVE PARKING BRAKE

TO OTHER GEAR

TO OTHER WHEELS

DUAL VALVE

ALTERNATE SERVO VALVE

TO ECAM

TO OPPOSITE WHEEL

NORMAL SERVO VALVE

DUAL SHUTTLE VALVE

TO OPPOSITE WHEEL

NORMAL SELECTOR VALVE

GREEN HP

HP ACCUMULATORS

ACCU PRESS

PSIX1000 BRAKES

0 433 11

A/SKID & N/W STRG

AUTO/BRK

LO | MED | MAX

DECEL | ON | ON  | ON  |

ACCU PRESS

PSIX1000 BRAKES

0 433 11

A/SKID & N/W STRG

AUTO/BRK

LO | MED | MAX

DECEL | ON | ON  | ON  |
Braking system

• Carbon disc brakes are standard.

• Normal system (Green hydraulic system supply):
  - electrically signalled through antiskid valves
  - individual wheel antiskid control
  - autobrake function
  - automatic switchover to alternate system in event of Green hydraulic supply failure.

• Alternate braking system with antiskid (Blue hydraulic system supply):
  - electrically signalled through alternate servovalves
  - hydraulically controlled through dual valve
  - individual wheel antiskid control
  - no autobrake function.

• Alternate braking system without anti-skid (Blue hydraulic system supply or Blue brake power accumulator):
  - hydraulically controlled by pedals through dual valve
  - brake pressure has to be limited by the pilot referring to the gauges.
  - no autobrake function
  - no antiskid system

• Parking brake (Blue hydraulic system supply or Blue brake power accumulator):
  - electrically signalled
  - hydraulically controlled with brake pressure indication on gauges.

• The Braking and Steering Control Unit (BSCU) is digital dual-channel double system (control and monitoring) computer controlling the following functions:
  - normal braking system control
  - anti-skid control (normal and alternate)
  - autobrake function with LO, MED, MAX.
  - nosewheel steering command processing
  - brake temperature signal processing
  - monitoring of all these functions.
A330 landing gear

Antiskid system schematic

\[
\begin{align*}
\gamma_{ir} & \quad \gamma_{prog} \\
V_{ir} & \quad V_{prog} \\
V_{AC} & \quad V_{ref} \\
\text{OFF} & \quad \text{ON} \\
\text{AUTO BRAKE} \\
\text{RELEASE ORDER} & \quad \text{RELEASE ORDER} \\
\text{IF WHEEL SPD} < 0.88 \, V_{ref} \\
\text{BLUE HYD} & \quad \text{GREEN HYD} \\
\text{NORMAL SERVO VALVE} & \quad \text{ALTERNATE SERVO VALVE} \\
\text{WHEEL SPEED} & \quad \text{WHEEL SPEED} \\
\end{align*}
\]
A330 landing gear

Braking principle

Antiskid system

• From touchdown, aircraft speed is computed based on touchdown speed (wheels) and integrated deceleration (ADIRS). This reference speed is compared with each wheel speed to generate a release order for closing the normal servovalve in case of skid exceeding 16%.

• Brake pedal orders open this servovalve which is also modulated by anti-skid closing signals.

Autobrake system

• From touchdown, a specific speed is computed based on touchdown speed (wheels) and programmed deceleration (low, medium, max). This programmed speed is compared with each wheel speed to generate a release order for closing the normal servovalve to meet selected deceleration.

• If the reference speed exceeds programmed speed (contaminated or iced runways), the former will take over for the antiskid to modulate the normal servovalve.
A330 landing gear

Nose gear steering principle

- BSCU
- LGIU 1/2
- LGIU 2
- NLG DOWNLOCKED AND COMPRESSED
- NLG DOWNLOCKED AND BOOGIES IN GROUND POS
- ENG
- ENG
- PRIM
- AUTO PILOT
- STEERING SERVO VALVE
- STEERING SELECTOR VALVE
- NWS ANGLE
- A/SKID & NW STRG
- ON
- OFF
- ON
- OFF
- NON TOWING POSITION
- AND
- OPEN
- CHANNEL 1
- CHANNEL 2
- GEEEN POWER FROM NOSE GEAR DOORS CLOSING CIRCUIT (WHEN DOORS ARE CLOSED)

- LGIU 1/2
- NLG DOWNLOCKED AND COMPRESSED
- NLG DOWNLOCKED AND BOOGIES IN GROUND POS
- ENG
- ENG
- PRIM
- AUTO PILOT
- STEERING SERVO VALVE
- STEERING SELECTOR VALVE
- NWS ANGLE
- A/SKID & NW STRG
- ON
- OFF
- ON
- OFF
- NON TOWING POSITION
- AND
- OPEN
- CHANNEL 1
- CHANNEL 2
- GEEEN POWER FROM NOSE GEAR DOORS CLOSING CIRCUIT (WHEN DOORS ARE CLOSED)
A330 landing gear

Controls and displays

- Rudder pedals
- Nosewheel handle
- ECAM system display
- Main Central Panel
- Landing gear panel
  - LDG GEAR UNLK
  - AUTO / BRK MED
  - BRK FAN ON
  - A / SKID OFF
- Brakes pressure indicator (alternate system)

PARK BRK

LDG GEAR GRVTY EXTN
RESET OFF DOWN

312VU

ON

ON
7. Fuel system
**A330 fuel system**

### Basic layout

- **Total fuel capacity**

<table>
<thead>
<tr>
<th></th>
<th>Outer tanks</th>
<th>Inner tanks</th>
<th>Center tank</th>
<th>Trim tank</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A330-200</strong></td>
<td>7300 litres</td>
<td>84 000 litres</td>
<td>41650 litres</td>
<td>6230 litres</td>
<td>139090 litres</td>
</tr>
<tr>
<td></td>
<td>(5730 kg)</td>
<td>(65940 kg)</td>
<td>(32625 kg)</td>
<td>(4890 kg)</td>
<td>(109185 kg)</td>
</tr>
<tr>
<td><strong>A330-300</strong></td>
<td>7248 litres</td>
<td>83808 litres</td>
<td></td>
<td>6230 litres</td>
<td>97 286 litres</td>
</tr>
<tr>
<td></td>
<td>(5690 kg)</td>
<td>(65790 kg)</td>
<td></td>
<td>(4890 kg)</td>
<td>(76 370 kg)</td>
</tr>
</tbody>
</table>

- **Ventilation**

  - Each wing tank and the tail tank is separately vented though its associated vent tank.
  - These vent tanks are open to the atmosphere via flame arrestors and NACA inlets.
  - Location of ducts and float valves is designed to ensure free venting over appropriate attitude ranges during refueling and normal ground and flight manoeuvres.
  - Pressure relief outlets protect the inner tank from over- or under-pressure in case of failure or blockage of the vent system or pressure refueling gallery.
A330 fuel system

Control and monitoring

The Fuel Control and Monitoring System (FCMS) controls the fuel system automatically.

Two identical Fuel Control and Monitoring Computers (FCMC) provide:
- fuel transfer control
- aircraft gross weight and center of gravity calculation based on zero fuel weight and zero fuel center of gravity entered by the crew.
- center of gravity control
- refuel control
- fuel quantity measurement and indication
- level sensing
- fuel temperature indication
- signals to FADEC for IDG cooling control.
A330 fuel system

Engine feed

- In normal operation, each engine is independently supplied by two continuously operating booster pumps located in a dedicated collector box.

  In the event of a pump failure, a standby pump automatically comes on line.

  Collector boxes are maintained full by a jet pump transfer action using booster pump pressure.

  In cruise conditions, a single booster pump is able to supply flow to both engines.

- A cross-feed valve allows the engine on either wing to be supplied from the opposite one.

- Supply of fuel to each engine may be shut off by an engine LP valve driven by a double motor actuator. It is controlled by either the ENG FIRE pushbutton or the ENG master lever.

- Automatic transfer of fuel from the outer tanks is performed by gravity. This occurs when trim tanks have been emptied and when either inner tank reaches 3500 kg.

 Outer tank fuel transfer valves are used to cycle the inner tanks contents between 3500 and 4000 kg. These valves are closed when outer tanks are empty for 5 minutes.

- Transfer to inner tanks can be manually selected through the OUTR TK XFR pushbutton.

  When selected ON, the outer tanks fuel transfer valves, outer and inner inlet valves are controlled OPEN.

- For A330-200 only:

  With fuel in the center tank, both CTR TK pumps are running and the inner inlet valves are used independently to cycle their respective inner tank contents between underfull and high level (Underfull is set at approximately 2000 kg below high level).

  When the center tank is empty, the pumps are automatically shut off, and both inner inlet valves close.
A330 fuel system

Jettison system (on A330-200 only - optional)

- The jettison pipe is connected to the refuel gallery in each wing. A dual actuator jettison valve is fitted.

- Fuel is jettisoned from the centre and inner tanks simultaneously. All normal and STBY pumps are running and a forward transfer into center tank is initiated.

- The aircraft weight will be reduced at a rate of not less than 70 tonnes/hour.

- Jettison is stopped when:
  - the crew deselects the jettison pushbutton
  - both level sensors dedicated to jettison become dry
  - a signal from the FCMC indicates that the remaining fuel on board reaches a value previously defined by the crew via the FMGS MCDU (option: Preselection of gross weight after jettison).
  - sum of both inner quantity reaches 10 000 kg.
A330 fuel system

Centre of Gravity control band relative to operational flight envelope

ACTIVE CG REGULATION LOGIC
System is active throughout ground and flight phases but normal auto-CG regulation occurs in cruise

END
- Remaining time to destination signal - 35 min
- (75 min in the event of TRIM tank forward transfer pump failure)
- FL 245 descent
- Wing fuel at a prescribed level
A330 fuel system

CG control

• Automatic CG control begins in climb at FL 255 and stops in descent at FL 245 or when FMGS time to destination is below 35 minutes (or 75 minutes if the trim tank transfer pump fails).

• Aft transfer

  * **A330-200**
    Fuel for trim tank aft transfer is provided by the center tank when it contains fuel or by the inner tanks when the center tank is empty.

  * **A330-300**
    The inner tanks provide fuel for trim tank aft transfer through the engines feed pumps.

Aft transfer is terminated for example when computed CG = target CG - 0.5%, or when an inner tank reaches the low level.

• **Forward transfer**

  - Forward transfer is required for example when computed CG = target CG.
  
  - Fuel transfer from the trim tank to the inner tanks is performed by the trim tank forward transfer pump through the trim pipe isolation valve.

  - On the A330-200, forward transfer is directed to the center tank when it is not empty.

  - Forward transfer is terminated when computed CG = target CG - 0.5%.
A330 fuel system

Controls and displays

A330-200

[Diagram of cockpit controls and displays]

- A. FLOOR
- IDLE
- EGT
- N1 %
- CHECK
- EWD
- CLB
- 102.6%
- 35°C
- 102
- 102
- 2250
- 2250
- FOB : 76470KG

[Diagram of fuel system]

- FUEL
- 1
- 7300
- KG
- USED
- 14600
- 2
- 7300
- KG
- FOB : 76470KG

- FOB : 76470KG
- APU
- GW
- 216000 KG
- CG
- 28%
A330 fuel system

Controls and displays

A330-300

A. FLOOR

IDLE

CLB

102.6%

35°C

FUEL

KG

USED

1

7300

14600

2

7300

73420 KG

FOB : 73420 KG

GW 185000 KG

CG 28%

- 15     °C     - 21 - 20°C

- 20°C4300
A330 fuel system

Left intentionally blank
Control and indication

• No crew action is required for normal operation except initiation and termination.

• Indications:
  - fuel data (quantity, temperature) are available from a Fuel Quantity Indication (FQI) system
  - Fuel quantity is permanently displayed on upper ECAM DU
  - Fuel system synoptic on lower ECAM DU is displayed according to ECAM logic
  - low level warning is totally independent from FQI.

• Abnormal operations:
  - Fuel feed sequence may be operated manually
  - cross-feed valve may be operated manually
  - forward and (some) inter tank transfers may be initiated manually
  - gravity feed is possible.
A330 fuel system

Refueling system

A330-200

A330-300
A330 fuel system

Refueling

- Two 2.5 inch couplings are installed in the leading edge of the right wing and of the left wing (optional on the A330-300), enabling all tanks to be filled from empty in some:
  - 33 minutes on the A330-200
  - 25 minutes on the A330-300 or 35 minutes if the left wing refueling point is not installed.

- An isolation valve is provided between couplings and the refueling gallery.

- A refueling inlet valve is provided for each tank, allowing distribution to a diffuser to reduce turbulence and avoid electrostatic build-up.

- An automatic refueling system controls the refuel valves to give preselected fuel load and correct distribution.

- Refueling/defueling is controlled from an external panel, located in the fuselage fairing under the RH belly fairing, and can be carried out with battery power only.

  Optional: Refueling can be controlled from the cockpit

- Gravity refueling can be achieved by overwing refueling points

- Defueling is accomplished by means of fuel pumps and for the outer and trim tanks, via transfer valves.
8. Engine controls
A330 engine controls

FADEC

• Thrust control is operated through Full Authority Digital Engine Control (FADEC) computers which:
  - command the engines to provide the power best suited to each flight phase
  - automatically provide all the associated protection required:
    • either in manual (thrust lever)
    • or in automatic (authorthrust) with a fixed thrust lever.

• Engine performance and safety improvement over current hydromechanical control system.

  Simplification of engine/aircraft communication architecture.

  Reduction of crew workload by means of automatic functions (starting, power management).

  Ease of on-wing maintenance.

• The system design is fault-tolerant and fully duplicated, with 'graceful degradation' for minor failures (i.e. sensor failures may lose functions but not the total system).

  The engine shut-down rate resulting from FADEC failures will be at least as good as today's latest hydromechanical systems with supervisory override.

• FADEC also called Engine Control Unit (ECU for GE engines) or Engine Electronic Controller (EEC for PW and RR engines) is a fully redundant digital control system which provides complete engine management. Aircraft data used for engine management is transmitted to the FADEC by the Engine Interface Unit (EIU).

  Each engine is equipped with a fan-case-mounted FADEC supporting the following functions:

    - gas generator control
    - engine limit protection
    - engine automatic starting
    - engine manual starting
    - power management
    - engine data for cockpit indication
    - engine condition parameters
    - reverser control and feedback
    - fuel used computation
    - fuel recirculation control (RR engines)
    - FADEC cooling (RR engines)
A330 engine controls - RR Trent

FADEC architecture

Diagram showing the FADEC architecture with various components such as ADIRS, THRUST LEVER ANGLE, ENG MAN START, ENG SENSORS, EIU, FADEC, HPSOV, FMU, FMV, VSV, CAB PRESS HP VALVE, HEAT MANAGEMENT, IGNITION SYSTEM, ENGINE BLEED VALVES, START VALVE, THRUST REVERSER SYSTEM, IP TURBINE CLEARANCE CONTROL, E/WD, SD, ECAM, ZONE CONT, LGCIU, SFCC, and FMGS (A/THR).
A330 engine controls

FADEC and EIU

One FADEC located on the engine with dual redundant channels (active and standby) each having separate 115 VAC aircraft power sources to provide engine starting on ground and in flight.

Additional features

Dedicated FADEC alternator provides self power above:
- 12% N2 for GE engines
- 5% N2 for PW engines
- 8% N3 for RR engines

- Dual redundancy for electrical input devices (ADIRS 1 + 2, TLAs, engine parameters).
- Dual redundancy for electrical part of control actuator.
- Simplex system for hydromechanical parts of the control.
- Fault tolerance and fail-operational capability.
- High level of protection against electromagnetic disturbance.
- Interface between the FADEC system and the other aircraft systems mainly performed by the EIU through digital data buses.
- One EIU per engine located in the avionics bay.
- Care taken to preserve system segregation for safety and integrity.
Thrust control system

- Engine thrust control is provided by the FADEC 1 and 2 controlling engines 1 and 2 respectively.

- Thrust selection is performed by means of:
  - thrust levers when in manual mode,
  - A/THR function of the FMGS when in automatic mode, but limited to the value corresponding to the thrust levers position.

- Limit thrust parameters are computed by the FADEC.

- Since there is no mechanization of the thrust levers (no servomotor) any thrust lever displacement must be performed manually.

- According to the thrust lever position the FADEC computes:
  - thrust rating limit
  - \( N1^* \) (EPR)** when in manual mode
  - \( N1^* \) (EPR)** which can be achieved in automatic mode (A/THR).

* for GE engines
** for PW, RR engines
A330 engine controls

Thrust control operations
**A330 engine controls**

**Indications on ECAM upper DU**

- **GE engines**
- **PWE engines**
- **RR engines**
Indications on PFD : FMA

- Following indications may appear on the PFD flight mode annunciator, in the upper left corner : (examples only)

- **ASYM** : One thrust lever not in CL detent.
- **CLB** : Flashing when aircraft is above thrust reduction altitude and thrust levers are not retarded to CL.
- **MCT** : Flashing in case of engine failure if the non-affected thrust levers are not set at MCT.
- **A-FLOOR** : When thrust is at MTO and an alpha-floor condition is encountered.
A330 engine controls

Thrust reverser

• Reverser deployment selection is performed through conventional reverser controls.

• Automatic maximum reverse power limitation versus ambient conditions with full aft throttle position.

• Display of reverser status on ECAM upper DU.
9. Auxiliary power unit
General principles

• **On ground**, the APU makes the aircraft self-contained by:
  - providing bleed air for starting engines and for the air conditioning system
  - providing electrical power to supply the electrical system.

• **In flight**, provision of back-up power for the electrical system, the air conditioning system and engine start.

• The APU can be started using either dedicated battery, external power or normal aircraft supply.

  The normal flight envelope does not impose any limitations for starting except when batteries are supplying starting power.

• The APU is automatically controlled by the Electronic Control Box (ECB) which acts as a FADEC for monitoring start and shut-down sequences, bleed air and speed/temperature regulation.

• Control and displays are located:
  - on the overhead panel for APU normal operation and fire protection
  - on the ECAM for APU parameter display
  - on the external power control panel next to the nose landing gear
  - on the REFUEL/DEFUEL panel for APU shut-down.

System display
A330 auxiliary power unit

Controls and display

APU
MASTER SW
FAULT
ON/R
START
AVAIL
ON

ECB

APU FIRE
APU SHUT OFF

(EXTERNAL CONTROL PANEL)

APU BLEED VALVE
2 STAGES COMPRESSOR
3 STAGES TURBINE
COMBUSTION CHAMBER
FUEL SUPPLY

FLAP MOTOR

APU GEN
OIL PUMP
GEAR BOX

925VU (EXTERNAL CONTROL PANEL)

2 STAGES COMPRESSOR
3 STAGES TURBINE
COMBUSTION CHAMBER
FUEL SUPPLY

FLAP MOTOR

APU GEN
OIL PUMP
GEAR BOX

925VU (EXTERNAL CONTROL PANEL)

2 STAGES COMPRESSOR
3 STAGES TURBINE
COMBUSTION CHAMBER
FUEL SUPPLY

FLAP MOTOR

APU GEN
OIL PUMP
GEAR BOX

925VU (EXTERNAL CONTROL PANEL)

2 STAGES COMPRESSOR
3 STAGES TURBINE
COMBUSTION CHAMBER
FUEL SUPPLY

FLAP MOTOR

APU GEN
OIL PUMP
GEAR BOX
10. Automatic flight system
A330 automatic flight system

Architecture block diagram

- ADR / IR
- ILS (MLS)
- ADF
- RA
- VOR
- DME
- CLOCK
- FCMC
- DATA BASE LOADER
- LGCIU
- SFCC

FMGC

FCU

Primary
- Flight controls
- Flight controls

Secondary
- ECAM
- Maintenance
- EFIS
- CPC
- ATSU option
- ACARS option

Back-up Nav

FADECs

Thrust levers

Flight controls

Maintenance

ECAM

EFIS

CPC

ATSU option

ACARS option
## A330 automatic flight system

### Architecture components

<table>
<thead>
<tr>
<th>Unit</th>
<th>Number per aircraft</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMGC</td>
<td>2</td>
<td>FMGEC 1 includes AFS/FIDS*</td>
</tr>
<tr>
<td>FCU</td>
<td>1</td>
<td>Includes three independent channels</td>
</tr>
<tr>
<td>MCDU</td>
<td>3</td>
<td>Colour display</td>
</tr>
<tr>
<td>A/THR instinctive disconnect switches</td>
<td>2</td>
<td>One for CM 1 and one for CM 2</td>
</tr>
<tr>
<td>AP take-over switches</td>
<td>2</td>
<td>One for CM 1 and one for CM 2</td>
</tr>
<tr>
<td>North reference switches</td>
<td>1</td>
<td>For EIS and MCDU display</td>
</tr>
<tr>
<td>FM source switch</td>
<td>1</td>
<td>For EIS display</td>
</tr>
</tbody>
</table>

* Fault isolation and Detection System

**OBRM (On-board Replaceable Modules)**

- Solid-state memory modules plugged into the front face of the computer.

- Cost and logistic improvement for software changes.

- Software change can be achieved *in situ* using a common replaceable module reprogrammer.
A330 automatic flight system

Flight Management Guidance and Envelope System (FMGS) crew interface
A330 automatic flight system

FMGS - AFS/FMS integration

- Composed of two computers (FMGC) including a management part (FM), a flight guidance (FG) and a flight envelope part (FE), this pilot interactive system provides:
  - flight management for navigation, performance prediction and optimization, navigation radio tuning and information display management,
  - flight guidance for autopilot commands (to EFCS), flight director command bar inputs and thrust commands (to FADECs)
  - flight envelope and speed computation.
- The FMGS offers two types of guidance achievable by AP/FD:
  - “managed”: guidance targets are automatically provided by the FMGS as a function of lateral and vertical flight plan data entered in the Multipurpose Control and Display Units (MCDU).
  - “selected”: guidance targets are selected by the pilot on the glareshield Flight Control Unit (FCU).
  Selected guidances mode always have priority over the managed guidance modes.
A330 automatic flight system

FMGS Crew interface

- Three MCDUs (only two at a time) on the central pedestal provide a long-term interface between the crew and the FMGCs in terms of:
  - flight plan definition and display
  - data insertion (speeds, weights, cruise level, etc.)
  - selection of specific functions (direct to, offset, secondary flight plan).

- One FCU on the central glare shield provides a short-term interface between the crew and the FMGCs.

- Two thrust levers linked to the FMGCs and FADECs provide autothrust or manual thrust control selection to the crew.

- Two PFDs and two NDs provide visual interface with flight management and guidance-related data such as:

  **on PFD:**
  - FMGS guidance targets
  - armed and active modes
  - system engagement status

  **on ND:**
  - flight plan presentation
  - aircraft position and flight path
  - navigation items (radio aids, wind).
A330 automatic flight system

General functions

• Guidance function
  Fail operational architecture*
  Operation
  Modes

• Autothrust
  Operation
  Modes

• Flight envelope
  Envelope protection ----------- (windshear, aft CG detection)
  Speed computation

• Flight management
  Functional architecture
  Navigation
  Flight planning functions ------ (assembly, fuel management, lateral revision)
  Optimisation performance ----- (speed/altitude, prediction)
  Vertical profile

* Fail operational refers to a single failure of a system which does not modify the aircraft’s flight path.
A330 automatic flight system - guidance function

Flight Control Unit (FCU)

Control knob philosophy:
- Pull + rotate = selected guidance (pilot input via FCU)
- Push = return to managed guidance (via FMS)
## A330 automatic flight system - guidance function

### AP/FD modes

#### Available modes

<table>
<thead>
<tr>
<th>Guidance</th>
<th>Managed mode</th>
<th>Selected mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral</td>
<td>NAV</td>
<td>HDG - TRK</td>
</tr>
<tr>
<td></td>
<td>B/C*, B/C, LOC*, LOC RWY</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RWY TRK</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GA TRK</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ROLL OUT</td>
<td></td>
</tr>
<tr>
<td>Vertical</td>
<td>SRS (TO and GA)</td>
<td>OP CLB, OP DES V/S - FPA ALT*, ALT</td>
</tr>
<tr>
<td></td>
<td>CLB, DES ALT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>G/S*, G/S FINAL DES FLARE</td>
<td></td>
</tr>
<tr>
<td>Speed</td>
<td>FMGC reference</td>
<td>FCU reference</td>
</tr>
<tr>
<td></td>
<td>ECON, Auto SPD, SPD LIM</td>
<td></td>
</tr>
</tbody>
</table>

#### Mode engagement (or arming as long as engagement conditions are not met).
- By pushbutton action (located on the FCU) LOC - APPR - ALT, AP1 - AP2 - A/THR.
- By action on the thrust levers. On the ground, setting the thrust levers to the TO/GA or FLEX/TO detents leads to AP/FD mode engagement (SRS/RWY). During approach, setting the thrust levers to TO/GA engages go-around mode.
- By action on the FCU selection knobs (speed selection knob, HDG/TRK selection knob, altitude selection knob, V/S-FPA selection knob).
  - Push action engages managed mode
  - Pull action engages selected mode - e.g speed or Mach selected mode pushed in flight engages managed speed profile (usually ECON).
A330 automatic flight system - guidance function

AP/FD operation

• The aircraft can be operated in ‘selected guidance’ with flight references selected by the crew, or in ‘managed guidance’ with references computed by the system.

• If the AP/FD controls a vertical trajectory the A/THR controls the target SPEED/MACH. If the AP/FD controls a target speed, the A/THR controls the thrust.

• Selected guidance always has priority over managed guidance, which means that the PF may select a speed, lateral or vertical path at any time; actions are acknowledged on the FCU itself and on the FMA (Flight Mode Annunciator).

• Selected guidance or managed guidance is available for SPEED/MACH control, LATERAL guidance and LEVEL CHANGE execution.

Lateral modes

NAV : lateral navigation

• Lateral track is defined by the FMGC according to the flight plan introduced in the system.

LOC : LOC axis capture and track

• LOC is armed if LOC pushbutton is pressed; LOC capture replaces NAV.

HDG/TRK

• Selection of HDG/TRK references is obtained by turning the dedicated switch located on the FCU.

• HDG/TRK is engaged by pulling on lateral selector; HDG/TRK value can be selected before or after pull action.

• Heading track preselection is possible on ground before take-off, in flight as from 30 ft height.
**A330 automatic flight system - guidance function**

### Vertical modes

#### Level changes [managed guidance (CLB, DES), selected guidance (OP CLB OP DES)]

- In CLB/DES modes vertical path is maintained as defined by the FMGC, taking into account the flight plan constraints inserted in the system at the clearance altitude selected on the FCU.

- OP CLB (OP DES) mode allows the aircraft to climb or descend uninterrupted toward FCU selected altitude, maintaining a TARGET SPEED (managed or selected) with a fixed given thrust. ALT constraints are ignored.

#### Altitude hold

- It is active if aircraft reaches FCU altitude, intermediate flight plan altitude constraints when ALT pushbutton is depressed on FCU or when V/S is set to zero.

#### V/S/FPA

- V/S/FPA is engaged by pulling on V/S/FPA selector. V/S or FPA value can be selected before or after a pull action.

### Common modes

#### Approach

- ILS available
  - GLIDE capture and track
  - FLARE
  - LAND
  - ROLL OUT

- ILS not available, RNAV approach selected on MCDU:
  - LATERAL guidance on the F-PLN
  - VERTICAL guidance and descent allowed down to MDA.

#### Take-off

- SRS
  - with engines running V2 + 10 holding
  - with one engine out VA (1) holding if VA>V2
  - V2 holding if VA<V2.

  (1) VA = aircraft speed when the engine failure occurs.

- RWY:
  - Track hold or LOC centerline hold.

#### Go-around

- SRS (as take-off).

- GA TRK hold.
**A330 automatic flight system - autothrust function**

**AP/FD and A/THR mode relationship**

1st case

AP/FD pitch mode controls a vertical fligh path (V/S or G/S or FINAL) then A/THR mode will control the target speed/Mach.

- e.g. if AP/FD V/S mode is selected
  - A/THR is in SPEED mode

2nd

AP/FD pitch mode controls the target speed/Mach then A/THR mode will control the thrust

- e.g. if AP/FD open CLB mode is selected
  - A/THR is in THR CLB mode
A330 automatic flight system - autothrust function

AP/FD and A/THR SPD/MACH modes

**In SPD/MACH managed mode**

- Is engaged by pushing the FCU SPD selector knob.
- AP/FD or A/THR holds the SPEED/MACH as provided by the FMS.
- Speed preset for next flight phase is available by entering preset value on the MCDU; speed preset becomes active at flight phase change.
- Crossover altitude is automatically provided.

**SPD/MACH selected mode**

- Is engaged by pulling the FCU SPD selector knob.
- Crossover altitude is automatically provided.
- Manual SPD/MACH selection is available to the pilot via the SPD/MACH conversion push-button.

AP/FD and A/THR SPD/MACH modes

**SPEED/MACH managed** or **selected** may either be controlled by AP/FD pitch mode or A/THR mode. The reasons for this are as follows.

- An AP/FD pitch mode may control a flight or an indicated airspeed - but not both at the same time.
- Thus, if the pitch mode (elevator) controls a flight path, (G/S of V/S) the A/THR controls the IAS, but if the pitch mode controls a speed (OPEN CLB/OPEN DES) then the A/THR will control a thrust.

Consequently, AP/FD pitch mode and A/THR are linked so that, if no AP/FD engaged, A/THR can be active in SPD/MACH mode.
A330 automatic flight system - autothrust function

A/THR operation - A/THR can be armed, active or de-activated

By pressing A/THR push button switch

By moving TLA in T O/G A or FLEX T O gates

Alpha floor activation

AUTOTHROUST
ARMED

A/THR
ACTIVE

At least one TLA above MCT : Thrust = f (TLA pos.)

No TLA above MCT : Max thrust = f (TLA pos.)
A/THR main features

Each engine thrust is electrically controlled by the associated FADEC (FULL Authority Digital Engine Control) which is fully integrated in the autothrust system.

The A/THR function is computed in the FMGC.

The FADECs receive A/THR commands directly from the AFS via an ARINC 429 bus.

Selection of thrust limit mode is obtained from the Thrust Lever Angle (TLA).
A330 automatic flight system - autothrust function

A/THR mechanisation

The thrust levers can only be moved manually by the pilot.

Take-off

Thrust mode selection

- On ground TO limit mode is automatically selected at power up.
- FLX/TO limit mode is selected by setting a FLX/TO temperature on the MCDU (TO page).

Take-off is performed:

- in limit mode, by manually setting the thrust lever to TO/GA detent.
- in FLX/TO limit mode, by manually setting to FLX/TO/MCT detent.

Notes:

- In both cases, this manoeuvre also engages FD TO mode (SRS RWY if ILS selected).
- The lowest FLX/TO thrust is limited to CL thrust.

Cruise

Thrust levers must be set:

- to be CLB detent
- to the MCT detent (engine failure case).
- The A/THR modes become active according to AP/FD mode selection.

Approach

Thrust levers must be set to CLB (or MCT engine failure case) detent:

- ATS SPD mode is active

Go Around

GA mode engagement is achieved by setting the thrust levers to TO/GA detent;

(A/THR armed; GA thrust is applied via the FADEC).

This manoeuvre also engages AP/FD GA mode.

Alpha floor

If the alpha floor function is activated, A/THR increases the thrust to the GA thrust limit.
Flight envelope protection

Flight envelope protection is achieved by generating maximum and minimum selectable speeds, windshear warning and stall warning. Also computed as part of this protection are the maneuvering speed and the flap and slat retraction speeds.

The alpha-floor signal is computed by the flight control computers.

Speed computation (PFD scale)
MCDU 3 switchable for FM function in case of MCDU 1 or 2 failure
A330 automatic flight system - flight management

Functional architecture - Normal configuration

- FMGC1
- MCDU 1
- MCDU 2
- MCDU 3
- DMC 1
- DMC 3
- DMC 2

FM NORM

BOTH ON 2
BOTH ON 1
A330 automatic flight system - flight management

Functional architecture - One FMGC failed

- FMGC1
- MCDU1
- MCDU3
- DMC1
- DMC2
- DMC3

Functional architecture - Normal configuration

- FMGC1
- MCDU1
- MCDU3
- DMC1
- DMC2
- DMC3

FM NORM BOTH ON 2 BOTH ON 1

MCDU2 brightness knob on "OFF"
Two FMGCs associated to two MCDUs provide a redundant configuration

- Normal mode operation: **dual mode**
  - Each FMGC makes its own computation.
  - One FMGC is **master** - the other one is **slave**.
  - Both FMGCs are synchronized.
  - Both MCDUs act independently (entries are automatically transmitted on the other MCDU and applied to both FMGCs).

- **Independent mode**
  - Automatically operative if mismatch occurs between FMGCs.
  - Independent operation of FMGC with associated MCDUs. (Data insertion and display related to the side concerned.
  - One FMGC remains master.

**Single mode**
- One FMGC fails.
- Either MCDU can be used to enter or display data related to the remaining FMGC.
Left intentionally blank
Position indication

- **Radio or GPIRS position (if GPS primary installed)**
- **FMGC position**
- **Mix IRS** = mean weighed average position of the 3 IRS positions
- **GPIRS** = GPS position integrity verified against IRS position

### POSITION MONITOR

- **FMGEC 1**
  - 3 IRS/DME/DME
  - Position: 4610.2N/00618.3E

- **FMGEC 2**
  - 3 IRS/DME/DME
  - Position: 4610.2N/00618.8E

- **RADIO**
  - 3 IRS/DME/DME
  - Position: 4610.1N/00618.2E

- **MIX IRS**
  - IRS 1
  - NAV 0.4
  - Position: 4609.7N/00618.0E

- **FREEZE**

### SELECTED NAVAIDS

- **VOR/DME**
  - AUTO
  - DESELECT
  - Position: 115.20

- **<GEN>**
  - Position: 115.10

- **<NIZ>**
  - Position: 115.40

- **<TOP>**
  - Position: 115.40

- **<RETURN>**

---

STL 472.755/92 Issue 4
MCDU

1  5  10  15  20  25
CRZ  ECON  DES  OPT  REC MAX  AI101

1L

2L

3L

4L

5L

6L

REQU DIST TO LAND = 70NM
DIR DIST TO DEST = 89NM
< REPORT
BRG / DIST
UPDATE AT
VOR 1 / FREQ ACY  FREQ / VORZ
ATH / 114.4  HIGH / 117.2 / DDM

ND

GS394TAS 388
249/16

33 34 35 0 1 2 3 4

CGC

AVD

CDN

LWG/004
93 NM
18/35

OL

2R

AVD

LWG

GAI

VOR2

TILT

-3.00

VOR1
CGCM
103 NM

NAV ACCY UPGRADED
Lateral navigation

• Position computation

- Before flight, the three IRSs are aligned on airfield or gate position (manually or via database).
- At take-off, the position is automatically updated to the runway threshold.
- In flight, position updating is computed using radio nav aids (DME, VOR, ILS and GPS when available).

The FMGC position is a blend of IRS and radio position. On a medium-term basis the FM position will tend towards the radio position, if any drift occurs.

• Navigation mode selection

- If the aircraft is equipped with GPS primary, the FMGC uses the GPIRS position in priority (IRS-GPS mode).
- if the GPIRS position is not available or if the aircraft is not equipped with GPS primary, depending upon availability of nav aids and sensors, FMGC automatically uses the best navigation means to compute the most accurate position:
  
  IRS - DME/DME
  IRS - VOR/DME
  IRS - ILS/DME
  IRS only.

• The FMGC position is associated with a high or low criterion which is based on an Estimated Position Error (EPE).

This EPE depends upon the flying area (en route, terminal, approach) and is permanently compared to Airworthiness Authorities Accuracy Requirements (AAAR).

If EPE > AAAR, then LOW is displayed on MCDU and the position must be cross-checked with raw data (ADF/VOR needles, DME reading).

Each time HIGH (or LOW) reverts to LOW (or HIGH) the message NAV ACCUR DOWNGRAD (or UPGRAD) is displayed on NDs and MCDUs.
Radio navigation

Each FMGC tunes its own side radio nav aids except when in single operation:

- one VOR, one ILS, one ADF (if belonging to the F-PLN) and five DMEs may be auto tuned at the same time.
- manual tuning always has priority over autotuning.
- autotune priority rules are done according to FMGS logics;

for example:

- VOR autotune (frequency course) priority is:
  - manual tune
  - specified navaid for approach
  - radio position computation
  - display purpose logic.

- Five DMEs can be scanned simultaneously
  - one DMEs for display purpose
  - two DMEs for radio position computation when in DME/DME mode
  - one DMEs for VOR/DME position computation when in VOR/DME mode
  - one DME is linked to ILS/DME.

Radio navigation architecture
Navigation and flight planning

Navigation

• Aircraft position determination.
• Aircraft position referenced to the flight plan.
• Automatic VOR/DME/ILS/ADF selection.
• Automatic guidance along flight plan from take-off to approach.
• IRS alignment.
• Ground speed and wind computation.
• Polar navigation.
• Optimum radio and inertial sensor mixing.
• Provision for GPS and MLS.

Flight plan stringing

• Flight plan definition by company route or city pair.
• Departure and arrival procedures including associated speed/altitude/time constraints.
• Standard flight plan revision (offset, DIR TO, holding pattern, alternate flight plan activation, etc.).
• Additional flight plan revisions linked to long-range flights (DIR TO mechanization, AWY stringing).
• Secondary flight plan creation similar to primary flight plan.
• Definition of five cruising levels on the flight plan.
• Extension of the data base capacity.
Left intentionally blank
A330 automatic flight system - flight management

Back-up NAV function

• A back-up source of navigation is available in the MCDU 1 and the MCDU 2, to cover failure cases.

• No database is available in the MCDUs. The FM F-PLN is permanently downloaded in the MCDUs (from the FMS to which the MCDU is linked) and the back-up NAV is selectable on MCDU menu page if FM source is on 'normal' position.

• The following features are provided.

  - Lateral revision using:
    . 'direct to' (DIR TO) modification
    . clearing of discontinuity
    . waypoint deletion
    . waypoint lat/long definition and insertion.

  - F-PLN automatic sequencing.

  - Track and distance computation between waypoints.

  - IRS position using one ADIRS (onside or ADIRS 3, according to pilot selection).

  - F-PLN display on ND with crosstrack error.
Flight plan aspects

• Flight plan optimisation through the performance database:
  - optimum speeds.
  - optimum and maximum recommended altitudes.
  - optimum step climb.

  The computation are based on:
  - flight conditions (multiple cruise levels, weights, center of gravity, meteorological data).
  - cost index given by the airline.
  - speed entered on the FCU or given in the flight plan.

• Performance predictions:
  - time, altitude, speed at all waypoints.
  - estimated time of arrival, distance to destination.
    estimated fuel on board at destination.
  - energy circle.

• Advisory functions:
  - fuel planning.
  - optimum altitude and step climb.
  - time/distance/EFOB to en route diversion airfields.

• Fuel vertical guidance related to flight plan predictions, from initial climb to approach.
A330 automatic flight system - flight management

Vertical profile

• **Take-off**
  SRS control law maintains V2 + 10 up to thrust reduction altitude where max climb thrust is applied. V2 + 10 is held up to acceleration altitude (ACC ALT).

• **Climb**
  Energy sharing is applied for acceleration (70% thrust) and for altitude (30% thrust) from ACC ALT up to first climb speed. Max climb thrust is kept - altitude and speed constraints are taken into account.

• **CRZ**
  Steps may exist and/or may be inserted.

• **Descent**
  Top of Descent (T/D) is provided on ND. From T/D down to the highest altitude constraint, ECON descent speed is held by the elevator and IDLE thrust by the A/THR. If this status can no longer be held or maintained, geometric segments will be followed between the constraints.

• **Approach**
  From DECEL point, a deceleration allows configuration changes in level flight.

  Approach phase is planned to reach approach speed at 1000 ft above ground level.

Flight plan - vertical definition
11. Environmental control system
Air conditioning

The hot compressed air is cooled, conditioned and delivered to the fuselage compartments and then discharged overboard through two outflow valves.

Fresh air can also be supplied to the distribution system through two low-pressure ground connections. A ram air inlet supplies emergency air to fuselage if there is a complete failure of the air generation system during flight. A mixing manifold, mixes fresh air with cabin air.

The cabin air that enters the underfloor area, is drawn through recirculation filters by fans. The recirculation fans then blow the air through check valves to the mixing manifold. The flight deck is supplied by fresh air only.

Hot bleed air is tapped downstream of the pack valves. The air flows through two hot air valves which control the pressure of the hot trim air going into two hot air manifolds.

To control the temperature in the different upper deck zones, the quantity of trim air added is controlled through the cockpit and cabin temperature control system. Hot air is delivered to the air supply ducts through the related zone trim air valves. The trim air valves are controlled through the temperature requirements of each zone and duplicated for cabin zone flexibility.

The trim air system has several features to ensure that no substantial comfort degradation occurs in case of trim air valve or hot air valve failure; a hot cross-bleed valve is installed between the two hot air manifolds and will open to maintain trim air supply to all riser ducts in the event of hot air failure (blocked closed). Moreover, in the event of trim air valve failure (blocked open) and/or duct overheat, as the shut-off valve is normally closed and there are two riser ducts per cabin zone, only half of each zone will lose its trim air supply. The flight deck is permanently supplied by a constant restricted trim air flow in addition to the normal controlled trim air supply.
A330 environmental control system

Air conditioning - Air bleed
A330 environmental control system

Pneumatic

• Pressurized air is supplied for air conditioning, air starting, wing anti-ice, water pressurization and hydraulic reservoir pressurization.

• System operation is electrically by Bleed Monitoring Computers (BMC), and is pneumatically controlled.

• A leak detection system is provided to detect any overheating in the vicinity of the hot air ducts.

(*) For engine 2 the bleed valve closure due to APU bleed valve open will occur only if the x bleed valve is not selected close.

(**) For GE engines only if installed
A330 environmental control system

Avionics ventilation

![Diagram of Avionics Ventilation System]
A330 environmental control system

Ventilation

• **Avionics ventilation**

  Provides ventilation and cooling of avionics and electronic equipment under digital control (AEVC) and without any crew intervention.

  • Cabin fans provide air blown to the avionics compartment.

  • Extract fan (continuously on) blows air through the overboard valve (on ground), or the under-floor valve (in flight).

  • Manual control opens the overboard valve (fan failure or smoke removal).

• **Pack bay ventilation**

  Provided to maintain a mean temperature compatible with the structure constraints. In flight, air is fed from outside through a NACA air inlet. On ground, air is blown by a turbofan which is carried out by the air bleed system.

• **Battery ventilation**

  Provided by ambient air being drawn around the batteries and then vented directly outboard via a venturi.

• **Lavatory and galley ventilation**

  Provided by ambient cabin air extracted by a fan and exhausted near the outflow valves.
A330 environmental control system

Cabin pressure control
Pressurization

• The pressurization control system operates fully automatically.

• Dual system with automatic switchover after failure. Alternative use for each flight. Two outflow valves are operated by one of three independent electric motors. Two of these are associated with automatic controllers.

• In normal operation, cabin altitude and rate of change are automatically controlled from FMGC flight plan data:
  - cruise flight level, landing field elevation, QNH
  - time to top of climb, time to landing.

• In case of dual FMGC failure, the crew has to manually select the landing field elevation. The cabin altitude varies according to a preprogrammed law.

• In case of failure of both pressurization system auto-controlers, the manual back-up mode is provided through the third outflow valve motor.
12. Electronic instrument system
A330 electronic instrument system

Cockpit arrangement

Captain:
- EFIS control panel
- Navigation display
- Master warning and caution lights
- Primary flight display

First Officer:
- EFIS control panel
- Navigation display
- Master warning and caution lights
- Primary flight display
General

The Electronic Instrument System (EIS) performs a display function for:

• **flight operation.** EFIS (Electronic Flight Instrument System) on each crew member instrument panel:
  - 1PFD (Primary Flight Display)
  - 1 ND (Navigation Display)

• **system operation.** ECAM (Electronic Centralized Aircraft Monitor)
  
  On the centre instrument panel for both crew members:
  - 1 E/WD (Engine/Warning Display)
  - 1 SD (System Display)

The crew remains in the INFORMATION/ACTION loop at all times and is able to CHECK and OVERRIDE the automation (if necessary).
A330 electronic instrument system

EFIS / ECAM architecture

EFIS 1

EFIS 2

PFD 1
ND 1

ECAM DU1

ND 2
PFD 2

ECAM DU2

WARNING

CAUTION

EFIS DMC 1

ECAM DMC 1

EFIS DMC 3

NAV & AFS SENSORS
PAGEC
FDI
LGCU
FCU

ECAM DMC 2

FMC 1

SDAC 1

AIC SYSTEMS SENSORS
INPUT FOR:
- ECAM
- NAVIGATION
- SYSTEM PAGE

SDAC 2

AIC SYSTEMS SENSORS
INPUT FOR:
- AMBER CAUTIONS
- SYSTEM PAGE

FMC 2

NORMAL FLOW
ALTERNATE FLOW
A330 electronic instrument system

Components

• **DU (Display Unit)**
  - Six identical full-colour DUs
  - 7.25in x 7.25in case size
  - Symbol generator resident in DU

• **DMC (Display Management Computer)**
  - Three identical DMCs
  - Each DMC has two independent channels: EFIS/ECAM
  - Each DMC is able to drive all six DUs with four independent formats (PFD, ND, E/WD, SD).

• **SDAC (System Data Acquisition Concentrator)**
  - Two identical SDACs
  - The SDCAs are connected to the DMCs and FWCs

• **FWC (Flight Warning Computer)**
  - Two identical FWCs
  - Each FWC is connected to all DMCs.

Display function

Acquisition and processing functions

Acquisition of system data for transmission to FWC and DMC

Acquisition and processing of:
- Alert messages
- Memos
- Aural alerts
- Flight phases
- Auto callout
**A330 electronic instrument system**

### Architecture

- **Fully redundant EIS architecture**
  
  Partitioned DMCs (three EFIS functions/three ECAM functions) to drive the six DUs.
  - Full reconfiguration capability.
  - Independence between EFIS and ECAM switching.

- **Benefits**
  - Dispatchability.
  - No operational degradation when a DMC fails or some external computers fail (ADIRS, FWC, SDAC, etc.)

### Availability objectives

- **Departure with one DMC and one DU failed all functions remain available:**
  - EFIS 1
  - ECAM
  - EFIS 2

- **After two failures (normal operation) or one failure (MEL operation) the following functions remain available:**
  - EFIS 1 or 2
  - ECAM
  - Copy of remaining EFIS on the opposite side.
A330 electronic instrument system

Reconfiguration possibilities - Architecture
A330 electronic instrument system

Reconfiguration - F/O on EFIS DMC3
Reconfiguration - ECAM on DMC1 + F/O on EFIS DMC1

A330 electronic instrument system
A330 electronic instrument system

DU reconfiguration

- PFDU1 FAILED
- PFDU2 FAILED
- NDU 1
- NDU 2
- E/WDU
- E/W DU FAILED
- SDU
- SWITCHING
  - ECAM/ WD XFR
  - NORM
- F/O
- CAP
- AUTO XFR
- MANUAL XFR
The **EFIS** (Electronic Flight Instrument System) is used for flight operation.

The two **PFDs** (Primary Flight Displays) provide **short-term flight information**:
- aircraft attitude
- air speed
- altitude and vertical speed
- heading and track
- autoflight information
- vertical and lateral deviations
- radio NAV information.

The two **NDs** (Navigation Displays) provide **medium-term flight information**:
- location of the aircraft with respect to navigation aids: FMS flight plan and map data
- weather radar information.
A330 electronic instrument system - EFIS

Control panels

The capt and F/O control panels are part of the FCU (Flight Control Unit)

Capt. EFIS control panel

Control the display of G/S and LOC scales of the PFD

Control the display of the flight director of the PFD

F/O EFIS control panel

Options keys

ND mode

ND range

VOR/ADF selector (ADF 2 optional on A330)
A330 electronic instrument system - EFIS

PFD - Approach

- Approach capability and decision height
- V_{FE} or actual configuration
- Speed trend
- Target airspeed
- Minimum selectable speed
- Alpha protection speed
- Alpha max speed
- Radio altitude
- ILS ident + freq
- ILS - DME distance
- Selected altitude
- G/S and LOC scales and DEV indexes
- Outer market “light”
- Altimeter baro setting display
- ILS course
- G/S and LOC scales
- CAT 2 DH 100
- AP/FD and A/THR engagement status
- VFE or actual configuration
- Speed trend
- Target airspeed
- Minimum selectable speed
- Alpha protection speed
- Alpha max speed
- Radio altitude
- ILS ident + freq
- ILS - DME distance
- Approach capability and decision height
- Selected altitude
- G/S and LOC scales and DEV indexes
- Outer market “light”
- Altimeter baro setting display
- ILS course
- G/S and LOC scales
A330 electronic instrument system - EFIS

ND - ARC mode

GS 394  TAS 388  LMG 004°
249/16  93 NM  18:35

103 NM

VOR1
CGCM

LMG 004°

TILT -3,00

GAI

ANG  CDN

AMB  AVD  CGC LMG TILT
A330 electronic instrument system - EFIS

ND - ROSE/NAV mode

GS 200  TAS 210
210 / 20

TOE / 163°
10.5 NM
18:35

ETA

Waypoint

Airport

Distance scale

ADF 2
M = manually tuned
A330 electronic instrument system - EFIS

ND - PLAN mode
A330 electronic instrument system - EFIS

ND - ROSE/ILS mode

Wind direction
Wind force
Localizer deviation bar
Glide deviation
Glide scale

GS 165 TAS 150
095/20

VOR 1
M = manually tuned

ILS APP

TBN

GS 165 TAS 150
095/20

TBN

ILS2 109.3
CRS 327°

VOR 1
M = manually tuned

15.3 NM

15.3 NM
A330 electronic instrument system - EFIS

ND - TCAS (optional)

- Resolution Advisory: RED
- Traffic Advisory: AMBER
- Proximate intruder: WHITE
- Relative altitude/vertical speed
- 2.5 nm range ring
- Other intruders: WHITE EMPTY
- No bearing intruders

GS 195
280/20

TAS 200

VOR APP

D-LG 065°
5.8 NM
18:35

5.2NM + 10†
12.4NM
A330 electronic instrument system - ECAM

Arrangement

• ECAM (EFIS) colour symbology
  - Warnings : RED for configuration or failure requiring immediate action.
  - Cautions : AMBER for configuration or failure requiring awareness but not immediate action.
  - Indications : GREEN for normal long-term operations.
    WHITE for titling and guiding remarks.
    BLUE for actions to be carried out or limitations.
    MAGENTA for particular messages, e.g. inhibitions.

• ECAM displays arrangement

  Upper DU
  - Engine primary indication
  - Fuel quantity information
  - Slats/flaps position
  - Warning/Caution or Memo messages.

  Lower DU
  - Aircraft system synoptic diagram or status messages.
### Audible warning definition

<table>
<thead>
<tr>
<th>WARNING SIGNAL</th>
<th>CONDITION</th>
<th>DURATION</th>
<th>SILENCING</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTINUOUS REPETITIVE CHIMIE</td>
<td>RED WARNINGS</td>
<td>PERMANENT</td>
<td>Depress* MASTER WARN lt</td>
</tr>
<tr>
<td>SINGLE CHIME</td>
<td>AMBER CAUTION</td>
<td>1/2 sec.</td>
<td></td>
</tr>
<tr>
<td>CAVALRY CHARGE</td>
<td>A/P DISCONNECTION BY TAKE OVER pb</td>
<td>1.5 sec</td>
<td>Second push on TAKE OVER pb</td>
</tr>
<tr>
<td></td>
<td>A/P DISCONNECTION DUE TO FAILURE</td>
<td>PERMANENT</td>
<td></td>
</tr>
<tr>
<td>CLICK</td>
<td>LANDING CAPABILITY CHANGE</td>
<td>1/2 sec (3 pulses)</td>
<td></td>
</tr>
<tr>
<td>CRICKET + &quot;STALL&quot; message (synthetic voice)</td>
<td>STALL</td>
<td>PERMANENT</td>
<td>NIL</td>
</tr>
<tr>
<td>INTERMITTENT BUZZER</td>
<td>SELCAL CALL</td>
<td>PERMANENT</td>
<td>Depress RESET key on ACP</td>
</tr>
<tr>
<td>BUZZER</td>
<td>CABIN CALL</td>
<td>3s</td>
<td>NIL</td>
</tr>
<tr>
<td></td>
<td>EMER CABIN CALL</td>
<td>3s REPEATED 3 TIMES</td>
<td>NIL</td>
</tr>
<tr>
<td></td>
<td>MECH CALL</td>
<td>As long as outside pb pressed</td>
<td>NIL</td>
</tr>
<tr>
<td></td>
<td>ACARS CALL or ALERT</td>
<td>PERMANENT</td>
<td>Message reading on MCDU or Depress MASTER WARN lt</td>
</tr>
<tr>
<td>C CHORD</td>
<td>ALTITUDE ALERT</td>
<td>1.5 sec or PERMANENT</td>
<td>new ALTITUDE selection or depress MASTER WARN lt</td>
</tr>
<tr>
<td>AUTO CALL OUT (synthetic voice)</td>
<td>HEIGHT ANNOUNCEMENT BELOW 400 FT</td>
<td>PERMANENT</td>
<td>NIL</td>
</tr>
<tr>
<td>GROUND PROXIMITY WARNING (synthetic voice)</td>
<td>UNSAFE TERRAIN IN CLEARANCE FORESEEN</td>
<td>PERMANENT</td>
<td>NIL</td>
</tr>
<tr>
<td>&quot;WINDSHEAR&quot; (synthetic voice)</td>
<td>WINDSHEAR</td>
<td>REPEATED 3 TIMES</td>
<td>NIL</td>
</tr>
<tr>
<td>&quot;PRIORITY LEFT&quot; &quot;PRIORITY RIGHT&quot; (synthetic voice)</td>
<td>A/PTAKE OVER pb</td>
<td>1 sec</td>
<td>NIL</td>
</tr>
<tr>
<td>&quot;RETARD&quot; (synthetic voice)</td>
<td>THRUST LEVER NOT IN IDLE POSITION FOR LANDING</td>
<td>PERMANENT</td>
<td>THRUST LEVER</td>
</tr>
<tr>
<td>TCAS CALL (synthetic voice)</td>
<td>TRAFFIC OR POTENTIAL COLLISION</td>
<td>PERMANENT</td>
<td>NIL</td>
</tr>
</tbody>
</table>

* All aural warnings may be cancelled by depressing the EMER CANC pb on ECAM control panel or the MASTER WARN lt except for some warnings like overspeed or L/G not down.

* If option is installed

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Display unit

Engine / warning display

- ENGINES control indication
- Total FUEL
- FLAPS / SLATS position

MEMO
- Reminder of functions temporarily used under normal operation
- TO or LDG MEMO (key items for TO or LDG)

WARNING / CAUTION messages
- Title of the failure
- Corresponding procedures (actions to be performed)

Overflow symbol

System display

- SYSTEM synoptics
- STATUS

- Operational status of the aircraft after failure including recovery procedures

Permanent data:
- TAT
- SAT
- UTC
- GW
- CG

MEMO
- Reminder of functions temporarily used under normal operation
- TO or LDG MEMO (key items for TO or LDG)

TAT = 19°C
SAT = 18°C
G.W. 170300 KG
C.G. 28.1 %
A330 electronic instrument system - ECAM

E/WD - engines

Typical

ECAM UPPER DISPLAY (E/WD)

ENGINE CONTROL PARAMETERS
FUEL QUANTITY INDICATION
FLAPS/SLATS POSITION

MEMO INFORMATION

- SEAT BELTS
- WING A.ICE

FOB : 55200 KG

N1 %
6 10 120

N2 %
102

EGT °C
1222

F.F KG/H
12250

EGT °C
1222

F.F KG/H
12250

N1 %
6 10 120

N2 %
102

EGT °C
1222

F.F KG/H
12250

N1 %
6 10 120

N2 %
102

EGT °C
1222

F.F KG/H
12250
A330 electronic instrument system - ECAM

S/D - A330 cruise page

System pages

14 system pages can be displayed:
- BLEED (Air bleed)
- COND (Air conditioning)
- PRESS (Cabin pressurization)
- ELEC AC (AC electrical power)
- ELEC DC (DC electrical power)
- C / B (Circuit breakers)
- F / CTL (Flight controls)
- FUEL (Fuel)
- HYD (Hydraulic)
- APU (Auxiliary power unit)
- ENGINE (Secondary engine parameters)
- DOOR / OXY (Doors / oxygen)
- WHEEL (Landing gear, braking, ground spoilers, etc.)
- CRUISE (Cruise)
Control panel

Note: In the event of complete failure of the ECAM control panel electronics, the CLR, RCL, STS, EMER CANC and ALL remain operative since the contacts are directly wired to the FWCs/DMCs.
A330 electronic instrument system - ECAM

Operating modes

• Four modes of ECAM system pages presentation:

  NORMAL mode: automatic flight phase related mode:
  - MEMO on E/WD
  - most suitable system page on SD.

  MANUAL mode: use of the ECAM control panel
  - any of the system pages may be called-up on SD by pressing the corresponding selector keys of the ECAM control panel.

  ADVISORY mode: parameter trend monitoring
  - corresponding system page on SD with affected parameter pulsing.

  FAILURE RELATED mode:
  - Failure indication and abnormal/emergency procedures on E/WD
  - affected system synoptic on SD.
A330 electronic instrument system - ECAM

Automatic flight phase

Engine** start

APU**

EIS associated system pages

DOOR WHEEL  *FLT CTL  ENGINE  CRUISE  WHEEL  DOOR

ELECPWR  1st ENG STARTED  2nd ENG T.O. PWR  OR  L/G EXTENDED AND ALT < 15000ft

FWS flight phases

1  2  3  4  5  6  7  8  9  10

FLT CTL page replaces wheel page for 20 seconds when either sidestick is moved or when rudder deflection is above 22°.

APU page or ENG START page automatically displayed during start sequence.
A330 electronic instrument system - ECAM

Failure-related mode

MASTER CAUTION
Engine / warning display

ENGINE control indication
Total FUEL
FLAPS / SLATS position

Failure indication corrective action

MASTER CAUTION
System display

Corresponding system synoptic with failure indication

TAT + 19°C
SAT + 18°C

G.W. 170300 KG
C.G. 28.1 %

17 H 03
A330 electronic instrument system

Architecture - Flight Warning System (FWS)
A330 electronic instrument system

• The FWS performs (in real time) the computation and management of central warnings and cautions

  - **Warning/caution hierarchical classification** (level 3: red warning, level 2: amber caution, level 1: simple caution) and **priority rules**.

  - **Warning/caution inhibitions**.

  - **Operational failure categorization**: independent failure, primary failure, secondary failure.

• The FWS directly activates the crew attention getters (aural and visual) and uses the EIS (ECAM: E/WD and SD) to display the warning/caution messages.

• The FWS also computes the MEMO information (presented on the E/WD) and performs an automatic radio height call-out function.
13. Radio management and communication
A330 radio management and communication

Radio Management Panel (RMP)
A330 radio management and communication

Concept

• Radio Management Panel (RMP) system provides:
  - crew control of all radio communication systems.
  - back-up to the two FMGCs for controlling all radio navigation systems.

• Basic installation includes:
  - two RMPs on pedestal
  - a third RMP on overhead panel (not available for NAV back up).

• The ATC transponder is tuned by a separate conventional control panel.
A330 radio management and communication

RMP architecture
Concept architecture

Communications tuning

Any communication receiver can be tuned from either of the three RMPs. Either RMP can take over from the other in the event of failure.

Navigation tuning

Three different operating modes exist:

- **Automatic tuning**: VOR/DME, ILS and ADF are automatically controlled by the FMGC.

- **Manual tuning**: for selection of a specific frequency through the FMGC MCDU which overrides the automatic function of the FMGC.

- **Back-up tuning**: when both FMGCs are inoperative, any NAV receiver may be tuned by the crew from RMP 1 or 2.

When one FMGC is inoperative, the remaining one controls all receivers.
A330 radio management and communication

COMM - Audio Control Panel (ACP)
A330 radio management and communication

COMM - Audio system

The audio integrating system provides the management of all audio signals produced by feeding the radio communications, radio navigation and interphone systems:

- Basic installation includes:
  - three Audio Control Panels (ACP) - two on pedestal, one on overhead panel.
  - one Audio Management Unit (AMU) in avionics bay.
  - one SELCAL code selector in avionics bay.

- Provision exists for supplementary ACPs.

- All selections and volume adjustments are carried out by the crew through ACPs.

- All ACPs are fitted for maximum capacity (three VHF, two HF, public address, calls, two VOR, two ADF, ILS and provision for MLS).

- Each ACP and associated AMU electronic card are fully independent and microprocessor controlled.

- Optional: The Satellite Communication (SATCOM) system allows the exchange of information between the ground station and the aircraft (technical information, voice transmission) via satellites.
A330 Central Maintenance System
Left intentionally blank
General

Line maintenance of the electronic systems is based on the use of a Central Maintenance System (CMS).

The purpose of the CMS is to give maintenance technicians a central maintenance aid to intervene at system or subsystem level from multipurpose CDUs located in the cockpit:

- to read the maintenance information.
- to initiate various tests.

Two levels of maintenance should be possible using the CFDS:

- maintenance at an out-station (LRU change).
- maintenance in the hangar or at the main base (troubleshooting).
A330 Central Maintenance System

Architecture

CMC 1

MCDU 1

2 3

ACARS MU

DATA LOADER

CMC 2

CMC : Central Maintenance Computer
ACARS : Aircraft Communication And Reporting System

VHF 3

PRINTER (A4 FORMAT)

BITE

Aircraft Systems

if installed
Advantage of the CMS

A revised maintenance concept provides a:

- reduction of the duration of operations
- reduction of the maintenance crew training time
- simplification of technical documentation
- standardization of the equipment
- simplification of the computers which no longer display any BITE

Integration of the CMS

The CMS includes:

• Basic equipment
  - the BITE (Built-In Test Equipment) for each electronic system.
  - two fully redundant Central Maintenance Computers (CMCs).
  - three MCDUs (Multipurpose Control Display Units)
  - one printer.

• Optional equipment
  - ACARS (Aircraft Communication And Reporting System) which dialogue with the CMC for display of information or initiation of tests.
  - Data Loader which allows to upload data bases and operational software or to download system reports from various onboard computers.
Example of use
## Example of use (cont’d)

### Maintenance Current Flight Report

**Aircraft Identification** / F-GGEA  
**Date** / MAR31  
**Flight Number** : AIB 1027  
**Engine On/Engine Off** / 1015/1720  
**Printing Date** : APR02  
**TYC** : 1406

### Cockpit Effects Faults

<table>
<thead>
<tr>
<th>ATA 36-11</th>
<th>UTC : 1032</th>
<th>Flight Phase : Takeoff Roll</th>
<th>Source : BMC3</th>
<th>Message : THR (5HA3)/FAN AIR-V (12HA3)/SENSE LINE</th>
<th>Intermittent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message Displayed</td>
<td>ENG 2 BLEED FAULT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
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<tr>
<th>ATA 30-11</th>
<th>UTC : 1033</th>
<th>Flight Phase : Climb</th>
<th>Source : PHC2</th>
<th>Message : R STATIC PROBE (8DA2)/PHC2 (6DA2)</th>
<th>Hard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message Displayed</td>
<td>ANTI-ICE F/O PROBE</td>
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<tr>
<th>ATA 24-53</th>
<th>UTC : 1822</th>
<th>Flight Phase : Cruise</th>
<th>Source : SDAC</th>
<th>Message : POWER SUPPLY INTERRUPT</th>
<th>Hard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message Displayed</td>
<td>ELEC AC 1.1 BUS FAULT</td>
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<td></td>
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**MAINTENANCE CURRENT FLIGHT REPORT**  
**LEG-00**  
**AIRCRAFT IDENTIFICATION** / F-GGEA  
**DATE** / MAR31  
**ENGINE ON/ENGINE OFF** / 1015/1720  
**PRINTING DATE** : APR02  
**TYC** : 1406

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