AIRLINE TRAINING

APS MCC
A320 STUDY GUIDE

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GLOSSARY OF TERMS & DEFINITIONS

ACARS	Aircraft Communications Addressing and Reporting System
ADC	Air Data Computer
ADF	Automatic Direction Finder
ADS	Air Data System
AFM	Aircraft Flight Manual
ANP	Actual Navigation Performance
APU	Auxiliary Power Unit
AS	Airspeed
ATC	Air Traffic Controller
CAS	Calibrated Airspeed
CDU	Control Display Unit
CMD	Command (Autopilot)
CP	Centre of Pressure
DME	Distance Measuring Equipment
EGPWS	Enhanced Ground Proximity Warning System
EGT	Exhaust Gas Temperature
FADEC	Full Authority Digital Engine Control
FD	Flight Director
FMC	Flight Management Computer
FMU	Fuel Management Unit
GCG	Gross Climb Gradient
GPS	Global Positioning System
GPU	Ground Power Unit
GPWS	Ground Proximity Warning System
IAS	Indicated Air Speed
ICAO	International Civil Aviation Organisation
ILS	Instrument Landing System
IRS	Inertial Reference System
ISA	International Standard Atmosphere
LDA	Landing Distance Available

LDR	Landing Distance Required
LSS	Local Speed of Sound
MCRIT	Critical Mach Number
MCT	Maximum Continuous Thrust
MTOW	Maximum Take-off Weight
ND	Navigation Display
NDB	Non-Directional Beacon
OEI	One Engine Operation
PFD	Primary Flight Display
RA	Resolution Advisory
RNAV	Area Navigation
RTO	Rejected Take-off
SID	Standard Instrument Departure
STAR	Standard Terminal Arrival Route
TA	Traffic Advisory
TAS	True Air Speed
TCAS	Traffic Collision and Avoidance System
VMD	Velocity Minimum Drag
VOR	VHF Omni Range
VZF	Minimum Safe Manoeuvring Velocity

INTRODUCTION

The aim of A320 Study Guide is to provide an understanding of the handling characteristics of a modern, swept-wing jet transport aircraft. The focus is on developing your handling skills by exploring various aspects of the flight envelope. All important elements of flying a high-performance jet aircraft will be covered in the training, from take-off profiles through to terrain escape manoeuvres and an airline-style simulator assessment.

A basic overview of Airbus A320 technical information is included to assist with the APS MCC A320 course. This course is NOT a type rating however, an understanding of aircraft systems is important to free up valuable mental capacity. Please don't feel the need to learn everything in Parts 2 and 3 of this manual however, a good working knowledge would be advantageous, therefore treat this as a reference manual.

It would be worthwhile learning the Airbus Specific Abbreviation list on the following pages. The Glossary of Terms & Definitions is only for reference and does not require committing to memory.

The VA A320 SOPs manual does however require thorough understanding.

AIRBUS SPECIFIC ABBREVIATIONS

Prior to commencing the APS MCC, trainees should know the abbreviations below and MUST know the abbreviations in **bold**.

A/BRK	**Autobrake**
ACP	**Audio Control Panel**
ADIRS	Air Data & Inertial Reference System
ADIRU	Air Data & Inertial Reference Unit
ADR	Air Data Reference
ADV	**Advisory**
A/THR	**Auto Thrust**
BUSS	Back Up Speed Scale
CDU	Control Display Unit
CPC	Cabin Pressure Controller
ECAM	**Electronic Centralised Aircraft Monitoring**
ELAC	Elevator Aileron Computer
E/WD	**Engine/Warning Display**
EMER GEN	Emergency Generator
EOSID	**Engine Out Standard Instrument Departure**
FAC	Flight Augmentation Computer
FADEC	Full Authority Digital Engine Control System
FCC	Flight Control Computer
FCU	**Flight Control Unit**
FD	**Flight Director**
FF	Fuel Flow
FLXTO	Flexible Takeoff
FMA	**Flight Mode Annunciator**
FMGC	**Flight Management & Guidance Computer**
FOB	Fuel On Board
FPA	Flight Path Angle
FPV	Flight Path Vector
FWC	Flight Warning Computer
IR	Inertial Reference
ISIS	Integrated Standby Instrument System
MCDU	Multipurpose Control & Display Unit
MCT	Maximum Continuous Thrust
ND	Navigation Display

NWS	Nose Wheel Steering
PFD	**Primary Flight Display**
PTU	**Power Transfer Unit (Hydraulic)**
RAT	Ram Air Turbine
RMP	**Radio Management Panel**
RNP	Required Navigation Performance
SAT	**Static Air Temperature**
SD	**System Display**
SEC	Spoiler Elevator Computer
SRS	**Speed Reference System**
TAT	**Total Air Temperature**
THS	**Trimmable Horizontal Stabiliser**
TOGA	**Takeoff – Go Around**
V1	**Decision Speed**
V2	**Takeoff Safety Speed**
Vapp	**Approach Speed**
Vdev	**Vertical Deviation**
Vls	**Lowest Selectable Speed**
Vref	**Landing Reference Speed**
ZFCG	**Zero Fuel Centre of Gravity**
ZFW	**Zero Fuel Weight**

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PART 1 - TRANSITIONING TO JET AIRCRAFT

1.1 – ENERGY MANAGEMENT

In order to bring any aircraft from cruising speed and altitude, down to a safe landing, the Kinetic Energy (K.E.) and Gravitational Energy (G.P.E.) must be dissipated. Compared to flying a light aircraft, there are factors that make jet transport energy management a lot more challenging.

Obviously, being larger, jet transports have more energy to dissipate. They are also *relatively* low drag compared to their mass, being optimised for the best ratio of TAS to drag. Since drag is the method by which the aircraft loses energy it stands to reason that this will make energy management more difficult.

Additionally, at idle, Jet engines still produce residual thrust, particularly if the idle value is being raised to provide sufficient bleed air for ice protection purposes. In comparison, Propeller engines will windmill at idle, adding extra drag.

Thus, even for the same energy, energy management needs more planning in a jet.

Now let's compare the cruising energy of a typical light aircraft (1,000 Kg, TAS 100 kts, 5,000') to a typical jet (75,000 Kg, TAS 400 kts, 35,000').

G.P.E. = m g h

m = mass (kg)

g = acceleration due to gravity = 9.82 m/s^2

h = height (m)

K.E. = ½ m v^2

m = mass (kg)

v = True Air Speed (m/s)

Firstly, for the light aircraft:

Converting aviation units into standard physics units.

1,000 kg

100 Kts = 51.4 m/s

5,000 ' = 1524 m

G.P.E. = 1,000 x 9.82 x 1,524 = 15 x 10^6 Joules (15 million joules)

K.E. = ½ x 1,000 x 51.4^2 = 1.3 x 10^6 Joules (5 million joules)

TOTAL ENERGY (light aircraft) = 16.3 x 10^6 Joules (16.3 million Joules)

Secondly, for the jet aircraft:

Converting aviation units into standard physics units.

75,000 kg

400 Kts = 206 m/s

35,000 ' = 10,670 m

G.P.E. = 75,000 x 9.82 x 10,670 = 7.9 x 10^9 Joules (7.9 billion joules)

K.E. = ½ x 75,000 x 100^2 = 1.6 x 10^9 Joules (1.6 billion joules)

TOTAL ENERGY (Jet Transport) = 9.5×10^9 Joules (9.5 billion joules)

If we divide the jet aircraft energy (9.5×10^9 J) by the prop aircraft energy (16.3×10^6 J):

$9.5 \times 10^9 / 16.3 \times 10^6 = 582$

In other words, **the jet aircraft has 582 times more energy!**

Even if we divide by 75, to correct for different masses:

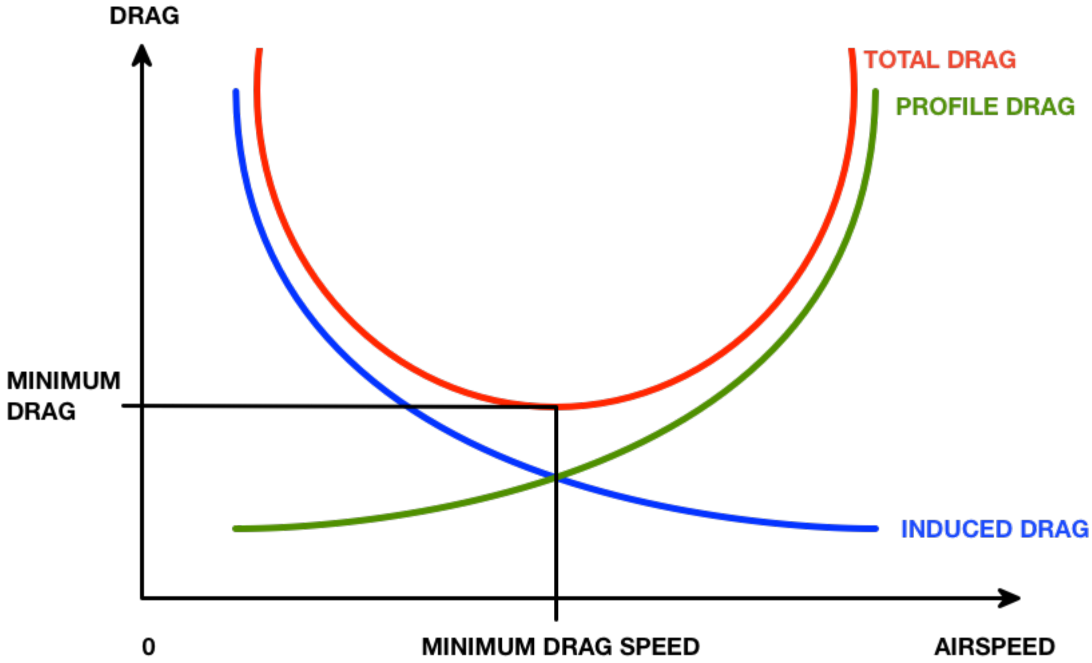
582 / 75 = 7.8

We can see that the jet has nearly 8 times as much energy per unit mass.

Clearly, this figure highlights the energy management issues involved when flying jet aircraft. When planning a typical descent from cruise altitude the distance required can be in excess of 120 miles.

1.2 - DRAG

Much the same as a light aircraft, the drag properties of a jet follow the drag curve, as illustrated below. At speeds below VMD, induced drag increases; at speeds above VMD, induced drag decreases.



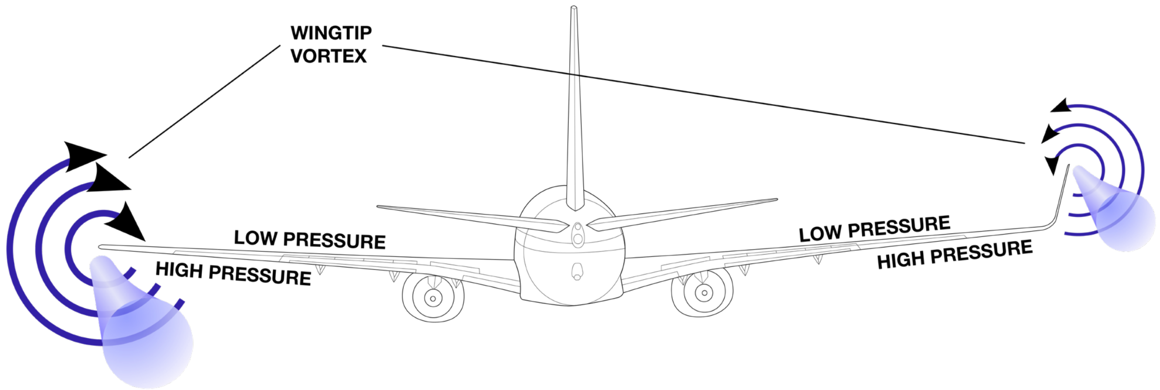
A hot spot with the jet aircraft is the backside of the drag curve. The phase of flight where this is most apparent is when on approach in the landing configuration where the aircraft is flying at a speed below VMD. The speed at this point is said to be unstable.

If an aircraft is in a 'speed unstable' zone, a decrease in airspeed can lead to a marked increase in drag, which leads to a further decrease in speed if left uncorrected.

Energy management in this critical region must therefore be carefully monitored.

1.3 - WINGLETS

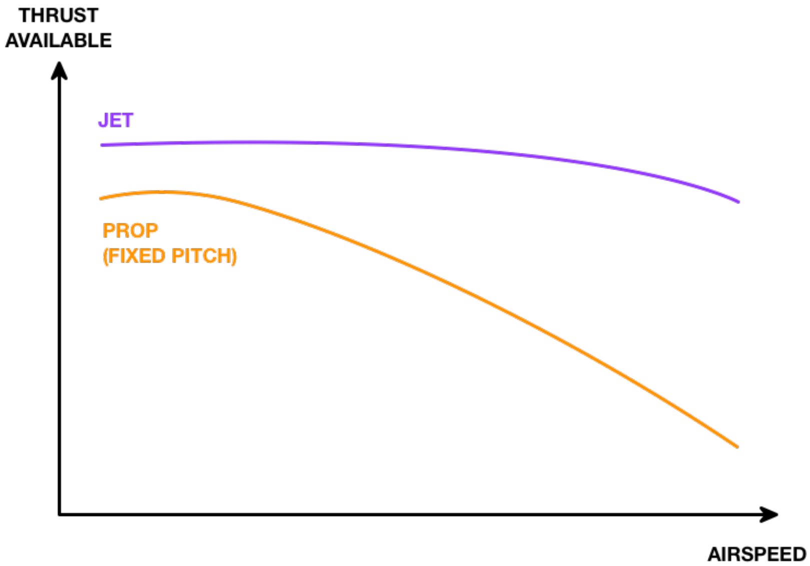
Winglets (Sharklets on the A320) are used on modern jet aircraft to reduce fuel burn by reducing wing-tip vortices, hence induced drag. This in turn has the effect of increasing the aircraft's effective range. However, winglets can affect handling characteristics, and this is most noticeable in crosswinds on take-off and landing as they allow the wind to 'pick up' the wing much more so than a similar aircraft with no winglets.



It should be noted that care must be exercised when using into-wind aileron on the take-off roll in crosswind conditions on aircraft such as the A320 and B737 series, as excessive control wheel deflection can result in roll spoiler deployment, which can increase the take-off distance required due to additional drag created, holds the aircraft on the runway for longer and increases the tendency to pitch up (recipe for a tail strike event) (see section 1.9.2 - Roll Spoilers)

1.4 - EXCESS THRUST

Thrust on a jet aircraft is relatively constant as speed increases, tapering off slightly at the upper end of the speed range due to the ram effect. This differs from a fixed-pitch propeller aircraft, whose thrust decreases as speed increases, as can be seen below.



Excess thrust available on a jet can be very pronounced in the lower levels. However, at high cruise altitudes, excess thrust diminishes substantially due to reduced air density. This will be illustrated during training in the low and high-level stalling exercises.

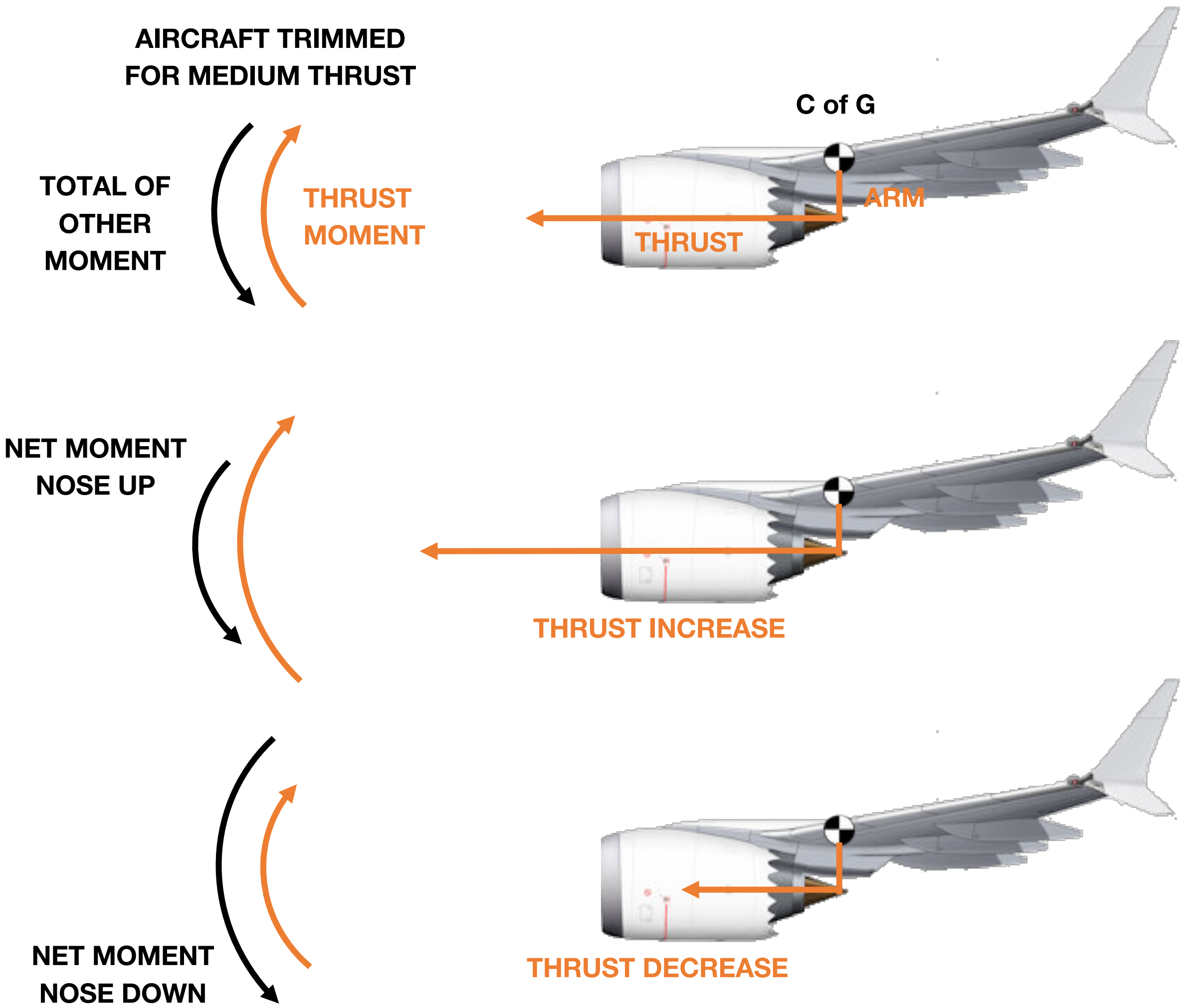
1.5 - SWEPT WINGS

The wing of the jet transport aircraft is swept back. Modern jets have ‘sweep’ that ranges from around 20 degrees to 32 degrees, the latter being the sweep of the Boeing 787. A swept wing has the effect of reducing the angle of incidence of the relative airflow from 90 degrees to less than 70 degrees. This reduces the lift produced by the wing and therefore the amount of induced drag. For this reason, the jet aircraft is able to fly at high cruise speeds but is unable to fly as slowly as a light piston aircraft. The swept wing design enables high-speed cruise with low drag. In addition to wing sweep, the camber of the swept-wing is also generally less than that of the light piston aircraft. This results in less airflow acceleration over the top of the wing. With less camber, therefore less lift produced for a given airspeed, the resultant MCRIT is higher.

MCRIT – the Mach number at which airflow over some point of an aircraft’s surface becomes supersonic

1.6 - PITCH POWER COUPLE

Jet aircraft with 'underslung' engines (i.e. engines mounted beneath the wing) display a characteristic that is referred to as 'Pitch Power Couple'. The engines have a thrust line that is below the aircraft's C of G, which has the effect of producing a pitch-up moment when power is applied and, conversely, a pitch-down moment when power is reduced. If the resultant force acting on the aircraft is not corrected by use of elevator and trim (when in level flight, for instance), the aircraft's pitch attitude will change and the aircraft will depart its altitude. The illustration below shows the forces involved.



Understanding pitch power couple is crucial to flying conventional jet aircraft.

Accurate trimming is the key to accurate manual jet handling.

To recap this important facet of jet flying:

When the aircraft is in trim in level flight and when thrust is INCREASED, a NOSE-DOWN elevator and trim input is required to maintain the aircraft's present trajectory

When the aircraft is in trim in level flight and when thrust is DECREASED, a NOSE-UP elevator and trim input is required to maintain the aircraft's present trajectory

Whenever thrust settings are changed, think PITCH and TRIM

When flying this configuration of aircraft manually, it is recommended not to engage A/THR, mainly because the pilot doesn't know exactly when and how much thrust will be added.

The A320 series aircraft has a very good auto trimming function (whilst in normal and alternate laws) which allows for manual flight with A/THR engaged. Indeed, this is the recommended configuration for a visual approach.

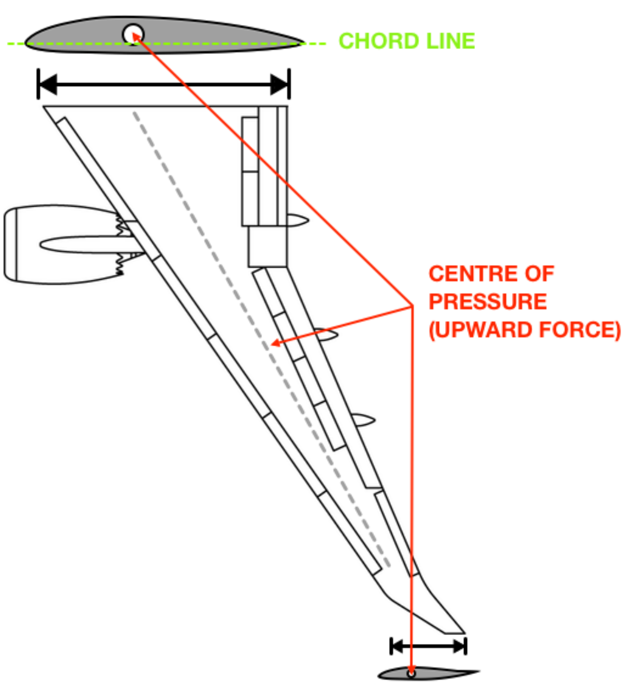
However when in direct law (after lowering the landing gear when already in alternate law) the pitch/power couple becomes a significant issue for the A320. For this reason, it is recommended to fly such an approach with manual thrust.

Direct law approaches are beyond the scope of the APS MCC Course.

1.7 - STALL

In practice, the whole (swept) wing does not stall at the same instant. A simple swept & tapered wing will tend to stall at the tips first because the high loading outboard (due to the taper) is aggravated by sweep back.

This resulting loss of lift at the tips will cause the centre of pressure to move forwards and thus result in a pitch up. This tendency is exacerbated by the pitch power couple on jets with underslung engines when attempting to recover from the stall. If an excessive amount of thrust is applied too rapidly, there is a risk of a secondary stall due to the pronounced pitch-up moment that occurs. More recent stall recovery techniques therefore focus on applying less than full thrust when recovering to avoid this possibility.



When the aircraft stalls, turbulent air that has broken away from the wing surface washes over the tailplane rendering the elevators less effective. This can lead to a 'deep stall', a condition that high 'T'-tail aircraft, in particular, may not be able to recover from.

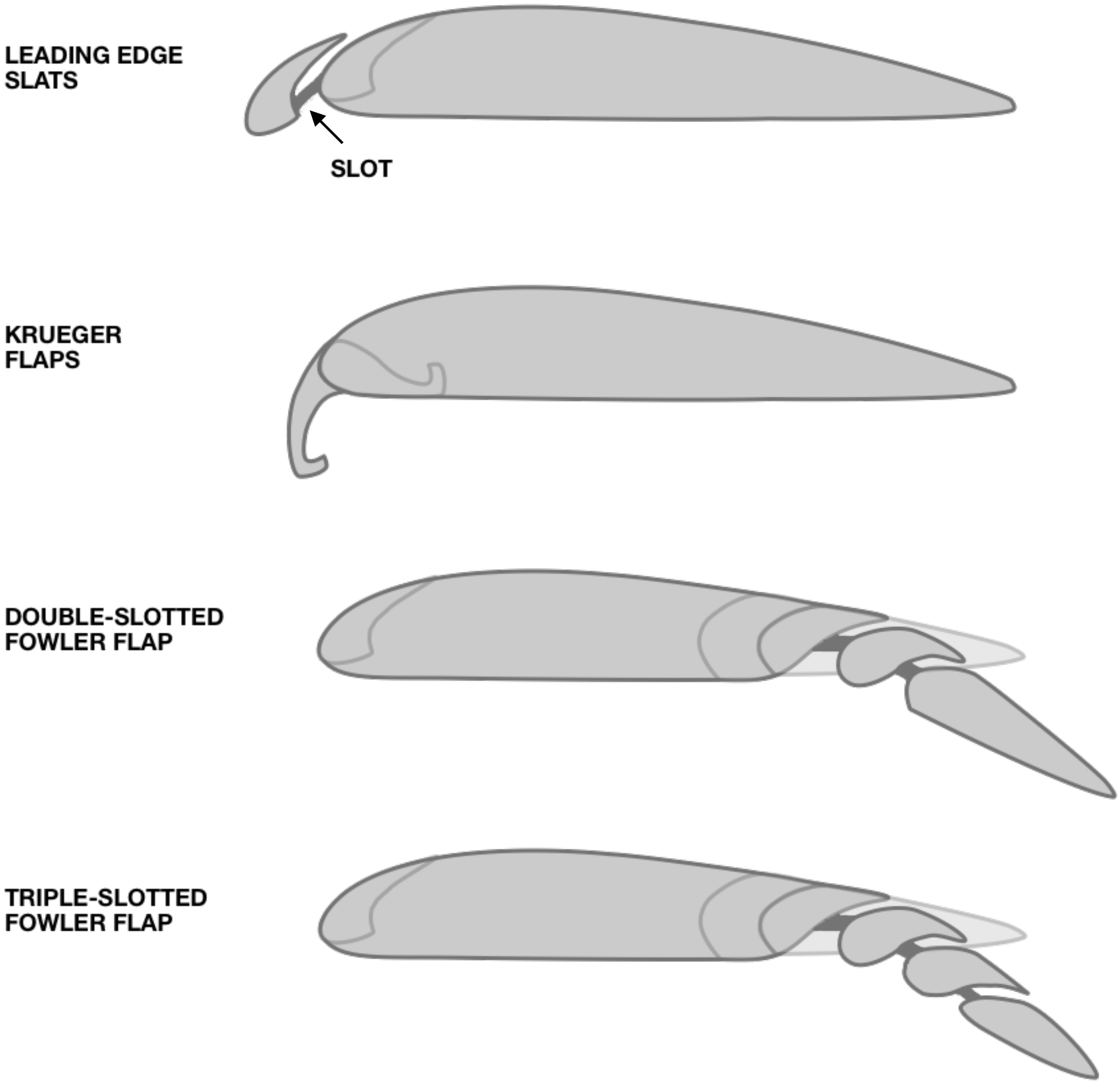
As a result of these unfavourable stall characteristics, modern swept-wing aircraft include some of the following stall prevention systems:

- Stick Pusher
- Vortex Generators
- Fly-by-Wire Elevator Limiter
- Slat Drive Systems
- Aural Warnings

1.8 - LEADING/TRAILING EDGE DEVICES

In order for jet transport aircraft to fly at low take-off and approach speeds, a mixture of leading-edge flaps/slats and trailing edge flaps are utilised. These high-lift devices, which increase the surface area (hence lift) of the wing, are more advanced than those of a light aircraft. Several designs are in use, including Krueger Flaps (leading edge devices) and Fowler Flaps (trailing edge devices), the latter being a very effective slotted design with either two or three slots. Leading edge slats are also used in which a slot is incorporated. The slot designed into both leading-edge slats and trailing edge flaps serves to re-energise the boundary layer, preventing the airflow breaking away from the surface.

The following illustration shows the typical devices used on a modern jet transport aircraft.



1.9 - SPEEDBRAKES, SPOILERS & YAW DAMPER

1.9.1 - SPEEDBRAKES/SPOILERS

Speedbrakes/Spoilers are panels located on each wing that can be raised or lowered manually by the use of a speedbrake lever. They also operate automatically in certain conditions. The panels raise symmetrically (except in the case of roll spoilers) reducing lift by increasing parasite drag. Due to the momentum and efficient wing design on a jet, the speedbrakes are a very useful device. They have several operational functions:

IN FLIGHT (Speedbrakes)

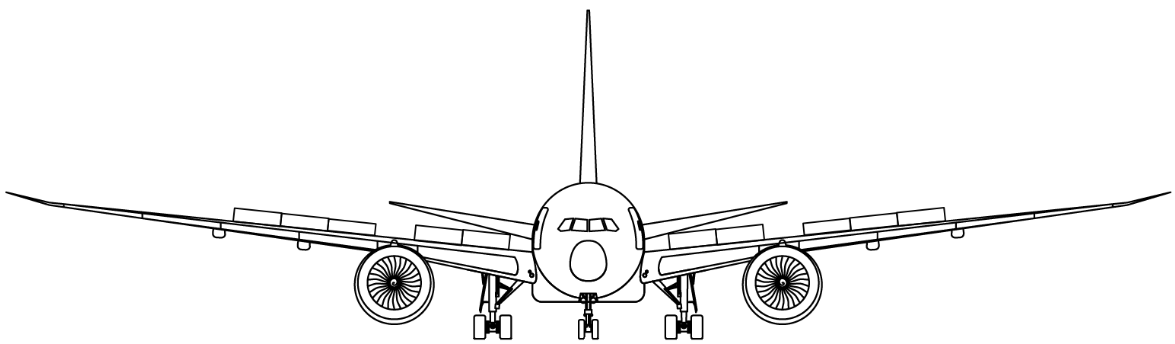
- Assist with reducing airspeed by increasing drag
- Assist with increasing descent rates by 'spoiling' the lift created by the wings
- Allow a combination of both (although they are less effective when used in combination)

To protect the airframe against high air-loads, there is a limit built into the protection system to which the speedbrake can be deployed in flight (which is less than when on the ground).

ON GROUND (Spoilers)

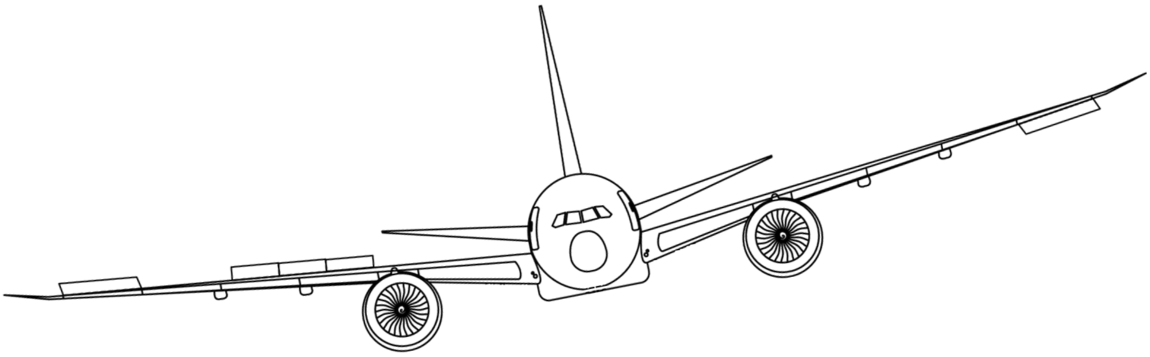
- When set to the 'Armed' position, the speedbrakes deploy automatically on landing ensuring the aircraft remains firmly on the ground by destroying residual lift and increasing the weight on wheels. In both cases, they assist with deceleration due to the drag created.

On ground, all speedbrake panels deploy to their full up position



1.9.2 - ROLL SPOILERS

When executing turns, the down-going aileron (up-going wing) produces more lift, therefore more induced drag. The result of this drag is that the turn becomes unbalanced due to there being more drag on the up-going wing than the down-going wing. To address this imbalance, roll spoilers are automatically deployed on the down-going wing once the roll input is moved beyond a certain deflection, thereby keeping each wing in equilibrium and reducing adverse roll. Pilots must be aware of the potential of roll spoiler deployment when using into-wind aileron when taking off in cross-wind conditions as take-off performance can be compromised.



1.9.3 - YAW DAMPER

Unlike a light piston aircraft where pilot rudder inputs are required to coordinate turns, the jet transport aircraft is fitted with a yaw damper to provide automatic application of rudder to coordinate turns and dampen out yaw in turbulence. On the A320 yaw damping is achieved automatically through the flight augmentation computers. Due to this automatic operation, no rudder input is required in flight by the pilot unless an engine failure occurs or for takeoff and landing in a crosswind.

One other important function of the yaw damper is to eliminate the effects of '*Dutch Roll'.* This phenomenon occurs on swept-wing aircraft due to the high speeds and altitudes at which they fly. It begins when one wing accelerates forward slightly ahead of the other wing. As the wing accelerates, it generates lift and rises causing the aircraft to bank slightly. As the wing rises, it causes induced drag, which in turn results in the wing decelerating. This deceleration produces less lift causing the wing to drop resulting in the aircraft banking in the opposite direction.

If uncorrected, this dynamically unstable condition will continue with the oscillation becoming greater and greater.

1.10 - MACH NUMBER

Mach numbers are an important aspect of operating a jet aircraft. Due to the high altitudes at which jets fly, indicated airspeed is no longer a useful speed reference due to the substantially reduced air density at these altitudes. For this reason, Mach number is the speed reference used. Mach is a measure of the True Airspeed (TAS) of the aircraft given as a percentage of the Local Speed of Sound (LSS).

$$Mach\ Number = TAS/LSS$$

$$LSS = 38.94\sqrt{T}\ (°K)$$

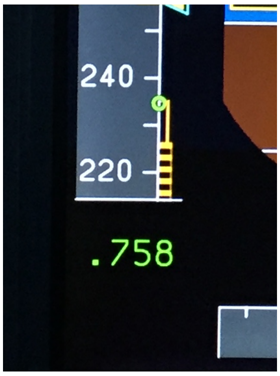
The 'transition' between using indicated airspeed (IAS) and Mach occurs operationally at around 26,000ft. Anything below this altitude is generally referred to by Air Traffic Control (ATC) as IAS; anything above is referred to as Mach.

To understand further why we use Mach number, we first need to understand what happens when flying at high altitude.
As the aircraft moves through the air, certain parts of the relative airflow speed up and slow down as the air passes over the airframe. Since the airflow over the wing has a higher velocity than the airflow beneath the wing, an indicated TAS of 450kts could mean that the airflow over the wing is travelling faster than this speed. If the aircraft speeds up further, the airflow will, over some point of the airframe, eventually become supersonic.

With subsonic jet transport aircraft, we need to know what speed the aircraft is travelling at in relation to the speed of sound to ensure the aircraft does not become supersonic at any point. Such high speeds are avoided due to the shockwaves that occur at or around the speed of sound, as there is a risk of structural damage to the aircraft and the possibility of Mach Tuck occurring.

When flying over oceanic airspace, such as the Atlantic, *Mach Number Technique* is used to ensure sufficient lateral separation is maintained between aircraft in a non-radar environment. An oceanic clearance is issued to each aircraft prior to entering oceanic airspace; one important part of the clearance is the Mach number at which the aircraft is cleared to fly.

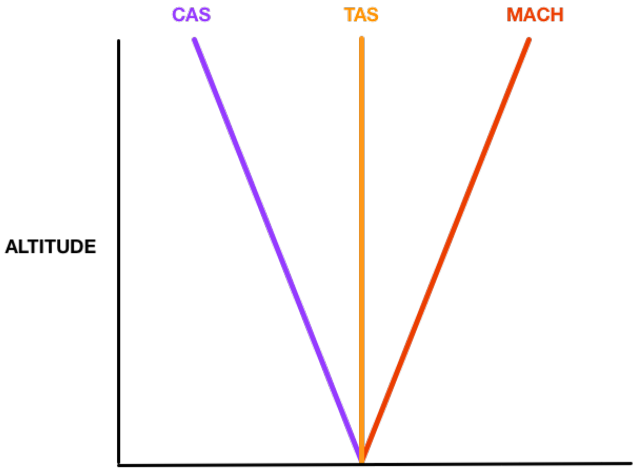
This speed must be adhered to across the entire stretch of ocean until the aircraft is once again identified on radar. Pilots operating in such airspace should always be aware that if the outside air temperature (OAT) increases significantly above ISA conditions, their Mach number may reduce to the point where they may be unable to maintain their cleared speed.



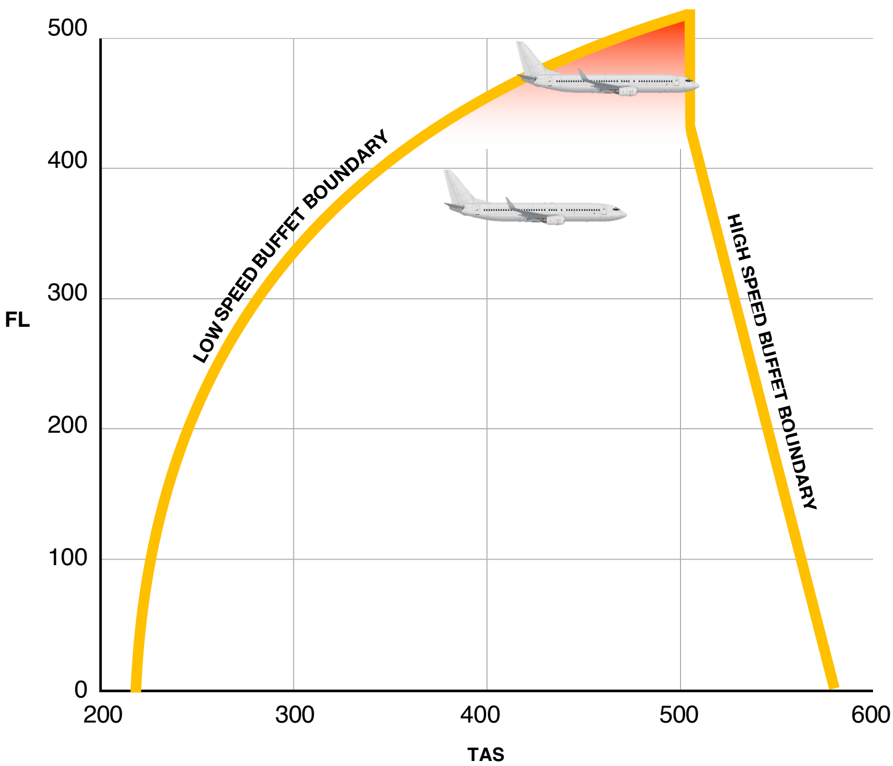
Note: If ATC requested your Mach Number, the response should be "Mach Decimal seven six".

1.11 - COFFIN CORNER

When climbing at a constant indicated airspeed (IAS) in a standard atmosphere, TAS and Mach number increase, as indicated in the diagram below.



As the aircraft's altitude increases, the margin between low-speed stall (as a CAS) and high-speed buffet (Mach) reduce, with the high-speed buffet moving towards the low-speed buffet (see section 1.10 - Mach Number). If the aircraft continues to climb above its optimum cruise altitude, it will eventually reach a critical altitude where the speed differential between the onset of low speed stall and high-speed buffet reduces to zero. This is referred to as coffin corner. Operationally, therefore, a sufficient 'buffet margin' must always be maintained to prevent the aircraft entering this potentially dangerous zone.



1.12 - VMO/MMO

VMO and MMO are maximum operating speeds for jet aircraft. They differ from VNE, which is a 'Never to Exceed' speed that applies to the light piston. Both VMO and MMO are based on structural limitation speeds with a built-in safety margin, as identified by the manufacturer's test pilots in the certification process. VMO is based on indicated airspeed and is relevant in the lower levels; MMO is based on Mach number and becomes relevant at high level. MMO is referenced to MCRIT, with a built-in percentage margin.

AIRCRAFT	VMO	MMO
A320-200	350kts	0.82M
B737-800	340kts	0.82M

1.13 - OPERATING ALTITUDES

1.13.1 - ABSOLUTE CEILING

The maximum altitude to which the aircraft can climb with the engines at maximum continuous thrust (MCT). The theoretical climb rate reaches zero at this altitude i.e. the aircraft is unable to climb further.

1.13.2 - AERODYNAMIC CEILING

The altitude at which high-speed buffet and low-speed stall meet (Coffin Corner).

1.13.3 - SERVICE CEILING

The maximum ceiling at which the aircraft can cruise, still being able to maintain a 500ft/min climb at that level and a 0.2g manoeuvre margin.

PART 2 - AIRCRAFT TECHNICAL

This chapter has been designed to prepare trainees for their APS MCC Course on the Airbus A320 CEO.

This is NOT a technical course. However, using the A320 as a platform, means that having “a working knowledge” of its basic systems, is vital.

This section includes some introductory notes on each system to allow the trainee to understand just enough about that system to successfully complete the Course. TKI will elaborate on these points bringing TEM into the discussion.

In addition some sections contain schematic diagrams. These are for reference only.

Finally, most sections illustrate the ECAM S/D (Systems Display) pages with keys. These are available to crews at any part of the flight. A working knowledge of what the information means (e.g. which are pumps, valves etc) is vital. Again don’t learn these but know your way to the information.

Pre-Course Study (designed to prepare you as well as possible for the Course):

Please read this chapter carefully and feel free to refer to this during the Course.

Learn the Airbus Specific Abbreviations (these will be tested on Day 1).

Read the SOPs and especially the Profile Diagrams.

Review the Self Study Questions – these will direct you to find the information from both the technical chapter and SOPs (including profile diagrams). Expect to be tested on these specific points on Day 1.

Any other reading will be a bonus. If time permits, please simply read:

- The SOPs again (these contain both vital operational instructions but also educational information)
- The Course QRH
- Airbus Protection Philosophies (Part 3 of this manual)

2.1 - AIR CONDITIONING/PRESSURISATION/VENTILATION

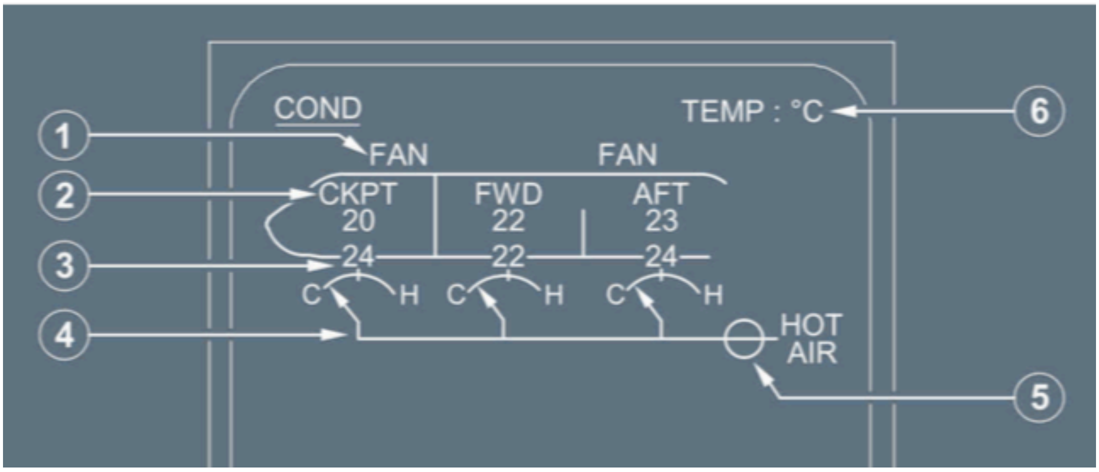
Air Conditioning system is fully automatic (supplied by two packs) which are controlled by temperature controllers on the overhead panel and fine-tuned by the Cabin Crew.

Pressurisation: Constant air being introduced to the pressurised hull and controlled by the outflow valve (either automatically or manually).

Automatic Pressurisation uses CPC (Cabin Pressure Controllers) which take turn on sectors to fully control the pressurisation. The FMGC automatically sets the Cabin Landing Altitude.

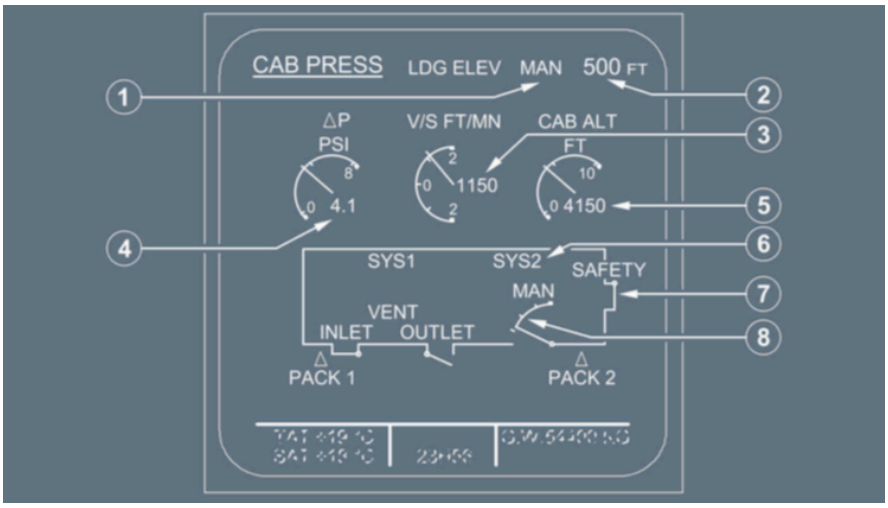
Manual Pressurisation: Flight crew controls the cabin altitude via the manual motor of the outflow valves, by operating controls on the pressurisation control panel.

ECAM COND Page



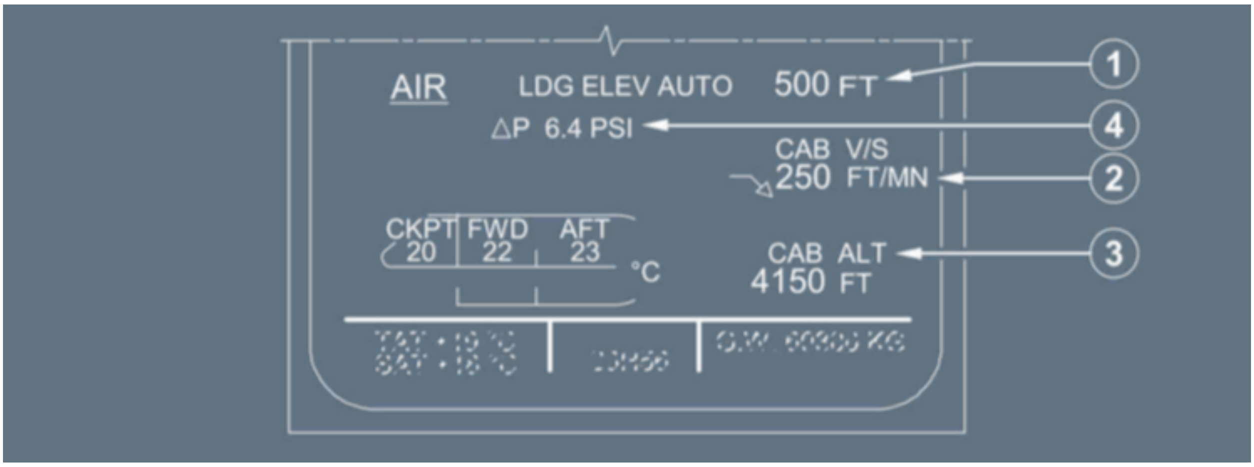
1	Cabin FAN fault indication	It appears in amber, if the recirculation fan is detected as faulty.
2	Zone temperature	It is in green.
3	Zone duct temperature	It appears in green, and becomes amber at 80 °C (176 °F).
4	Zone trim air valve position	The arrow is green. It is replaced by amber crosses (“XX”) if the valve fails. C = Cold valve fully closed. H = Hot valve fully open.
5	Hot air pressure regulating valve	In line – Green : Valve is normally open. In line – Amber : Valve is abnormally open (disagrees with control position). Crossline – Green : Valve is normally fully closed. Crossline – Amber : Valve is closed and pushbutton OFF, or valve position disagrees with control position.
6	TEMP	Unit of measure (°C or °F) is indicated in cyan.

ECAM CAB PRESS Page



1	LDG ELEV AUTO/MAN	- LDG ELEV AUTO: appears in green when the LDG ELEV selector is in AUTO. - LDG ELEV MAN: appears in green when the LDG ELEV selector is not in AUTO. Neither appears when the indications from SDAC are not valid.
2	Landing elevation	The landing elevation selected either automatically by the FMGS or manually by the pilot appears in green (but not when the MODE SEL pushbutton switch is in MAN).
3	V/S FT/MIN (cabin vertical speed)	The analog and digital presentations appear in green when V/S is in the normal range. The digital presentation pulses when V/S > 1 750 ft/min (resets at 1 650 ft/min).
4	ΔP PSI (cabin differential pressure)	The analog and digital presentations appear in green when ΔP is in the normal range. They appear in amber when ΔP ≤ –0.4 PSI or ≥ 8.5 PSI. The digital presentation pulses if Δp > 1.5 PSI (resets at 1 PSI) during flight phase 7. (Refer to DSC-21-20-50 Warnings and Cautions).
5	CAB ALT FT (cabin altitude)	The analog and digital presentations appear in green, in normal range. They appear in red if the cabin altitude goes above 9 550 ft. The digital presentation pulses if the cabin altitude is at or above 8 800 ft (resets at 8 600 ft).
6	Active system indication (SYS 1 or SYS 2 or MAN)	SYS 1 or SYS 2 appears in green when active and in amber when faulty. When either system is inactive, its title does not appear. MAN appears in green when the MODE SEL switch is in MAN.
7	Safety valve position	SAFETY appears in white and the diagram in green when both safety valves are fully closed. SAFETY and the diagram appear in amber when either valve is not closed. Note: The safety valve opens when the cabin differential pressure is between 8.2 and 8.9 PSI. The range is due to the reduced accuracy of ΔP measurements (in MAN mode), combined with the decrease in cabin differential pressure that occurs immediately after the safety valves open.
8	Outflow valve position	The diagram is green when the valve is operating normally. The diagram becomes amber when the valve opens more than 95 % during flight.

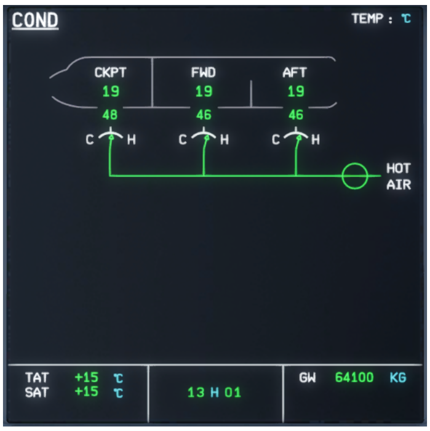
ECAM CRUISE Page



1	LDG ELEV AUTO/MAN	Identical to the CAB PRESS page
2	CAB V/S FT/MIN (cabin vertical speed)	Green, in normal range. Pulses, when the V/S > 1 750 ft/min (resets at 1 650 ft/min). 
3	CAB ALT FT (cabin altitude)	Green, in normal range. Red, for excessive cabin altitude : ≥ 9 550 ft. Pulses for cabin altitude at, or above, 8 800 ft (resets at 8 600 ft).
4	ΔP indication	It is normally green. Pulses green when CAB ΔP ≥ 1.5 PSI before landing. It becomes amber, when out of normal range Δp ≤ -0.4 PSI or ≥ 8.5 PSI.

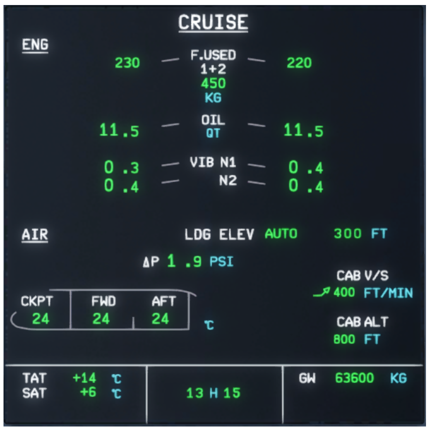
Actual Aircraft Displays

COND Page



CAB PRESS Page

CRUISE Page

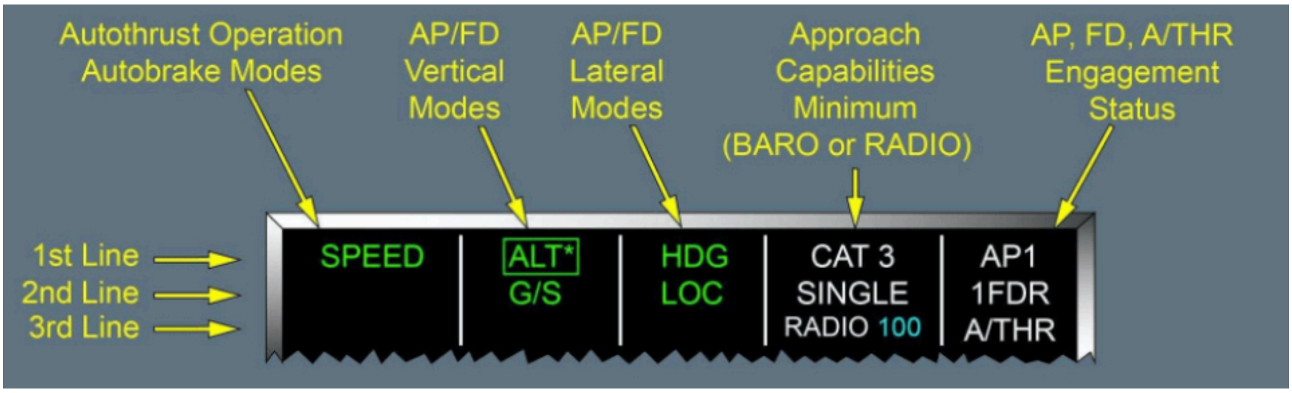


2.2 – AUTOMATION

FCU (Flight Control Unit) on the glareshield is the short-term interface between the flight crew and the FMGC

The FMA (Flight Mode Annunciator) on the top of the PFD has five windows:

A/THR	Vertical Mode	Lateral Mode	Approach Capabilities & MDA/DH	AP/FD/A/THR status



This is the heart of the pilot's interface with the automation.

Pulling a Speed (or Mach), Heading (or Track), Altitude, V/S (or FPA) knob commands "a Selected" value

Pushing the same knobs commands "a Managed" value (Managed means generated by the FMGC).

<u>Flight Directors (FD)</u>

Displays guidance from the FMGC on the PFD. Flight crew may manually fly the aircraft following the FDs or engage the AP to follow.

Flight crew can choose HDG V/S or TRK FPA for their reference & display

<u>Autopilots</u>

AP1 or AP2 can be engaged at 100'. Both APs can only be engaged in LOC/glide-slope or go-around mode.

If engaged with at least 1 FD on, the AP will engage in the current active AP modes. If engaged with both FDs off, then AP engages in HDG V/S or TRK FPA mode (depending upon which is selected on the FCU)

<u>Thrust Levers</u>

Crews can use the thrust levers for:

- Engage takeoff and G/A modes
- Arm & activate autothrust (A/THR)
- Manually selecting engine thrust
- Engage Reverse Thrust

When A/THR is disconnected the TLs control thrust directly.

Five Detents:

TO GA	Max takeoff thrust
FLX MCT	Max Continuous Thrust or FLX at takeoff
CL	Maximum climb thrust
IDLE	Idle thrust for both forward & reverse thrust

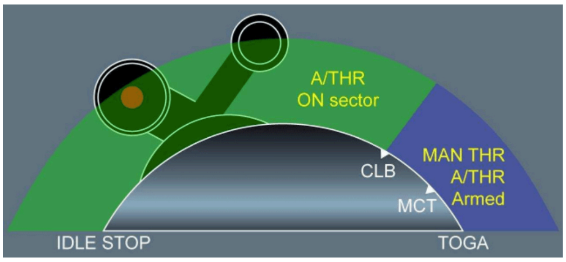
MAX REV Maximum reverse thrust

<u>Autothrust</u>

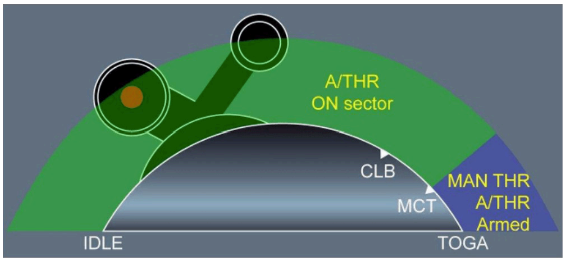
Flight crew arm the autothrust by selecting the A/THR pb on the FCU (on ground) or by setting FLX or TOGA (in the air)

To engage the A/THR from an armed position:

Two Engine Ops: TL in the CL detent



OEI: One TL in the MCT detent



Should the TLs be below the above gates, the A/THR will be limited.

Note: Normal Ops (with A/THR engaged) TLs do not move from the CL gate. For OEI the TL remains in the MCT gate.

To disconnect the A/THR (press either "instinctive disconnect switch" on the side of the TLs

The 2 FACs (Flight Augmentation Computers) controls rudder, rudder trim & yaw damper inputs. It computes data for the flight envelope & speed functions. It also provides low energy aural alert & windshear detection.

2.3 – FMGS

Flight Management Guidance System (for reference only - don't commit to memory).

The flight management and guidance system (FMGS) performs navigation functions and lateral and vertical flight planning functions. It also computes performance parameters and guides the aircraft along a pre-planned route.

The Flight Management (FM) part controls the following functions:

- Navigation
- Management of flight planning
- Prediction and optimisation of performance
- Management of navigation radios
- Management of displays

2.3.1 – NAVIGATION

Essential navigation functions are:

- Computation of position
- Evaluation of position accuracy
- Radio navigation tuning
- Alignment of Inertial Reference System

2.3.1.1 – POSITION COMPUTATION

Each FMGC computes its own aircraft position (called the "FM position") from a MIX IRS position and a computed radio position, or a GPS position

The FMGS selects the most accurate position, considering the estimated accuracy and integrity of each positioning equipment

GPS/INERTIAL is the basic navigation mode, provided GPS data is valid and successfully tested. Otherwise, navaids plus inertial or inertial only are used

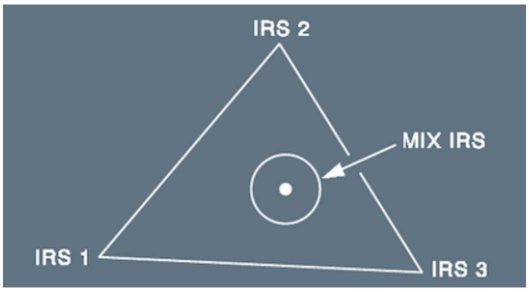
Each FMGC uses onside navaids to compute its own radio position. These navaids are displayed on the SELECTED NAVAIDS page.

The available navaids are:

- DME/DME
- VOR/DME
- LOC
- DME/DME-LOC
- VOR/DME-LOC

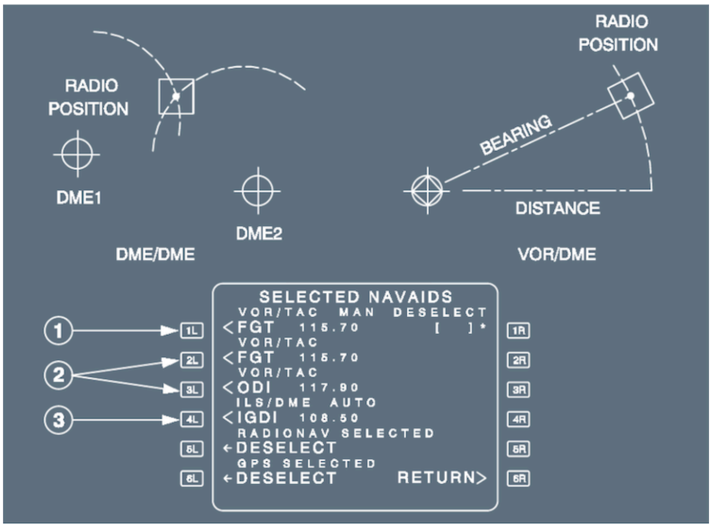
2.3.1.2 - MIX IRS POSITION

Each FMGC receives a position from each of the three IRSs, and computes a mean-weighted average called the "MIX IRS" position:



If one of the IRSs drifts abnormally, the MIX IRS position uses an algorithm that decreases the influence of drifting IRS with the MIX IRS position.

2.3.1.3 - RADIO POSITION

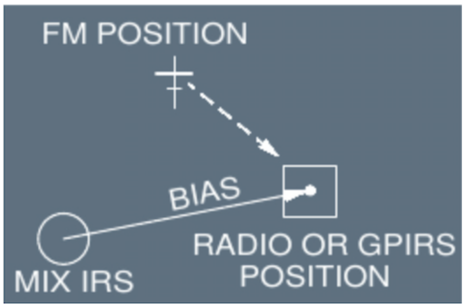


1. VOR/DME selection (auto or manual) for display (onside VOR).

2. DMEs automation selection for DME/DME onside radio position.

3. ILS selection (auto or manual) for LOC update computation.

2.3.1.4 – FM POSITION



At flight initialisation, each FMGC displays an FM position that is a MIX IRS/GPS position (GPIRS):

- At takeoff, when the FM position is updated to the runway threshold position as stored in the database, possibly corrected by the takeoff shift entered on PERF TO Page.

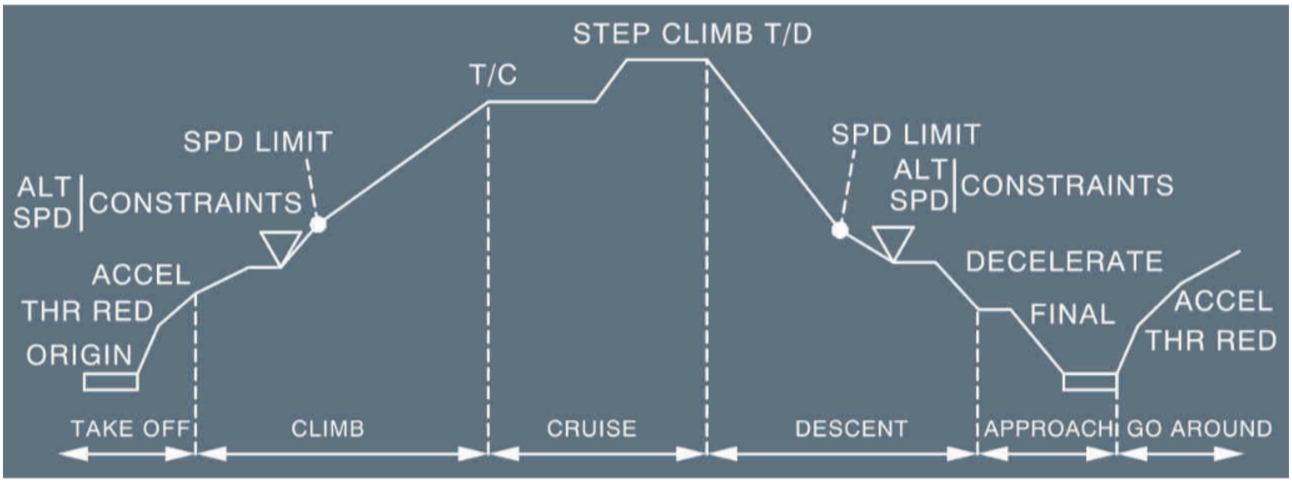
- In flight, the FM Position approaches the radio position or the GPD position at a rate depending upon the aircraft altitude.

Note: The FM position update at takeoff is inhibited when GPS PRIMARY is active.

2.3.2 – VERTICAL FLIGHTPLAN

The vertical flight plan is divided into the following flight phases:

Preflight - Takeoff - Climb - Cruise - Descent - Approach - Go-Around - Done.
All but "Preflight" and "Done" phases are associated with speed and altitude profiles.



Each phase has an assigned profile of target speeds. For each phase the FMGS computes an optimum (ECON) speed as a function of the strategic parameters (CI, CRZ FL, ZFW, ZFWCG, block FUEL) and performance criteria.
ECON speed is the basis of the managed speed profile.

The ECON speed can be modified by:

- Presetting a speed or Mach number on the MCDU (PERF page) for the next phase
- Selecting on the FCU a speed or a Mach number for the active phase
- Inserting speed constraints or speed limits on the MCDU vertical revision (VERT REV) page.

The vertical flight plan includes vertical constraints (altitude, speed, time) that may be stored in the data base or entered manually by the flight crew through vertical revision pages.
The flight crew may also define step climbs or step descents for cruise purposes. If the flight crew plans to climb to a higher flight level or descend to a lower level, they can use a vertical revision at any waypoint to insert the new level.

When all the vertical data has been defined, the FMGC computes the vertical profile and the managed speed/Mach profile from takeoff to landing.

2.3.3 – OPTIMISATION

The FMGC minimises cost by optimising the following items:

- Takeoff, approach, and go-around speeds (F, S, Green Dot, VAPP)
- Target speed for CLB, CRZ and DES phases (ECON SPD/MACH) - Flight Level (for flight crew's information
- Descent profile from CRZ FL down to the destination airport.

These items depend on the data the flight crew inserts during lateral and vertical flight planning and revision procedures.

Most are displayed on the PERF pages associated with the appropriate flight phases.

WIND PROFILE

To obtain the best predictions, the flight crew must enter the wind for the various flight phases and specifically for waypoints in cruise.

- ON GROUND:
  During flight planning initialization, enter the winds for the climb and cruise phases using the HISTORY WIND and WIND pages. Enter, manually or with ACARS, different wind values in the climb and cruise phases. The system will compute a wind for all waypoints of the F-PLN using linear interpolation between manual/ACARS entries.
  The wind profile will be displayed on the F-PLN B page, and is called forecast wind profile. Flight crew or ACARS entries are displayed in large font, and system-computed winds in small font.

- IN FLIGHT:
  The system updates the predictions and the current ECON speed, using the measured wind at the present position. It combines actual wind and forecast winds to compute the wind ahead of the aircraft, but this is totally transparent to the flight crew.
  During cruise, the flight crew will enter the descent winds and the approach wind. The system will update the final predictions, compute the optimum descent profile and compute the optimum speed in descent and approach.

The forecast wind profile will be used to compute fuel and time predictions, as well as ECON speed/Mach targets.

2.3.4 – COST INDEX

The cost index is a fundamental input for the ECON SPEED or ECON MACH computation. ECON SPEED and ECON MACH reduce the total flight cost in terms of flight time and fuel consumption (and not only in terms of fuel saving). CI is the ratio of flight time cost (CT) to fuel cost (CF).

CI = CT/CF (kg/min or 100 lb/h).
CI = 0 corresponds to minimum fuel consumption (Max Range).
CI = 999 corresponds to minimum time.
CI = Long Range Cruise

Note: The airline's operations department usually defines the cost index, to optimize each company route. The flight crew does not ordinarily modify the cost index during a flight.

2.3.5 – COMPUTATION OF PREDICTIONS

The system calculates various predictions for the active flight plan and updates them continually during flight as functions of:

- Revisions to the lateral and vertical flight plans
- Cost index
- Current winds and temperature
- Present position versus lateral and vertical flight plans
- Current guidance modes
- Speed control (managed/selected)

The MCDU and the ND show these predictions, each of which is based on specific assumptions.

Note: During computation, prediction fields on the MCDU pages display dashes.

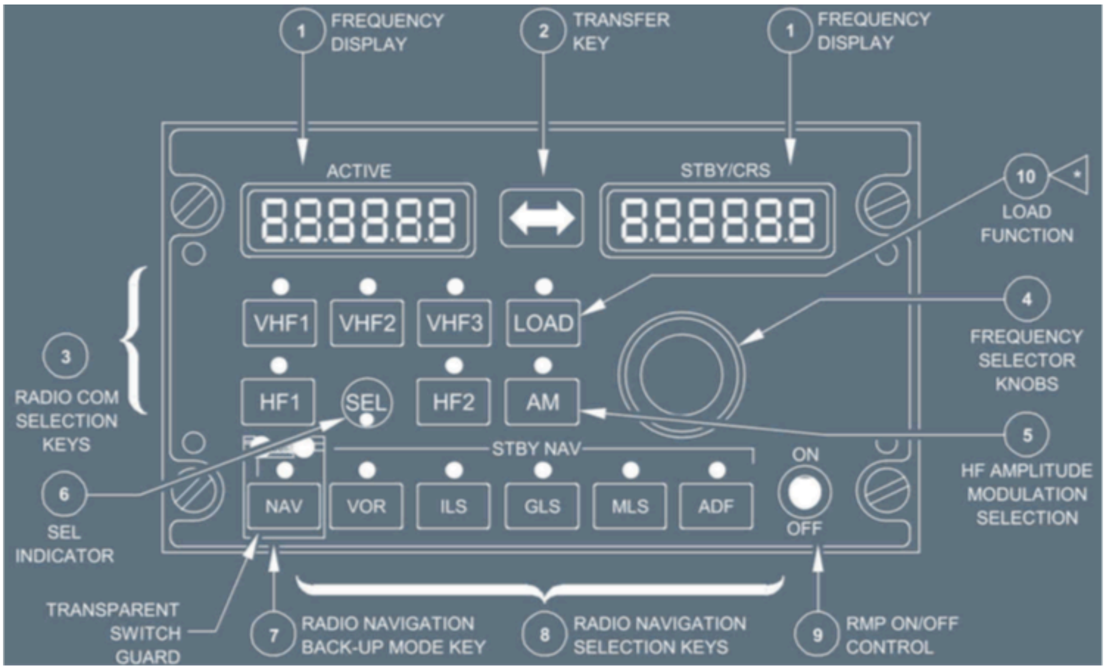
2.4 - COMMUNICATIONS

Consists of VHF/HF transceivers, Radio Management Panels & Audio Control Panels.

Audio Control Panel allows pilots to receive nav ident, use interphone systems, call systems, PA.

Cockpit Voice Recorder (automatic on a 2 hr loop).

RMP



1	Frequency displays	The ACTIVE display window shows the active frequency of the selected radio, which is identified by a green light on the selection key. The STBY/CRS (standby/course) display window shows a standby frequency that the pilot can activate by pressing the transfer key or change by rotating the tuning knobs
2	Transfer key	Pressing this key moves the active frequency to the standby window and the standby frequency to the active window. This tunes the selected receiver to the new active frequency.
3	Radio com selection keys	When the pilot presses one of these keys: • The ACTIVE window displays the frequency set on that radio. • The STBY/CRS window displays the selected standby frequency or course. • The selected key displays a green monitor light.
4	Frequency selector knobs	The pilot uses these concentric knobs to select the STBY frequency or CRS. The outer knob controls whole numbers; the inner knob controls decimal fractions.
5	AM pb-sw	If the aircraft has HF radios and the flight crew has selected an HF transceiver, this switch selects the AM mode. (The default mode is the SSB, or single side-band, mode). This key displays a green monitor light when the AM mode is active.
6	SEL indicator	The SEL indicator on both RMPs comes on amber when a transceiver normally associated with one RMP is tuned by another: • VHF 1 tuned by RMP 2 or RMP 3, • VHF 2 tuned by RMP 1 or RMP 3. • VHF 3, HF 1, HF 2 ( ) tuned by RMP 1 or RMP 2.
7	NAV pb sw (with transparent switchguard)	The pilot presses this key to be able to select navigation receivers and courses through the RMP. It does not affect the selection of communication radios and their frequencies.
8	Radio navigation selection keys	The pilot presses one of these keys to select a navigation radio to control through this RMP. This turns on the green monitor light in the key.

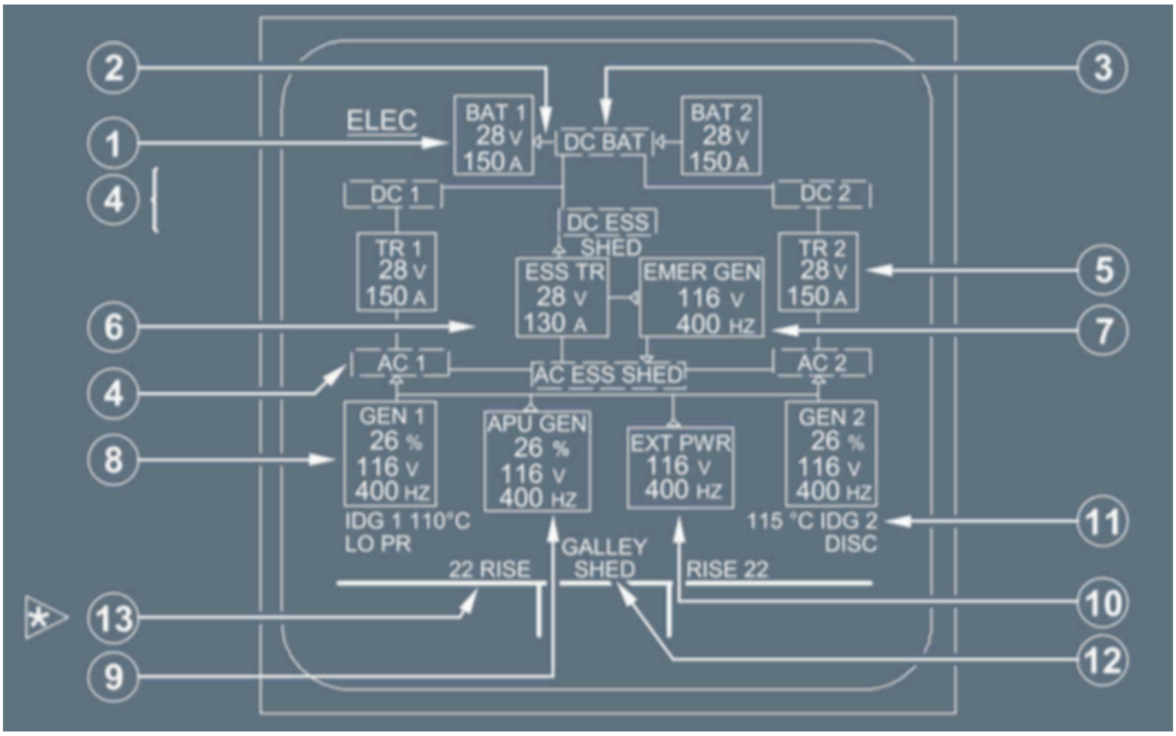
9	ON/OFF sw	This switch controls the power supply to the RMP. Note: RMP 3 is able to control VHF and HF transceivers through RMP 1 and RMP 2 even when they are OFF.
10	LOAD FUNCTION	When the ATC sends (CONTACT or MONITOR) CPDLC messages to the flight crew, a white light above the LOAD key comes on to indicate that the sent frequency is available to be loaded. Press on this LOAD key before closing the CONTACT/MONITOR messages to load this VHF frequency to the STBY/CRS window.

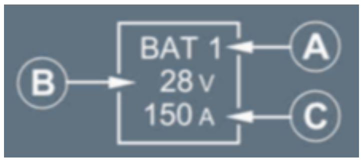
2.5 - ELECTRICAL

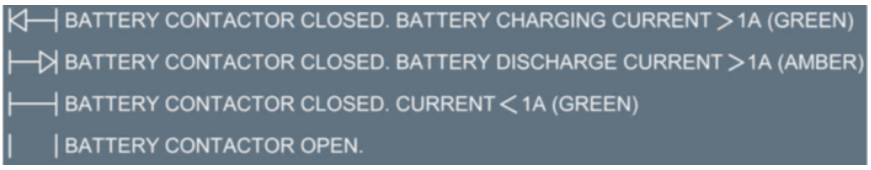
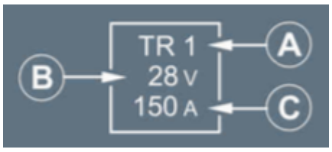
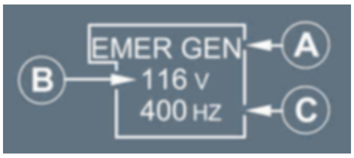
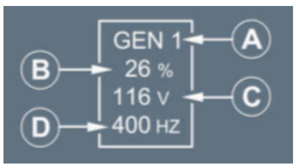
Consists of an AC three-phase, 115/200V 400Hz plus a 28V DC system

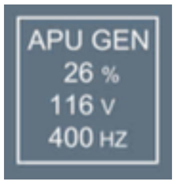
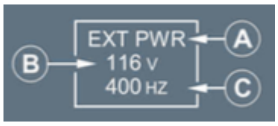
AC generated normally by two engine driven generators with an APU generator as backup in the air and for main supply on the ground. Any one generator can supply AC power to all electrical bus bars. Some DC power is generated from this AC power. On the ground, external AC supply can be connected.

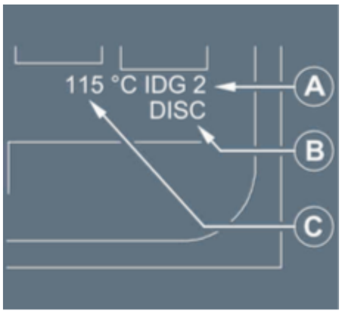
ECAM ELEC Page



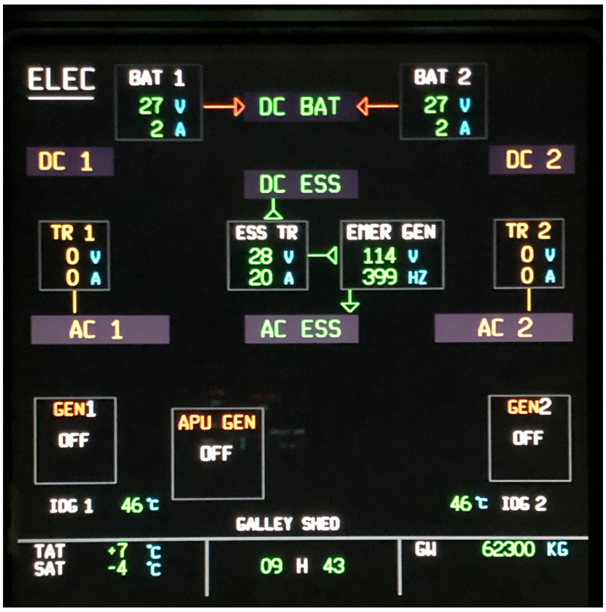
1	Battery indications	- BAT pb-sw at OFF: Legend is in white  	- BAT pb-sw at Auto:  A. Legend is normally white, but becomes amber: - when voltage and current indications change to amber, or - in case of a BAT FAULT warning. B. Battery voltage is normally green, but becomes amber if V > 31 V or V < 25 V. C. Battery current is normally green, but becomes amber if discharge current > 5

2	Battery charge/discharge indication	
3	DC BAT indication	It is normally in green. It becomes amber, if DC BAT voltage ≤ 25 V.
4	Bus indication	It is normally in green. It becomes amber, when the corresponding bus is off. SHED appears in amber, when AC or DC SHED ESS BUS is off.
5	TR 1 (2) indication	 A. Normally white, this legend becomes amber when legends B and C do. B. The TR voltage is normally in green. It becomes amber, if V > 31 V, or V < 25 V. C. The TR current is normally in green. It becomes amber, when the TR current ≤ 5 A.
6	ESS TR indication	 This legend follows the logic of the above-noted TR 1 (2) legend. The voltage and current are not displayed, when the essential TR contactor is open.
7	EMER GEN indication	 A. This legend is normally in white. It becomes amber when either the voltage or frequency legend becomes amber. B. This legend is normally in green. It becomes amber, if: - V > 120 V or - V < 110 V. C. This legend is normally in green. It becomes amber, if: - F > 410 Hz or - F < 390 Hz . Voltage and frequency indications are not displayed, when the EMER GEN line contactor is open.
8	GEN 1/2 indications	- GEN pb-sw is OFF: GEN is amber. OFF indication is white 1 or 2 indication is white if the associated engine is running, amber if it is not.  - GEN pb-sw is ON.  A. GEN 1 or GEN 2, normally white, becomes amber if any of the following legends become amber.

		B. The load legend, normally green, becomes amber if load > 100 %. C. The voltage legend, normally green, becomes amber if V > 120 V or V < 110 V. D. The frequency legend, normally green, becomes amber if F > 410 Hz or F < 390 Hz.
9	APU GEN indications	- When the APU MASTER sw is OFF this legend is white regardless of the position of the APU GEN pb-sw.  - When the APU MASTER sw is ON, and the APU GEN pb-sw is OFF: The APU GEN legend is amber. The OFF legend is white.  - When the APU MASTER sw is ON and the APU GEN pb-sw is ON: The indications are the same as for GEN 1 (2). 
10	EXT PWR indications	- External power is not available.  - When external power is available:  A. This legend is normally white, but becomes amber, if either of the following legends turns amber. B. This legend is normally green, but becomes amber, if V > 120 V or if V < 110 V. C. This legend is normally green, but becomes amber, if F > 410 Hz or if F < 390 Hz.  - This legend appears during the static inverter test, and when pressing the ELEC pb on the ECAM control panel while ESS BUSES are supplied by the batteries. It is normally green, but becomes amber, if: V < 110 V or V> 120 V. F < 390 Hz or F > 410 Hz.

11	IDG indications	 A. <u>IDG1 (2) legend</u> The IDG legend is normally white, but becomes amber, if: • Oil outlet temperature > 185 °C. • Oil pressure gets too low. • IDG becomes disconnected. The 1 or 2 is white if the corresponding engine is running, amber if it is not and the FADEC is powered. B. <u>DISC/LO PR indication</u> The DISC legend appears in amber, when the IDG is disconnected. LO PR appears in amber, when IDG low pressure is detected and the associated engine is running. C. <u>Oil outlet temperature</u> This legend is normally in green, but appears amber, if T > 185 °C. It flashes, if 147 °C < T < 185 °C (advisory).
12	GALLEY SHED indication	<u>This legend appears in white when:</u> - The GALLEY pb-sw is OFF, or - The main galleys are shed, meaning • In flight, only one generator is operating. • On ground, the aircraft is being supplied by one engine generator only. The legend is not displayed, when the aircraft is in its normal configuration.
13	RISE indication	This number, displayed in green, is the difference between the temperature at the IDG inlet and that at the IDG outlet.

In the event of a total AC generator failure; an emergency generator (powered by the RAT) can supply essential services. If this fails, the electrical system can invert DC power from the batteries for a limited period.



Circuit Breakers (Some monitored by ECAM)

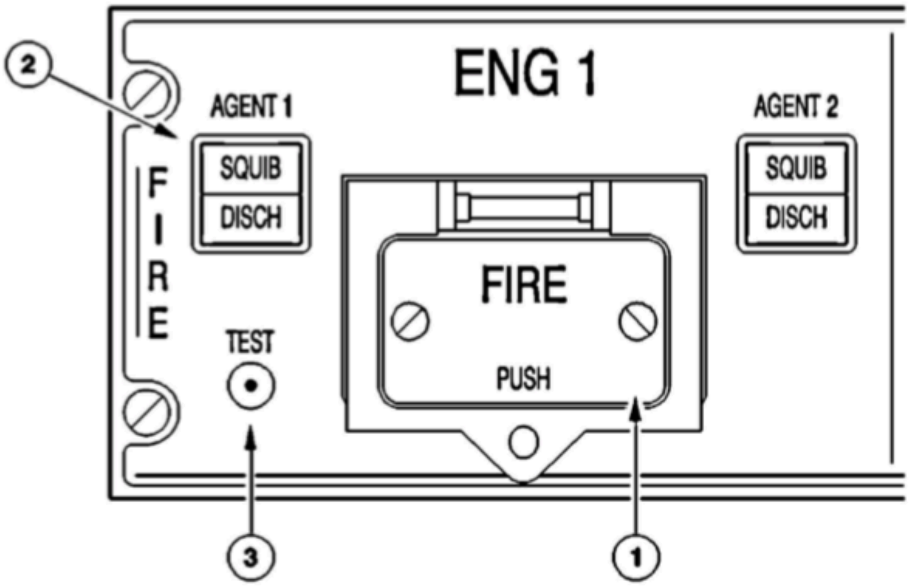
See QRH for C/B Tripped abnormal procedures. Because of the often complex interaction between aircraft computers & computer controlled systems, the practise of tripping & resetting circuit breakers is totally restricted to procedures detailed in the FCOM/QRH.

2.6 - FIRE PROTECTION

Engines:

2 identical detection loops + 2 crew activated fire extinguisher bottles in each engine

ENG FIRE PANEL



The aircraft has two identical ENG FIRE panels, which contain the following switches and indicators:

1	ENG 1 (2) FIRE pb	This pushbutton's normal position is in, and guarded. The pilot pushes it to release it. It pops out, sending an electrical signal that performs the following for the corresponding engine: - Silences the aural fire warning - Arms the fire extinguisher squibs - Closes the low-pressure fuel valve - Closes the hydraulic fire shut off valve - Closes the engine bleed valve - Closes the pack flow control valve - Cuts off the FADEC power supply - Deactivates the IDG
	ENG 1 (2) FIRE lt	This red light comes on, regardless of the pushbutton's position, whenever the fire warning for the corresponding engine is activated.
2	AGENT 1 and AGENT 2 pb	Both of these buttons become active when the flight crew pops the ENG FIRE button for their engine. A brief push on the button discharges the corresponding fire bottle. - “SQUIB” lights up white when the flight crew pops the ENG FIRE button for its engine to help the flight crew identify the AGENT pushbutton to be activated. - “DISCH” lights up amber when its fire extinguisher bottle has lost pressure.

3	TEST pb	This button permits the flight crew to test the operation of the fire detection and extinguishing system. When the flight crew presses it: - A continuous repetitive chime sounds. - The MASTER WARN lights flash. - ENG FIRE warning appears on ECAM. - On the FIRE panel: • The ENG FIRE pushbutton lights up red. • The SQUIB lights come on white if discharge supplies are available. • The DISCH lights come on amber. - On the ENG panel (pedestal): • The FIRE lights come on red.

APU:

Fire & Overheat detection system.

1 fire extinguisher (crew activated in the air & automatic on the ground)

Avionics Bay:

1 smoke detector but no extinguisher

Cargo compartments:

Smoke detectors in each hold with crew operated extinguisher in each compartment

Lavatories:

Smoke detector in the extraction duct and an automatic extinguisher in the waste bin

Automatically fire extinguishing for lavatories

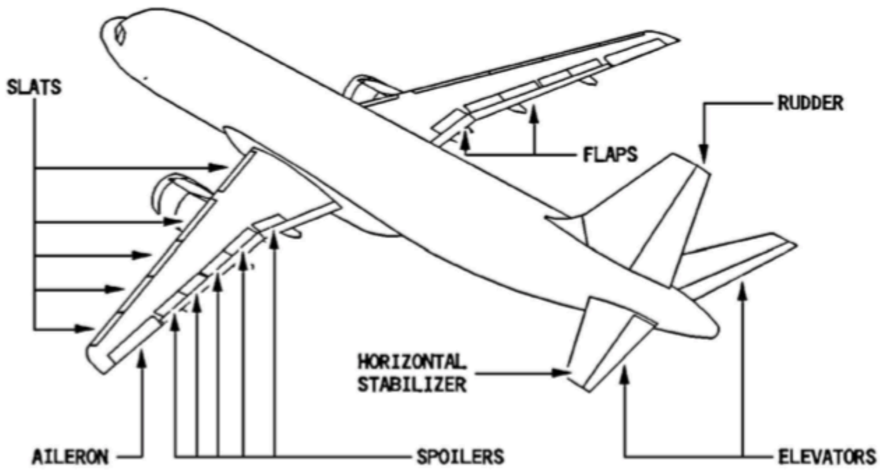
2.7 - FLIGHT CONTROLS

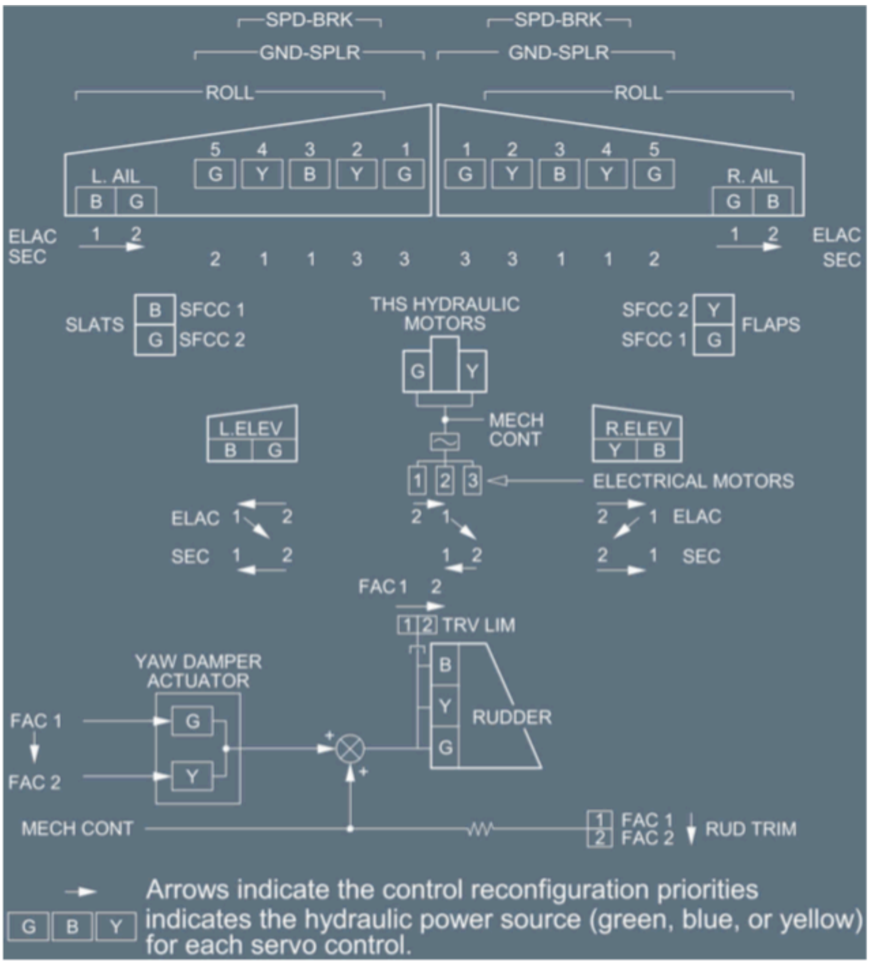
Fly-by-wire system was designed & certified to render the new generation of aircraft even safer, cost efficient and pleasant to fly.

Flight controlled surfaces are all

- Electrically controlled
- and Hydraulically activated

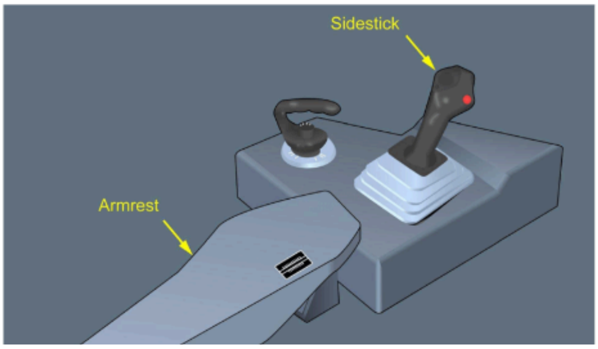
The stabiliser and rudder can also be mechanically controlled (using hydraulic power) in Mechanical Backup Mode (to restore the 5 fly by wire computers after a temporary & total electrical loss).

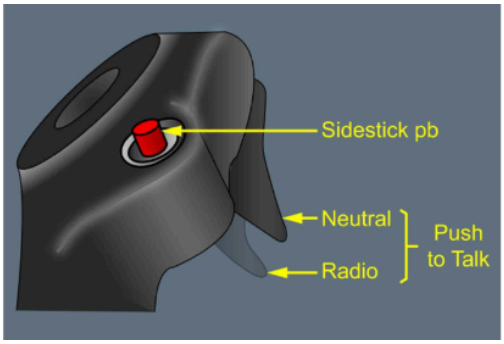




Cockpit Controls:

Each pilot has a sidestick controller to exercise pitch and roll control. The side sticks are NOT coupled mechanically and they send separate sets of signals to the FCCs (Flight Control Computers). Inputs are SUMMED together if "Dual Input" applied – therefore cockpit warnings draw immediate attention to the pilots.





Each pilot has a set of rudder pedals which ARE rigidly interconnected.

1 speed brake lever on the centre pedestal

Mechanically interconnected handwheels on each side of the centre pedestal available to control the THS (Trimmable Horizontal Stabiliser) ONLY when in Direct Law

1 single switch rudder trim on the centre pedestal

No manual switch for trimming ailerons.

There are 7 Flight Control Computers process pilot & autopilot inputs according to normal, alternate or direct flight control laws

2 ELACs (Elevator Aileron Computer)

For normal elevator & stabiliser control

Aileron control

3 SECs (Spoilers Elevator Computer)

For Spoiler control

Standby elevator & stabiliser control

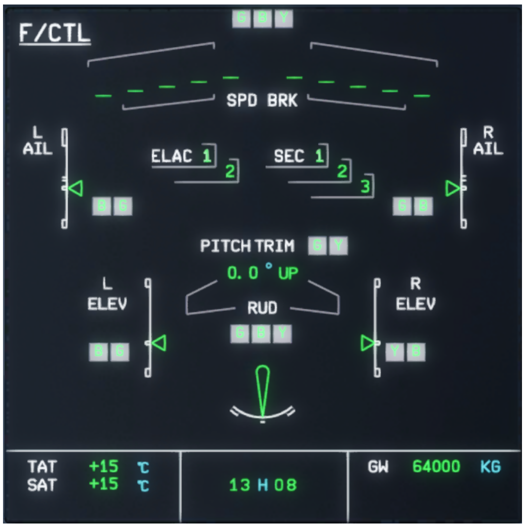
2 FACs (Flight Augmentation Computer)

For electrical rudder control

Flaps & Slats

Surfaces are electrically controlled & hydraulically operated & controlled together by one lever on the centre pedestal.

ECAM F/CTL Page



ECAM WHEEL Page

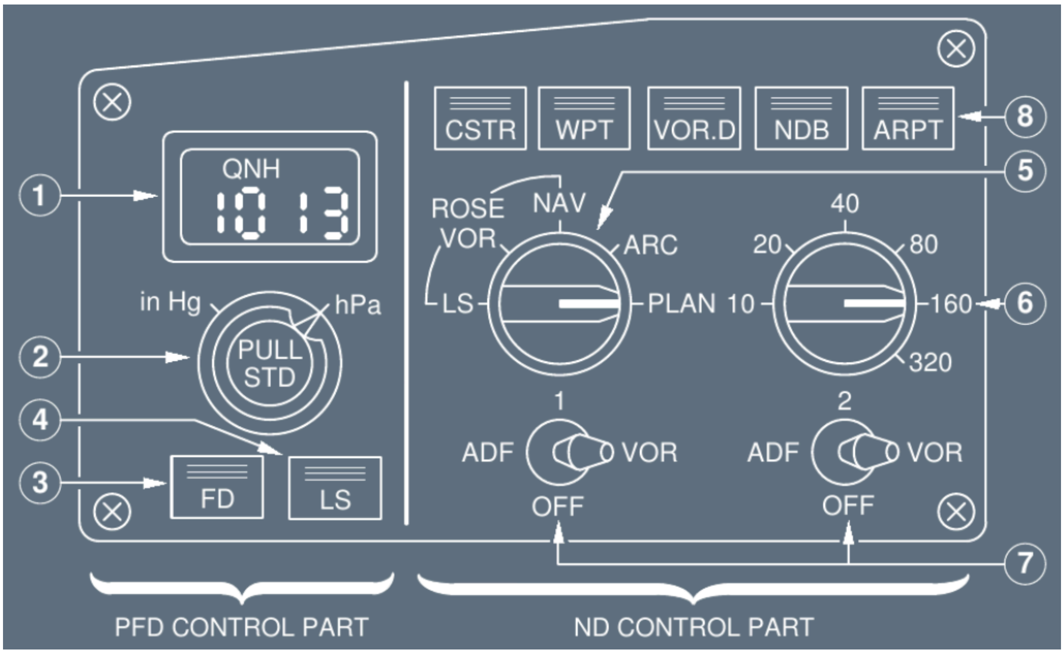
Control Laws

Basically Normal Law provides “Protections”. Alternate Law (which applies during various serious abnormal situations provides “Warnings”. Direct Law is similar to “a conventional aircraft” where the manual pitch trim is used – however the handling is challenging.

See Part 3 (Protection Philosophies) for further information.

2.8 – EFIS

EFIS CONTROL PANEL



1	Barometer Reference Display Window	Range : 745 hPa to 1 100 hPa.
2	Barometer Reference Selector	a. Outer ring : For selection of the units for the barometer reference-either, hectoPascals (HPA) or inches of mercury (in Hg). *Note: The unit selected does not appear on the PFD.* b. Inner knob : For selection of the reference value displayed in the barometer reference display window and on the PFD below the altitude scale. At FCU initialisation, the window displays 1 013 or 29.92, depending on the unit selected. - Pulling the knob selects the standard BARO reference setting. The PFD then displays “STD.” (Rotating the knob has no effect.) - Pushing the knob from the STD position makes the last selected QFE or QNH BARO setting available. - Pushing the knob again changes from QNH to QFE or vice versa. The window displays “QNH” or “QFE” according to the pilot selection. Note: QFE option is a pin program installed on the FMGC. The FMGC operates using the selected pin program (QNH or QFE), independently of the BARO reference setting selected on the EFIS CTL panel.
3	FD pb	Pushing this button removes the FD bars from the associated PFD (or removes the flight path director symbol if the TRK FPA reference is selected). The pushbutton light goes out. Pushing it again restores the FD bars (or the FPD symbol) and the green pushbutton light comes on.

4	LS pb	Pushing this button displays the localizer and glide slope scales on the PFD. Deviation symbols appear if there is a valid ILS signal. The green pushbutton light comes on.
5	Mode Select Switch	This switch selects a navigation display for the onside ND.
6	Range Select Switch	This switch selects a range scale for the onside ND. *Note: If the mode or the range data fails, the default selection is the ROSE NAV mode and 80 NM range.*
7	ADF-VOR Select Switches	These switches select ADF or VOR bearing pointers and DME distance on the onside ND, as well as the corresponding NAVAID data characteristics in any mode except PLAN mode.
8	Optional Data Display Pushbutton	Pushing this button displays optional data in addition to the data permanently displayed in PLAN, ARC, or ROSE NAV modes. The green pushbutton light comes on. Only one option can be activated at a time.

PFD/ND

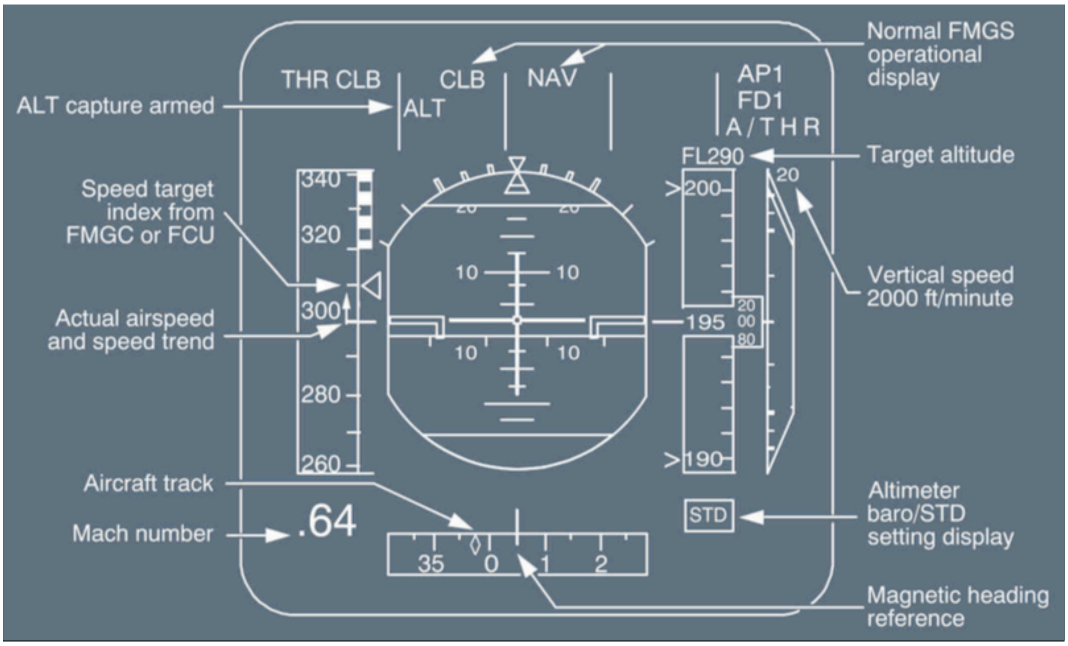
PFD **ND**

PFD

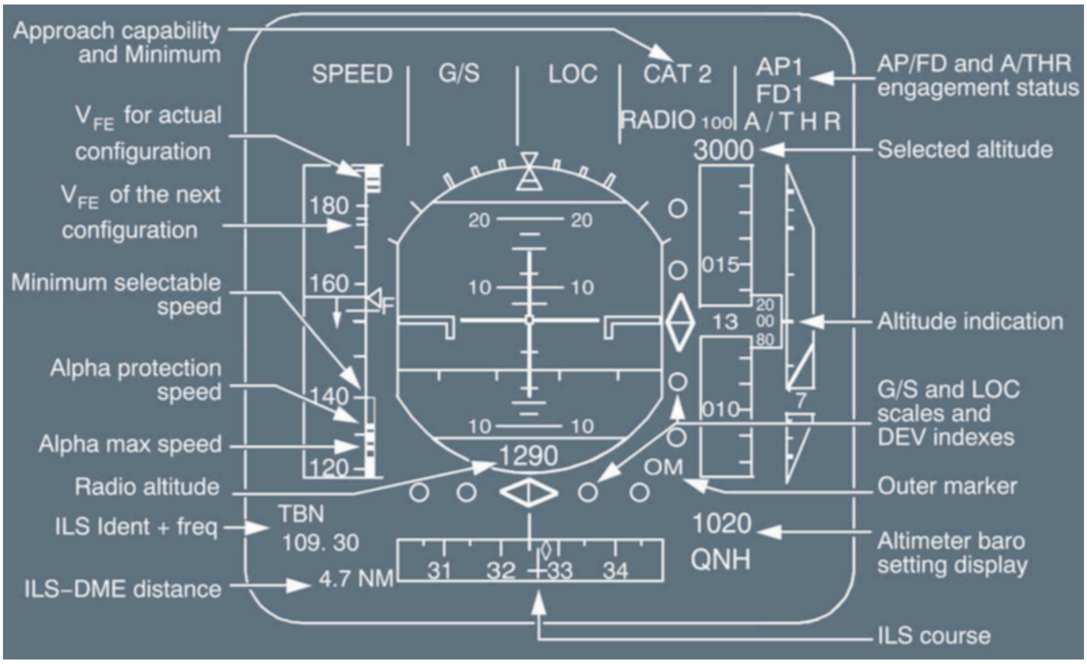
The Flight Management and Guidance System generates the following information to the EFIS Primary Flight Display:

- Armed and engaged modes on the Flight Mode Annunciator (FMA)
- FMGS guidance targets (SPD, ALT, HDG)
- Vertical deviation from descent profile - Messages
- Navigation information.

CLIMB PHASE



APPROACH PHASE

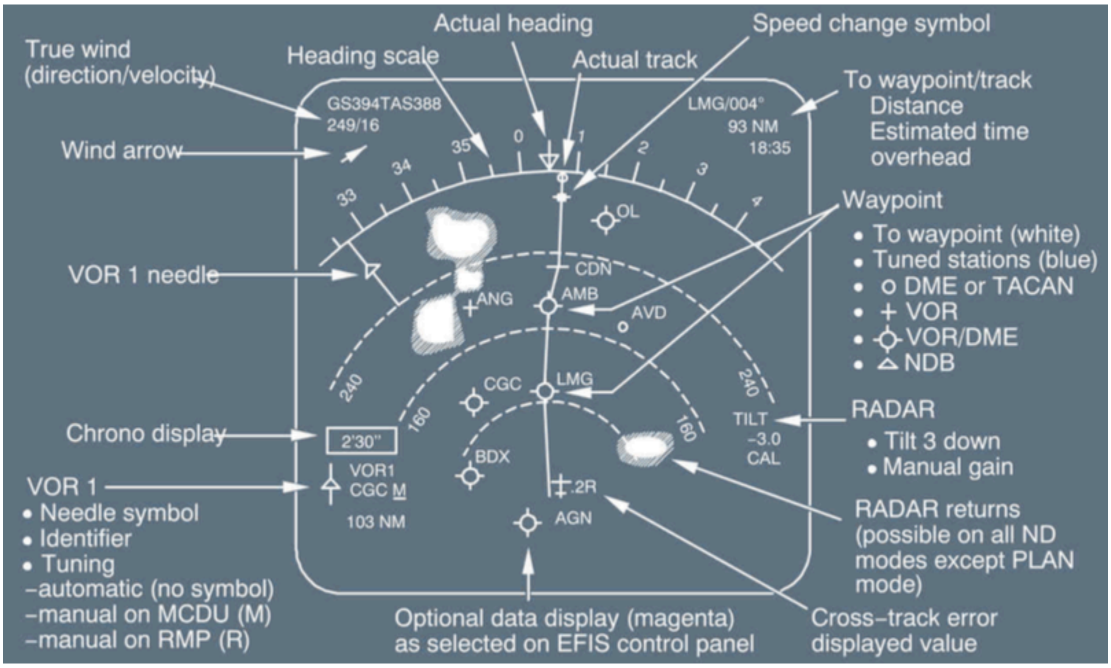


ND

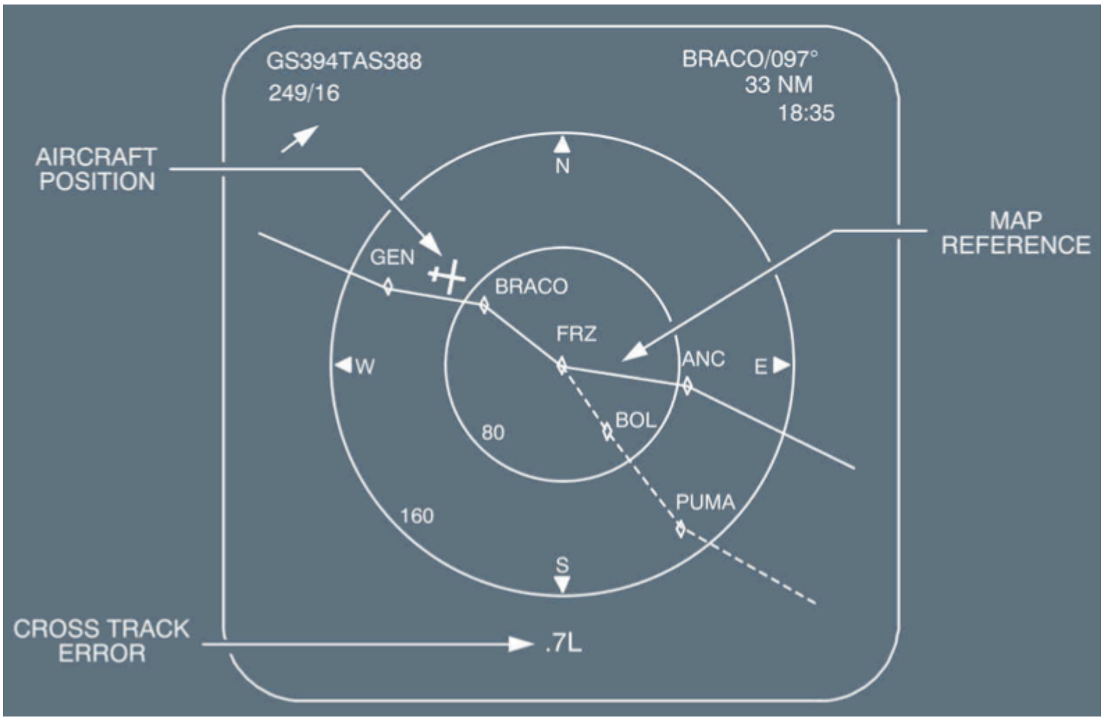
The FMGS generates the following information, displayed on the EFIS Navigation Displays: - Flight plan (active secondary, temporary, dashed)

- Aircraft position and lateral deviation from the flight plan
- Pseudo-waypoints along the flight plan
- Raw data from tuned Navaids and type of selected approach
- Various display options (waypoints, Navaids, NDBs, airports, constraints)
- Wind information and various messages

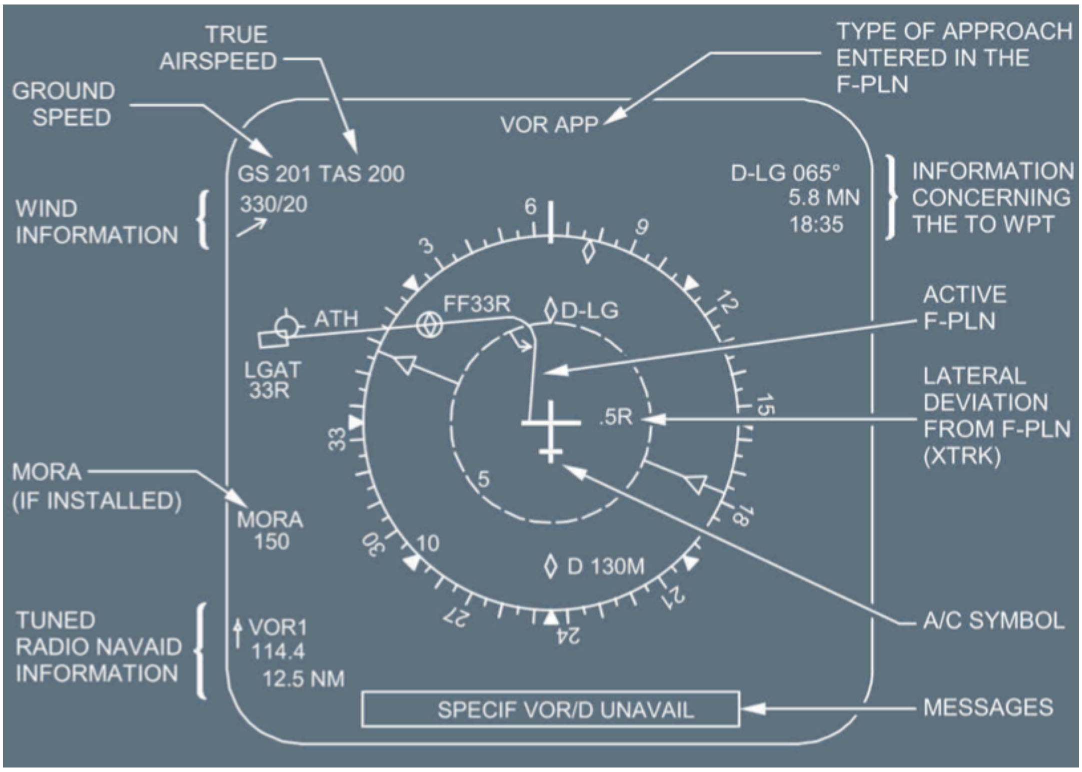
ARC MODE



PLAN MODE



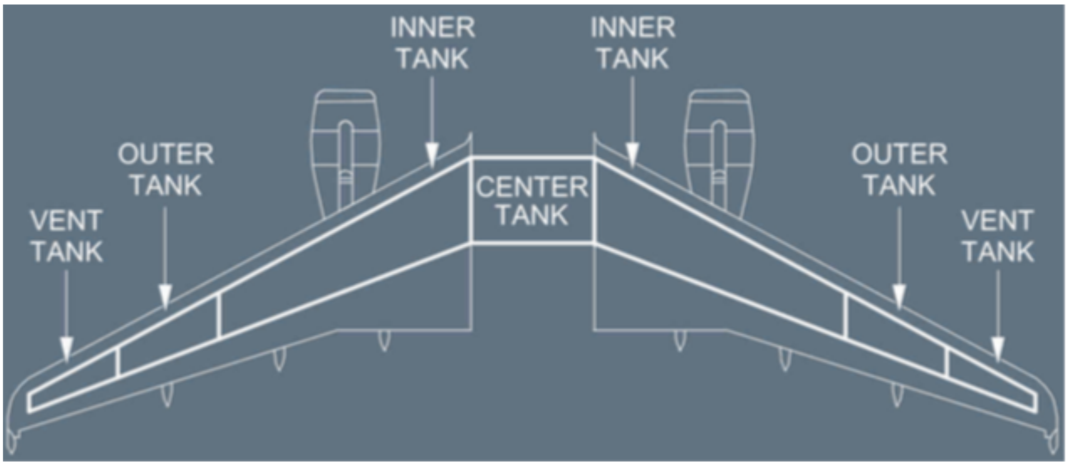
ROSE MODE


TRUE AIRSPEED
GROUND SPEED
TYPE OF APPROACH ENTERED IN THE F-PLN
VOR APP
GS 201 TAS 200
330/20
WIND INFORMATION
D-LG 065°
5.8 MN
18:35
INFORMATION CONCERNING THE TO WPT
ATH
FF33R
D-LG
ACTIVE F-PLN
LGAT
33R
LATERAL DEVIATION FROM F-PLN (XTRK)
.5R
MORA (IF INSTALLED)
MORA
150
D 130M
A/C SYMBOL
TUNED RADIO NAVAID INFORMATION
VOR1
114.4
12.5 NM
SPECIF VOR/D UNAVAIL
MESSAGES

2.9 - FUEL

Fuel stored in wings (inner and outer) and a centre tank for longer flights.

All flights during the course use wing tanks only. Full wings = 12,494 kg

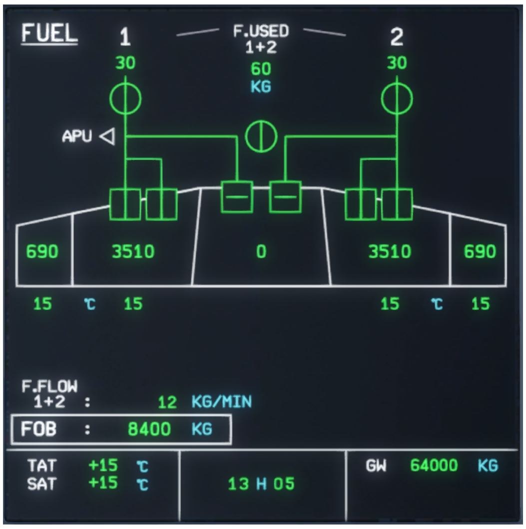


Fuel supplies engines & APU. Also circulates fuel to cool the IDGs (which in turn warms fuel). An automatic valve system leaves fuel in the outer tanks (to aid wing bending and flutter relief) until the inner tanks are depleted to 750 kg. Outer tank fuel then transfers to the inner tank automatically.

Normal Ops: Leave all TK PUMPS ON

Fuel Cross Feeding: Must use QRH to perform this function.

TEM: Be VERY careful not to open the fuel cross feed with a fuel leak.

ECAM FUEL Page	**ECAM Upper Display**
	

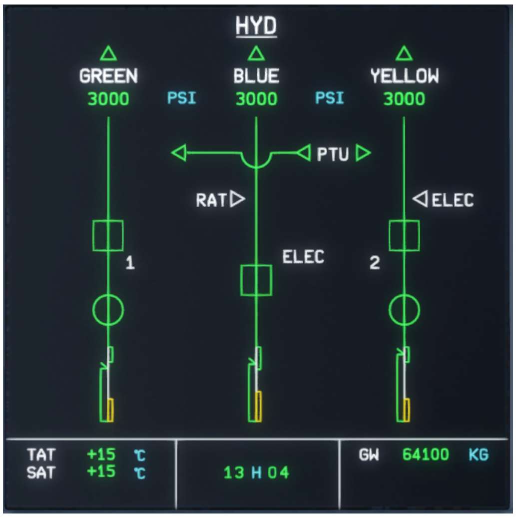
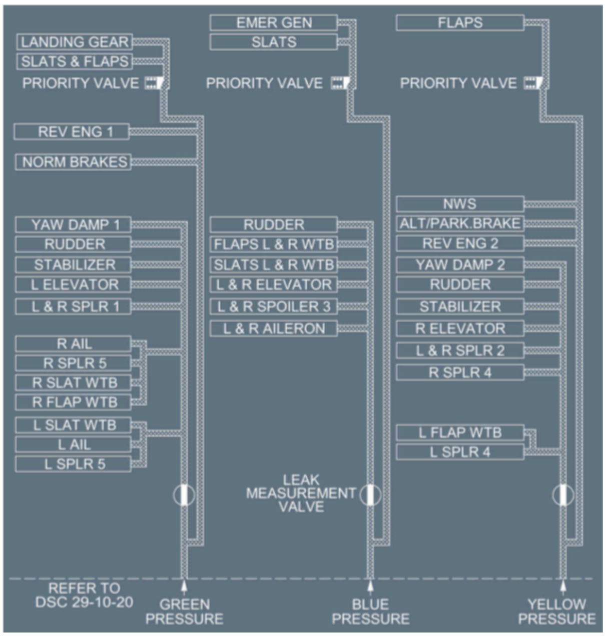
2.10 - HYDRAULIC

Three continuously operating systems: Green, Yellow and Blue normally operating at 3000psi.

Hydraulic fluid can't be transferred between systems.

Various redundancies with pumps and PTU (power transfer unit).

Also RAT will supply 2500 psi to the Blue System (Blue is basically a standby system)

ECAM HYD Page	DISTRIBUTION Diagram
	

Most services are supplied by more than one hydraulic system for redundancy.

A single hydraulic system failure is a minor abnormal

A dual hydraulic system failure is a complex abnormal (Mayday)

A triple hydraulic system failure is essentially "Goodnight Vienna!"

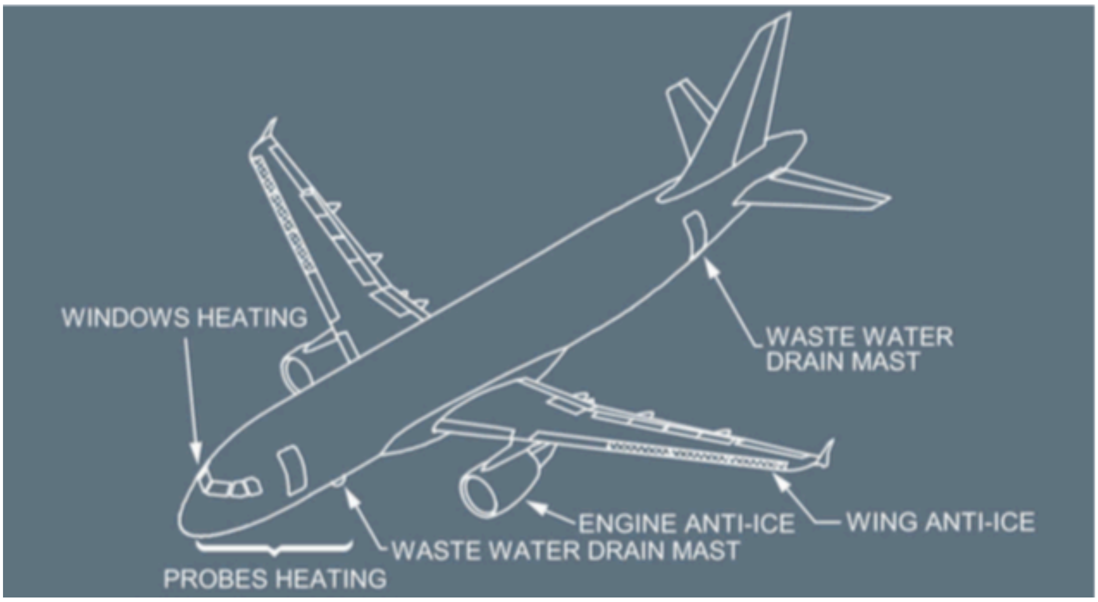
2.11 - ICE & RAIN PROTECTION

Hot air (from the Bleed System) protection:

Engine Anti-Ice: Engine air intakes [Often used: Icing conditions]

Wing Anti-Ice: 3 outboard leading edge slats on each wing [Rarely used]

Icing Conditions: TAT +10°C or below; Visible moisture (clouds, vis <1600m, precipitation, wet runways/taxiways).
SAT <-40°C = no need for engine anti-ice.



Probes & Window Heat:

Normal Ops: PROBE/WINDOW HEAT leave in Auto (heated automatically in flight and on ground with 1 engine running)

Wipers: Rain Protection (max speed 230 kts)

2.12 - LANDING GEAR

LG retraction & extension powered by Green HYD.

Gear rests on locks that can be removed by a hand crank on the centre pedestal in the event of a HYD or ELEC failure.

Nose Wheel Steering powered by Yellow HYD. Tiller steers up to 75° in either direction. Rudder steers +/- 7° and with the steering disconnected for pushback it can be turned 95°.

Normal brakes powered by the Green HYD. Alternate brakes use the Yellow HYD. Both systems have anti-skid that works >20kts. Autobrake system can be armed for LO, MED (or MAX for the RTO) which provides a set deceleration based on braking + amount of selected reverse.

<table>
<tr><th colspan="2">ECAM WHEEL Page</th></tr>
<tr><th>Gear DOWN</th><th>Gear UP</th></tr>
<tr><td>
</td><td>
</td></tr>
</table>

Autobrake is normally disarmed by the crew applying enough deflection to at least one brake pedal.

2.13 - LIGHTS

External:

BEACON: Crew should only turn on when cleared to start. Crew should turn off after parking when N1 < 10%

NOSE: TAXI (for taxi) or TO (for take-off & landing)

RWY Turn Off: For take-off & landing and as required during taxi

The PM should automatically turn the NOSE & RWY TURN OFF lights OFF/ON with Landing Gear retraction/extension

LANDING LIGHTs: Retractable (slight drag when used)

NAV & LOGO Lights: Always ON (Normally use NAV & LOGO LT 1. *However NAV & LOGO LT 2 is used only when NAV & LOGO LT 1 fails*

STROBES: Auto = come on automatically when airborne

Internal:

DOME Light (right) always available (hot-wired from battery)

All lights adjustable with ANN LT switch (dim and bright)

Various rheostats on spotlights and flood lights

Signs:

No SMOKING: Always ON

SEAT BELTS: When in Auto the signs automatically come on with LG or and flaps/slats extended

2.14 - NAVIGATION

3 ADIRS (Air Data & Inertial Reference System) supplies temp, baro pressure & inertial parameters to EFIS (PFD & ND) & other systems including FMGC, FADEC, ELAC, SEC, FAC, SFCC, ATC, GPWS, CFDIU, CPC.

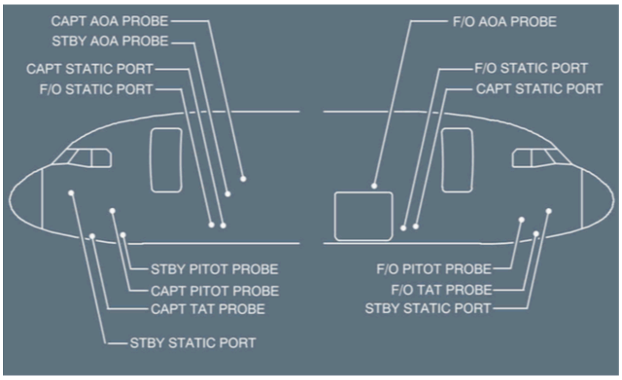
Each ADIRU consists of two parts:

ADR (Air Data Reference) which supplies barometric altitude, airspeed, mach, AoA, temp & overspeed warnings

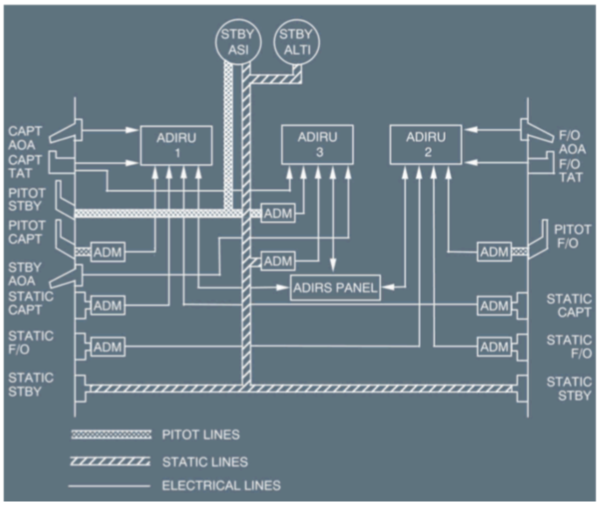
IR (Inertial Reference) which supplies altitude, flight path vector, track, headings, accelerations, angular rates, ground speed & aircraft position

Various electrically heated sensors:

PROBES LOCATION



PROBES SCHEMATIC



GPS

2 independent GPS receivers which also input into the ADIRUs and FMGCs

Standby Instruments

Compass (pulls down from the top of the windshield centre post)

ISIS (Integrated Standby Instrument System) which displays Attitude, IAS/Mach, Altitude, Barometric Pressure, LS function & bugs

Navaids

Three modes of Tuning:

Automatic Tuning: Normal Ops; FMGC tunes as required depending on position and route

Manual Tuning: Crew can “hard tune” navaids as required in the MCDU (interface of the FMGC)

Back-Up Tuning: In case of FMGC Failure, the crew can tune navaids using the Radio Management Panels

RadAlt

Two RAs fitted: RA1 displays on the Captain’s PFD and RA2 displays on the F/O PFD

RAs provide info for FWC generated radio height synthetic call outs

2.15 - OXYGEN

Cockpit fixed oxy system (2 high pressure cylinders) allows breathing oxy for all cockpit personnel in case of depressurisation or emission of smoke &/or fumes.

Fixed chemical generators for all pax located in units above pax seats, lavatories and galley. Lasts ~15 minutes

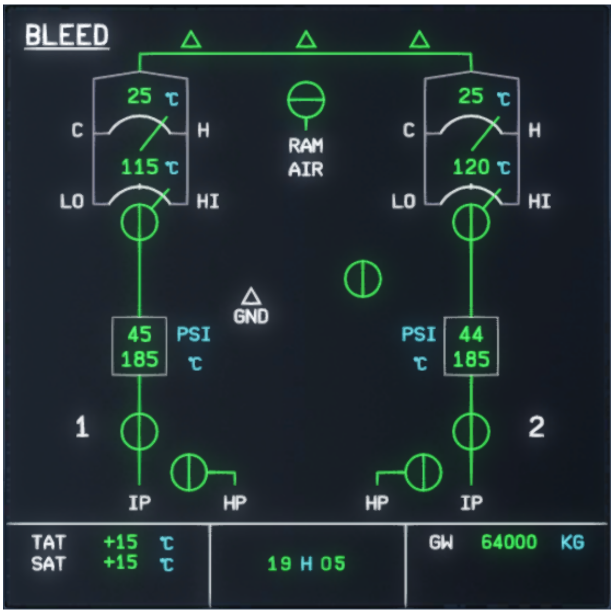
Plus various portable smoke hoods (chemical generated oxy) for fighting fires (lasts 15 minutes)

2.16 - PNEUMATIC

Uses Engine bleed, APU bleed or HP ground connection to supply high pressure for AirCon, Engine starting, Wing Anti-Ice, Water Press, HYD Reservoir Press & Cargo Heating.

A crossbleed valve on the crossbleed duct allows the air supply of both engines to be isolated or interconnected.

ECAM BLEED Page



2.17 - APU

Self-contained unit in the tail that supplies pneumatic & electrical power.

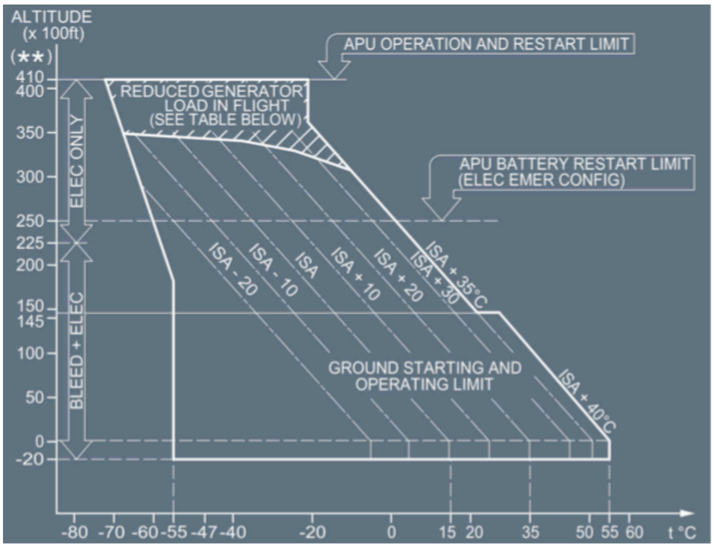
Normal Ops: On ground: Supplies elec power & bleed air for aircon and engine starting

Abnormal Ops: In flight: Backs up elec system, aircon and can be used for engine relight.

Start APU from battery power or ground elec power

ECAM APU Page

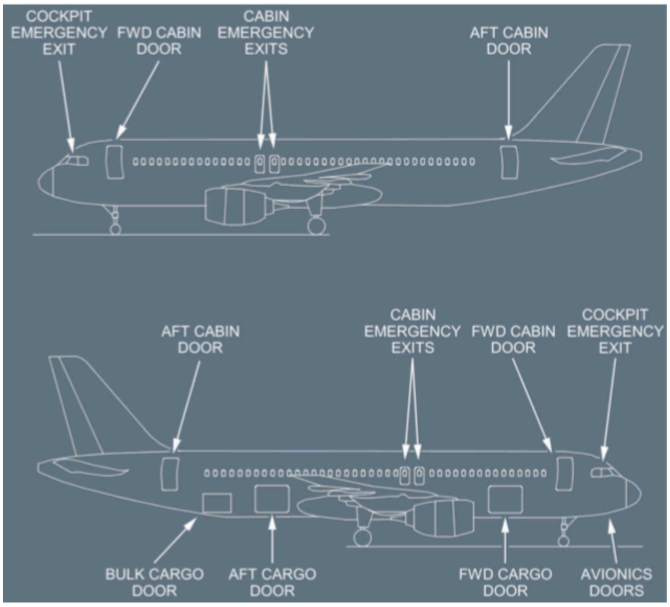
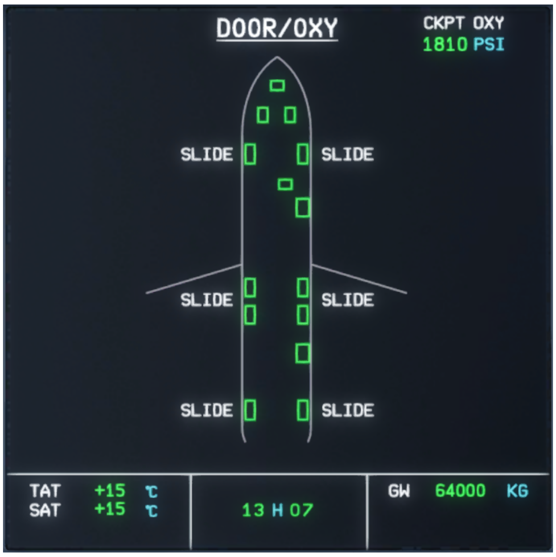
Operational Envelope Diagram (LIM)



2.18 - DOORS

4 pax doors with emergency slides

4 emergency exits in the cabin (with escape slides over the back of the wings)

DOORS	ECAM DOOR/OXY Page
	

Emergency Exit Slides remain permanently armed.

Cabin crew arm the 4 main doors before pushback and approaching the parking position.

2.19 - COCKPIT WINDOWS

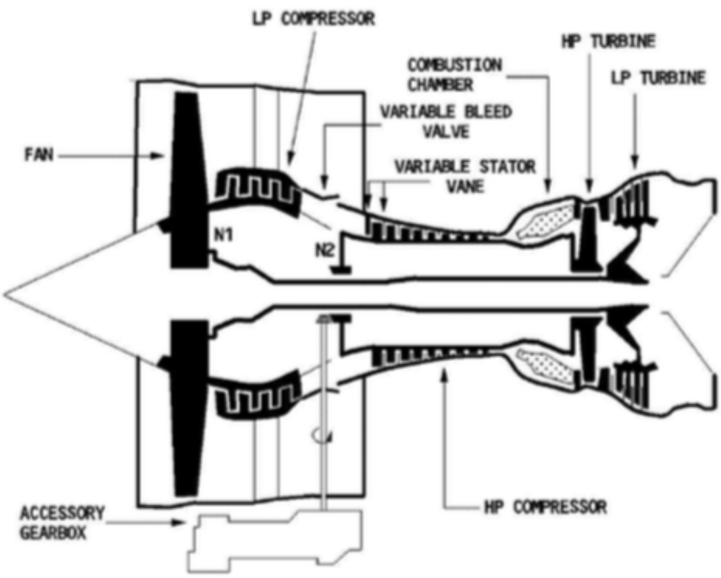
Each pilot has a sliding window for ventilation and escape (with an attached rope above) should escaping via the cabin be problematic.

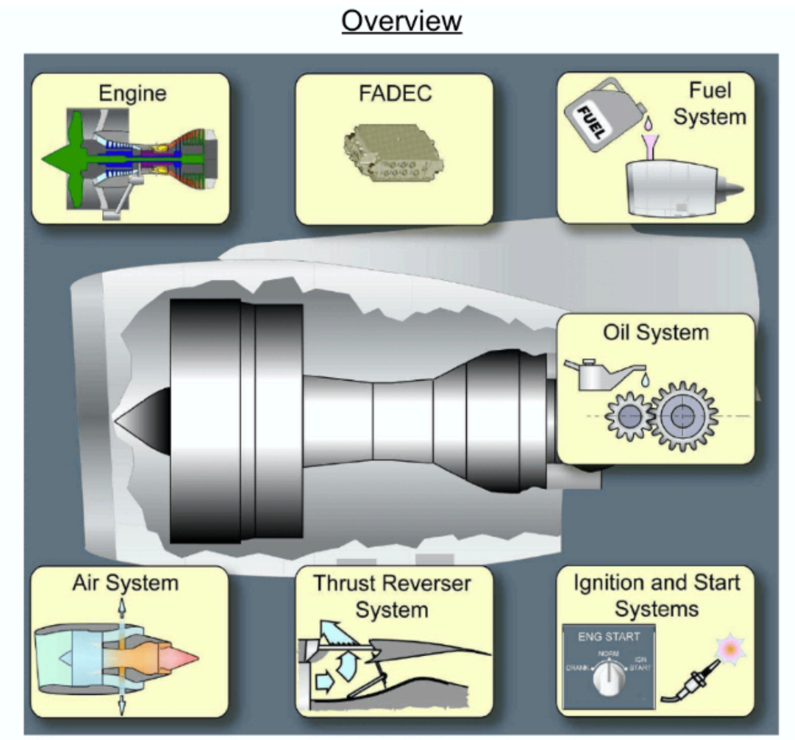
Do NOT open the sliding window in the simulator

2.20 - ENGINES

High bypass ratio, FADEC (Full Authority Digital Engine Control) with thrust reversers.

Engine Schematic





The Accessory Gearbox on each engine operates:

- Oil feed pump that provides the oil system with oil
- Main engine fuel pump that provides the combustion chamber with fuel
- Hydraulic Pumps that pressurise the GREEN & YELLOW hydraulic systems
- Engine driven generators
- FADEC alternator that provides the FADEC with electrical power
- Pneumatic starter that enables the engine start

Engine ECAM displays:

This is referred to as the E/WD page and is always available

Pilots reference N1 (low pressure rotor speed (in %)) when flying

This is referred to as the SD page. This is selectable and therefore not always displayed.

Engine Starting (Automatic):

All engine starts on the APS MCC Course will be automatic (and only covered in this section).

ENG MODE START SELECTOR

NORM: Normal mode of operation.

IGN/START: Use the IGN/START position to:

- Initiate the automatic sequences of the associated engine, when the ENG MASTER lever is set to OFF, or
- Initiate the ignitors in flight as required.

ENG MASTER SWITCH

ON: The FADEC initiates the automatic start sequence of the associated engine, when the ENG MODE selector is set to IGN/START.

OFF: The FADEC shuts down the associated engine or aborts the start sequence.

PART 3 – PROTECTION PHILOSPHIES

3.1 – INTRODUCTION

The A320 series is a family of single isle medium size jets with 2 engines. It has a fly by wire system designed and certified to render the new generation of aircraft even more safe, cost effective, and pleasant to fly.

Fly by wire aircraft are unique in that they use computers and hydraulics to move the control surfaces. The stabiliser and the rudder are the only surfaces that can also be mechanically controlled (in mechanical backup mode – but of course only with hydraulics available)

Multiple computers are used in interpret the pilots input and move the control surfaces. The advantages are that the aircraft surfaces and frame cannot be overstressed. Simply put the aircraft protects itself and will not allow the pilot to carry out excessive manoeuvres or exceed the flight envelop in pitch and roll. There are however, no protections for the rudders.

Airbus uses a set of laws and conditions and they are all labelled "Reconfiguration Control Laws". You do not need to know this in detail as it is not a type rating but it is important to understand the basic principles.

There are three Control Laws and these depend on whether systems are all functioning correctly or you have some failures.

1. Normal Law
2. Alternate Law
3. Direct Law

3.1.1 - NORMAL LAW

Normal Law is made up of five protections and we will discuss what this means for the pilot.

B<u>ank Angle Protection (Lateral)</u>

33 - In a turn that is up to 33° AoB then you do not need to trim, if you put a deflection on the side stick and let go it will keep the angle of bank you have selected.

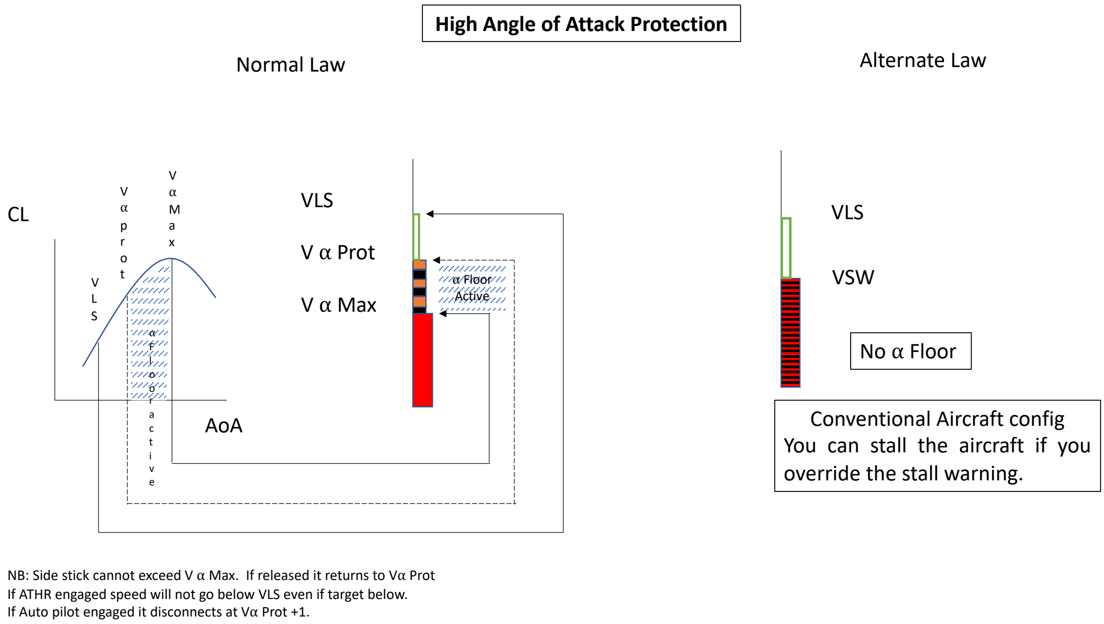
45 - Between 33° and 45° you will need to apply some back pressure. If you let go of the side stick it will return to 33°.

67 - Max bank angle with full side stick deflection in 67°.

L<u>oad Factor Limitation</u>

The computers will not allow you to overstress the airframe. (limits for interest are +2.5g and -1g clean)

Angle of Attack Protection



Pitch Attitude Protection

Indicated by the green symbols "=" on the PFD

Limits

30° nose up (CONF 0 to 3)

25° nose up (CONF FULL)

15° nose down

If you try to pitch the a/c too high or too low the flight directors will disappear.

Speed (High)

If you try to push the nose down to exceed MMO or VMO the computer reacts commanding a nose up signal. It will reduce the pilot's ability to use the side stick to put the nose down. The speed therefore reduces. This is fine as long as you do not encounter unreliable airspeed.

In order to reduce the stress on the aircraft in high speed protection if you release the side stick the aircraft will roll wings level. With side stick input you become limited to 45^0 AoB.

3.1.2 - GROUND MODE, FLIGHT MODE, FLARE MODE AND DIRECT LAW

As the aircraft gets airborne in Normal Law it blends from ground mode into flight mode and the protections all become active. When it comes into land it does the same but passes through Flare mode where it works with pilot to land the aircraft. You will not know this is happening as it replicates the ground effect when an aircraft lands. In Alternate law, however, a number of the protections and modes are lost so it uses Direct Law to land. This only occurs when the gear goes down in Alternate Law.

3.1.3 - ALTERNATE LAW

On the PFD you will know you are in Alternate Law as amber Xs replace the green =.

Protections are reduced and this would replicate a more conventional aircraft.

There are normally three protections available and these are now referred to as "Stabilities".

Low Speed Stability

Replaces AoA protection and it is active between 5-10 kts above the stall warning speed. The computer will introduce a gentle progressive nose down signal. The pilot can override this command and can therefore stall the aircraft. There are Aural Warnings (Crickets and Voice)

High Speed Stability

Above VMO and MMO a nose up command is introduced. There is also an aural warning and the pilot can also override this.

Load Factor Limitation - similar to normal law.

In Alternate Law there is no Flare Mode so the aircraft drops into a basic mode called Direct Law. This allows the pilot to land the aircraft in a conventional way.

3.1.4 - DIRECT LAW

Related to the landing gear being down and on the PFD you will see the words "USE MAN PITCH TRIM"- you will need to trim the aircraft manually the Stab trim wheel located either side of the thrust levers.

Avoid large thrust changes, or sudden speedbrake movements, to help keep the aircraft in trim

3.1.5 - MECHANICAL BACK UP

It's not your day and you have had a severe electrical problem, loss of fly by wire computers; loss of elevators, ailerons and spoilers. The manufacturer is not expecting a pilot to land an aircraft in this configuration, it is designed only to stay flying while you restore the lost systems. The PFD will display "MAN PITCH TRIM ONLY" in RED.

Careful smooth application of the THS required using the trim wheel due to its large size.

The rudder provides lateral control, but again be careful as it induces a significant roll with a slight delay. Anticipation is required!

PART 4 – PERFORMANCE

4.1 - TAKE-OFF

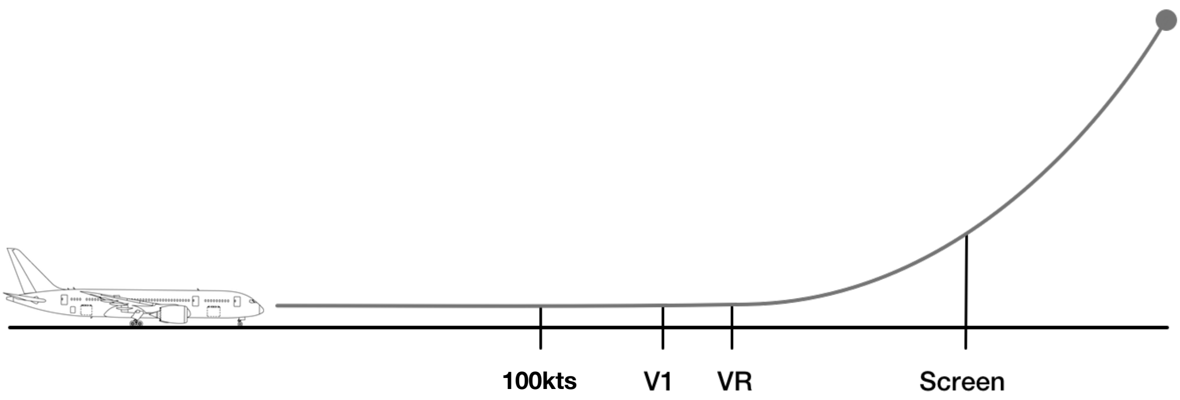
The first section on performance is aimed at linking the theory from your ATPL studies to how we apply it practically in every day operations.

V1 is the speed by which the first action to reject a take-off must have been taken. Above this speed, the take-off must be continued.

VR is the speed at which rotation is initiated

V2 is the take-off (climb-out) safety speed. It provides an adequate margin above VMCA and the stall speed. This speed must be reached by the screen height (35ft DRY, 15ft WET)

MFRA Minimum Flap Retract Altitude is the minimum altitude at which the aircraft attitude can be reduced to accelerate and retract flaps.



The take-off roll up to (but not including) V1 can be split into two parts. From 0-100kts is the low-speed regime where it is generally safe to reject the take-off for any abnormality.

From 100kts up to (but not including) V1 is the high-speed regime. The decision to abort the take-off becomes more critical at high speeds and is therefore only made for situations that may affect the aircraft getting airborne safely. Abort items should be covered in the crew's pre-take-off safety brief and will include items such as:

- Any sudden loss of engine power
- Any fire or smoke
- Red ECAM
- Any unflyable condition
- Amber ECAM

The aeroplane is normally climbed at between V2+15 and V2+20 during normal operations as this provides a better climb angle than V2. At MFRA (usually 1000ft AAL), the pitch attitude is reduced enabling the aircraft to accelerate. The flaps are then retracted in stages according to a speed schedule.

Take-off performance is calculated before every take-off to ensure that the aircraft can become airborne within the runway length available and that all safety criteria are met. The main factors that affect take-off performance are:

- Aircraft weight
- Airfield elevation
- Temperature
- Runway slope
- Wind

In order to determine take-off performance and thrust settings, the following items must be taken into account:

- Runway length and condition (dry, wet, contaminated)
- Obstacles in the take-off flight path
- ATC, climb gradient or SID requirements

Take-off performance for jet aircraft is calculated from performance graphs published by the aircraft manufacturer then presented in either tabular form for the pilots, cockpit devices (eg EFB, iPad) or delivered by Ops to ACARS. Our Course uses this latter method.

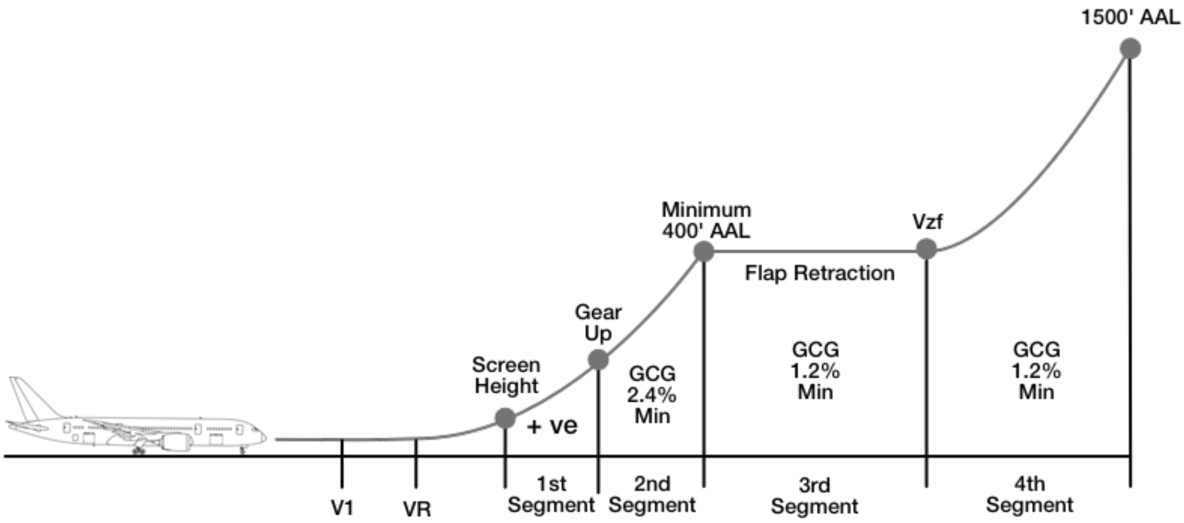
Take-off parameters for each flight are entered into the Flight Management Computer (FMC) allowing accurate take-off performance calculations to be made.

Data entered into the FMC must always be cross-checked by both pilots to ensure no gross errors have been made.

Below are the regulatory requirements for take-off performance.

4.2 - CLIMB GRADIENT

For planning purposes, performance must satisfy minimum climb gradient requirements, as detailed in the illustration below.



Screen Height:

- Wet runway - 15ft
- Dry runway - 35ft

These gradients are based on one engine inoperative (OEI) and are split into two categories:

- Gross Climb Gradient (GCG) – the minimum climb performance that can be achieved in optimum conditions (test pilot, perfect aircraft, perfect day)
- Net Climb Gradient – this is GCG less a specified factor, which is based on the number of engines an aircraft has. The GCG of a twin-engine aircraft, such as the A320, is reduced by 0.8% to achieve the net climb gradient.

As an example, if a twin-engine jet aircraft can achieve a GCG of 6.2%, its net climb gradient would be 5.4%.

Climb gradients are important as they are used to establish whether an aircraft can meet climb requirements for obstacle clearance and ATC SID constraint purposes.

4.3 - OBSTACLE CLEARANCE

When planning a departure, if it is established that the aircraft is unable to meet the required climb gradient, the crew can consider:

- Choosing a more favourable runway if conditions permit
- Reducing the weight of the aircraft (less fuel uplift)
- Using an approved emergency turn procedure. These are generally published for aerodromes with high terrain in the vicinity e.g. Zurich or Milan

An example of such a procedure is detailed below.

EMERGENCY TURN PROCEDURE

Manchester Rwy 23R

EOSID: STD At 1700’ turn right to MCT HP.
D113.55 MCT HP inbound 053 right turn.

NOT TO BE USED IN FLIGHT OPERATIONS

Emergency turns are normally found in the take-off performance tables or in the ACARS Performance print-out.

4.4 - REDUCED THRUST TAKE-OFF

Operationally, it is very common that full take-off power is not required for the majority of departures. Full thrust is only generally used if the runway length is limiting or conditions and circumstances dictate (weather or climb gradient requirements). Reduced thrust take-offs have two main advantages:

- Reduction in engine wear
- Reduced noise footprint

One small disadvantage is a slight increase in fuel burn; this is because it takes the aircraft longer to climb to altitude where the engine is more fuel efficient (this is a common interview question).

We can reduce thrust using FLX Temperature – this tells the engine that the outside temperature is hotter than it actually is, therefore reducing the target N1 Speed.

4.5 - LANDING

General

When the aircraft flies an approach in managed speed, the speed target displayed on the PFD in magenta is variable during the approach.
This managed speed target is computed in the FMGS using the “ground speed mini function”.

Ground Speed Mini Function Principle

The purpose of the "ground speed mini function" is to take advantage of the aircraft inertia when the wind conditions vary during the approach. It does so by providing the flight crew with an adequate indicated speed target. When the aircraft flies this indicated speed target, the energy of the aircraft is maintained above a minimum level ensuring standard aerodynamic margins versus stall.

If the A/THR is active in SPEED mode, it will automatically follow the IAS target, ensuring an efficient thrust management during the approach.
The minimum energy level is the energy level the aircraft will have at touch down if it lands at VAPP speed with the tower reported wind as inserted in the PERF APPR page.

The minimum energy level is represented by the Ground Speed the aircraft will have at touch down. This Ground Speed is called “GROUND SPD MINI”.
During the approach, the FMGS continuously computes the speed target using the wind experienced by the aircraft in order to keep the ground speed at or above the “Ground Speed Mini”.

The lowest speed target is limited to VAPP and its upper limit is VFE of next configuration in CONF 1, 2, 3 and VFE-5 in CONF FULL.
The speed target is displayed on the PFD speed scale in magenta when approach phase and managed speed are active. It is independent of the AP/FD and/or A/THR engagements. Wind is a key factor in the "ground speed mini function".

TWR Wind

It is the MAG WIND entered in the PERF APPR page. It is the average wind as provided by the ATIS or the tower. Gusts must not be inserted, they are included in the ground speed mini computation.

TWR Headwind Component

The TWR HEADWIND COMPONENT is the component of the MAG WIND projected on the runway axis (landing runway entered in the flight plan). It is used to compute VAPP and GS mini.

Current Headwind Component

The actual wind measured by ADIRS is projected on the aircraft axis to define the CURRENT HEADWIND COMPONENT (instantaneous headwind).
The CURRENT HEADWIND COMPONENT is used to compute the variable speed target during final (IAS target).

VAPP Computation

VAPP, automatically displayed on the MCDU PERF APPR page, is computed as follows:

- VAPP = VLS+1/3 of the TWR HEADWIND COMPONENT, or
- VAPP = VLS +5 kt, whichever is the highest.

"1/3 of the TWR HEADWIND COMPONENT" has two limits:

- 0 kt as the minimum value (no wind or tailwind)
- +15 kt as the maximum value.

The flight crew can manually modify the VAPP and TWR wind values on the PERF APPR page.

Speed Target Computation

The FMGS continuously computes a speed target (IAS target) that is the MCDU VAPP value plus an additional variable gust.

The gust is the instantaneous difference between the CURRENT HEADWIND COMPONENT and the TWR HEADWIND COMPONENT. It is always positive (or equal to zero for no wind or tailwind).
The IAS target is displayed on the PFD as a magenta triangle moving with the gust variation.

The IAS targets have 2 limits:

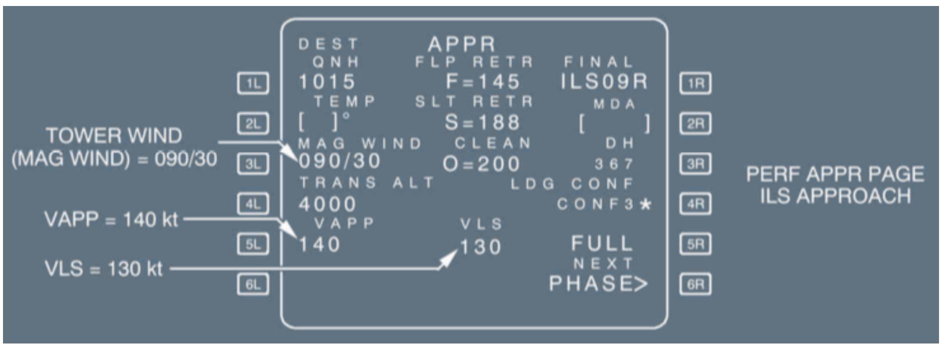
- VAPP, as the minimum value
- VFE -5 kt in CONF FULL, or VFE of the next configuration in CONF 1, 2 or 3 as the maximum value.

Ground Speed Mini (GS Mini) Computation

Ground speed mini concept has been defined to prevent the aircraft energy from dropping below a minimum level during final approach. The GS mini value is not displayed to the flight crew.

Example:

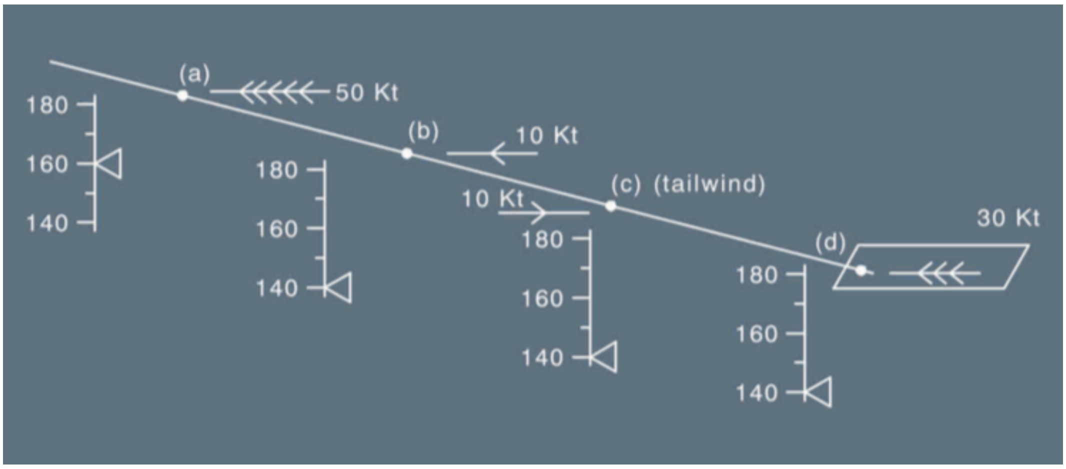
Approach on runway 09, the tower wind direction is on the runway axis.



IAS Target Values

If we turn the previously explained speed target definition into formulae, we obtain the following result:
IAS TARGET = Max [VAPP, (VAPP + CURRENT HEADWIND - TWR HEADWIND)]

Current Wind in Approach	IAS Target
(a) 090/50	Max [VAPP, (140 +50 -30)] = 160 kt
(b) 090/10	Max [VAPP, (140 +10 -30)] = 140 kt
(c) 270/10	Max [VAPP, (140 +0 -30)] = 140 kt
(d) 090/30	Max [VAPP, (140 +30 -30)] = 140 kt



4.6 - LANDING PERFORMANCE

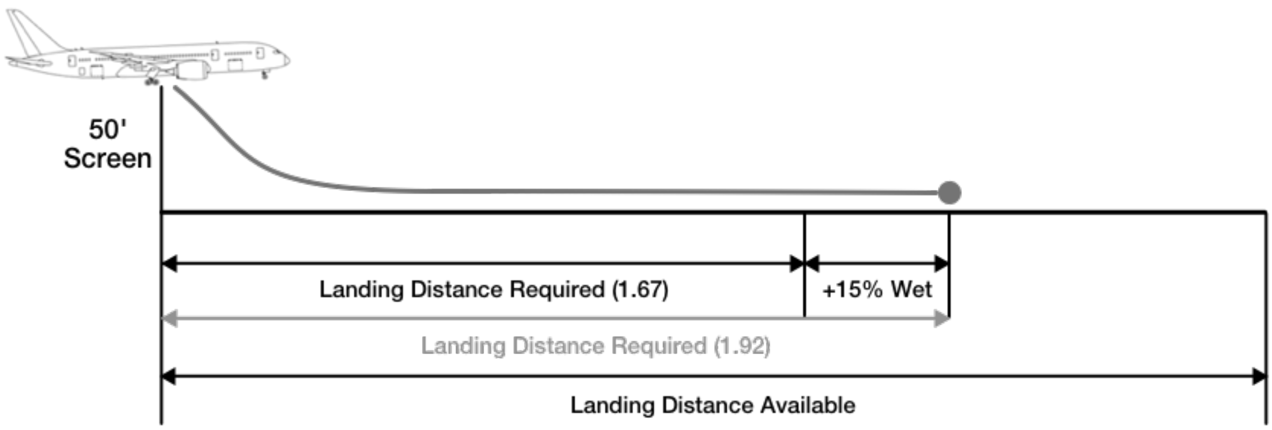
The modern jet aircraft uses a combination of the following to facilitate deceleration on landing:

- Wheel brakes
- Reverse Thrust
- Spoilers

With the increased momentum of the jet, far greater stopping distances are needed.

For planning purposes, the regulations state that the aircraft Landing Distance Required (LDR) - i.e. from the 50ft screen height to a full stop - must be less than 70% of the Landing Distance Available (LDA). For a wet runway, the LDR multiplied by 1.15 must be within 70% of the LDA.

Put another way the LDR multiplied by 1.67 must not exceed the LDA for a dry runway. For a wet runway the LDR is factored by 1.92.



4.7 - MISSED APPROACH (GO-AROUND)

When planning to make an approach and landing we need to consider the missed approach and whether we can satisfy the required climb gradient in the event of a balked landing. There are two cases:

- **Missed Approach Climb Gradient** is where the approach is discontinued from minima with one engine inoperative, allowing for the gear to be retracted and the flap to be selected to a go-around setting with go-around thrust on the remaining engine. The required minimum GCG is 2.1%.

- **Landing Climb Gradient** is a balked landing situation with the thrust levers at TOGA, the gear down and landing flap with all engines operative. The required minimum GCG is 3.2%.

Prior to making an approach, it is important to establish that the aircraft is able to meet the missed approach climb gradient.

4.8 - DRIFT-DOWN

Following an engine failure in the cruise, it is unlikely that the aircraft would be able to maintain altitude, so will have to descend, or “drift down”, to a lower level.

There are 2 strategies:

- Standard strategy: M0.78/300kts to give the best chance of a windmill start
- Obstacle strategy: Green Dot to clear terrain

Procedure:

- Set both TLs to MCT
- Disconnect A/THR

- Pull HDG

Determine correct strategy

- Choose and select speed

It is a requirement that as the aircraft drifts down that it clears all terrain within 5 miles either side of track by at least 1000ft vertically and all high terrain by 2000ft. The net level-off altitude must be above the MSA.

END OF MANUAL