Introduction

Dear Reader,

This Airbus A320 simulator flight training book, is the second edition of the successful A320-family book of the Aerosoft series – You have Control. However, it is the first edition to be published in English.

The book is based on the German edition, but has been reworked completely and newly categorized.

Important Reference

This book has been written with the FSX-Flight-Simulation-Pilot in mind and is not intended for the professional or the professional-to-be pilot.

It describes procedures which are of concern to the FSX-Flight-Simulation-Pilot and provides additional information of interest. The book is *not* a flight training manual and shall not be used for professional flight training. The FSX-Flight-Simulation-Pilot uses the book for his/her own personal information only.

All information contained in the book are provided to the best of the author's knowledge. The author further does not lay claim or guarantee the correctness and completeness of information, data and details. Exchange of the content of the book, complete or in part, with third parties or application for commercial use, needs the written consent of the publisher Aerosoft GmbH, Lindberghring 12, D- 33142 Bueren, Germany.

Emphasis is given to the operation, procedures and systems of the A320 Aircraft. However, the differences between the members of the A320 family (A318, A319 und A321) are also mentioned. Side topics such as weather, navigation systems/charts are not part of this book and only addressed if necessary, for the understanding of the subject matter. Malfunctions are not covered, they are beyond the scope of this book.

The book takes the Microsoft-Flight-Simulator Add-on-software "Airbus A318-319 und A320-A321" from Aerosoft GmbH as the reference. Nevertheless, all topics have been worked out in a general manner to ensure, that they are applicable for other Add-on products as well.

Cross-references to the Aerosoft add-on-software are given in selected cases, whenever necessary for clarifications between the Add-on-software and the real Airbus procedure. Most of the screenshots have been taken from the Aerosoft Add-on-software and the APT (Airbus Procedure Trainer). Though, to some extent, it was necessary to alter the flight instrument indications by means of photo composition.

The content at the beginning of the book offers a short explanation of each chapter, giving a good overview of the book's topics. Detailed content pages are provided at the start of each chapter.

This partitioning shall ease the reading of the book by avoiding to turn pages back and forth in order to search for a specific subject in the chapter.

Acknowledgment

This book is dedicated to my friend John Smith, General Manager of the L3 Asian Aviation Training Centre in Bangkok (AATC).

Without his unparalleled and generous support, this book and the preceding German version would never have been possible. Thanks also for the right to use pictures taken from the flight simulators and the APT at the centre.

I also like to thank all my friends who are active Airbus pilots with commercial Airlines. Their valuable tips and inputs have been of importance to provide accurate, comprehensive and up-to-date information. In particular, I like to mention Captain Gaylord Wawrik and First Officer Marco Haemmer.

The team of EVS-Flight-Training Center Berlin has been very supportive with information regarding flight simulator equipment. Also thank you for the usage rights of the pictures.

Finally, last but not least many thanks to the Aeorosoft Team for the excellent cooperation and teamwork.

The Autor

The author possesses an extensive project management record in the Aviation industry with over 30 years and more than 1.000 hours of practical experience in full-flight simulators (FFS). The experience includes simulators for Boeing, Embraer, Bombardier, MD-Douglas and particularly Airbus.

He also started his professional flight training early in the 70s but had to discontinue on medical grounds. In the late 80s he took over several senior management positions in the South-Est-Asian region (Singapore, Thailand/Bangkok, Myanmar und India). During this time, he kept on with his flight simulation passion, amongst others, at the Asian Aviation Training Centre Bangkok.

After returning to Munich for retirement, he again assumed positions within the Aviation sector. Since 2009 he is acting as instructor of Airbus simulator event flights as well as co-tutor for management seminars, based on full-flight simulators. Currently, he is further engaged as IATA Senior Expert for the SESAR (Single European Sky) project.

Introduction

The Author in front of the A320-L3-Reality-Seven Full-Flight Simulator (FFS) at AATC Bangkok.

Sepp E. Tietze

Munich, March 2019

Chapter 1

Content

1. The Basic Jet-Training

Many well-known Airlines have recently changed their training schedules to the latest incidents, giving more room for the training of manual flying techniques. Airlines further encourage their pilots to practice manual flying during the line operation, as far as meteorological and operational conditions permit.

Airbus has also changed their type-rating training accordingly. Pilots transitioning to the A350 need to complete a manual flying program.

The following chapter is solely dedicated to manual Jet flying techniques.

Nowadays, various designations are used to determine the role of each crew member in the cockpit.

Pilot controlling the aircraft: PF – pilot flying or PH –pilot handling
Pilot supporting: PNF – pilot non-flying, FM – pilot monitoring, PNH – pilot not handling

In this book, the traditional designations of PF and PNF have been used.

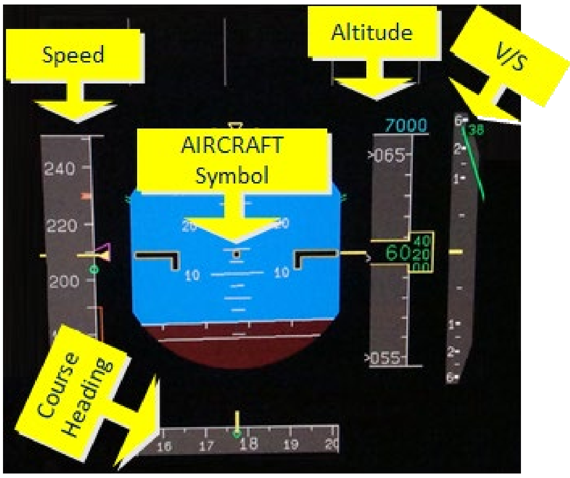
1.1 The Primary Flight Display (PFD)

1.1.1 The PFD-Interpretation

The so-called Raw-Data are the basic PFD information for manual flying, because no automation (AP, FD) is used to control the aircraft.

What are Raw-Data?

These Flight Data are made available by on-board equipment, without the need for further processing. That's why they are called Raw-Data.



The following PFD indications are Raw-Data:

- Artificial Horizon with the aircraft symbol (Attitude)
- Speed (SPD)
- Compass course (Heading-HDG)
- Altitude (ALT)
- Vertical Speed (V/S)

The aircraft symbol determines the attitude, which is the way the aircraft behaves within the ambient air. In the example the A320 is in a straight climb with a pitch attitude of 14º.

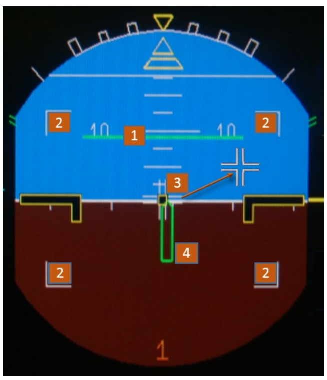
Above the horizon, the FMA (Flight Mode Annunciator) is displayed. For the basic training, only the three indicated data are of importance; SPEED is the AutoThrust control mode (selected speed), while A/THR confirms the mode of operation (active).

The message line provides the pilot with system specific operation information.

A complete description of the Airbus Flight modes (called the AFS-modes) are included in chapter 4.

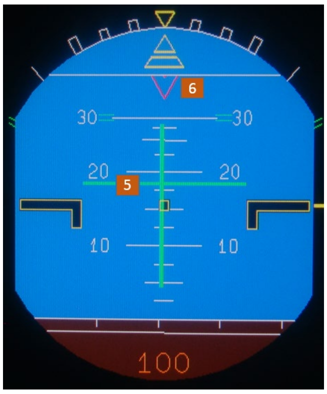
Specific PFD Indications

From the engine start-up to the rotation the following specific indications are provided:



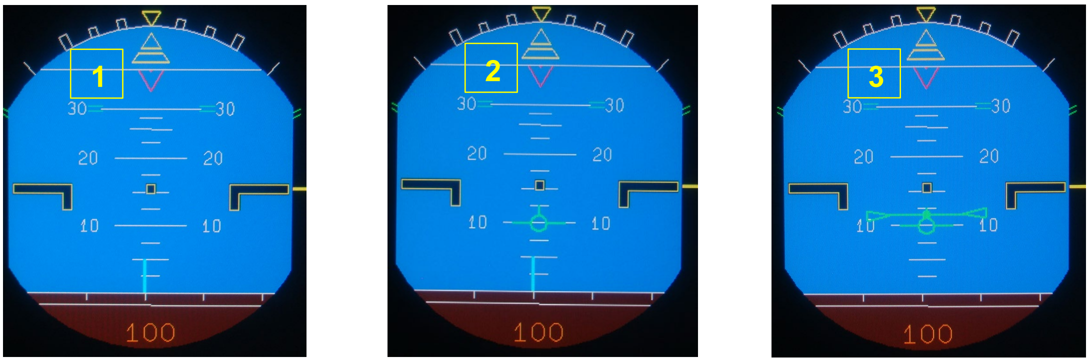
1. Maximum allowable pitch demand during the rotation (pitch bar). Exceeding this limit will increase the risk of a tail strike.
2. Maximum range of stick deflection, horizontal and vertical.
3. Stick Symbol (double cross) which moves according to the stick input of either Captain / FO or the sum of both.
4. Vertical Ground Roll Guidance Bar. This symbol shows the deviation between the aircraft and the RWY centreline. It is only available if a localizer signal is available.

The information 2, 3 and 4 are fading-out after passing 30 feet.



5. After rotation, the pitch bar will be replaced by the Flight Director (FD), provided it has been switched ON.
6. Additionally, the Pitch Limit Indicator (PLI) is blended in (**V**). The PLI marks the maximum permissible pitch.
   In the left picture, the pilot commands a pitch 15º (aircraft symbol) but the FMGS commands a pitch of 17.5º (FD). This is a normal pitch value for a low GW take-off, because otherwise the climb speed of V2 + 10 (maximum +25) would be exceeded.

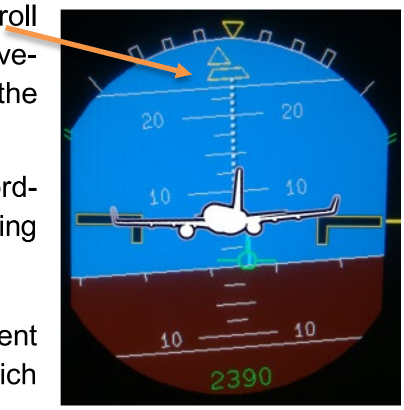
The PFD provides the following variations of data representation:



1. The Basic-Representation: The aircraft Symbol shows the actual pitch and bank values (raw data).
2. The Airbus bird or flight path vector (FPV): This symbol depicts the aircraft movement in space (atmosphere) relative to the air flow. It shows the actual flight path or flight path angle (FPA). A Pitch of 15º result in an FPA of 10º.
3. The flight path director (FPD) substitutes the FD when the TRK-FPA modus has been selected on the FCU. Like the FD, the FPD commands the flight profile the pilot need to follow.
4. The Flight Director representation is shown on top of the page.

All above PFD pictures illustrate the same aircraft attitude (shortly after rotation). The FD is not used for the exercises in this chapter, only the FPV.

The Side Slip Indicators



The side slip indicator, or beta target, is the lower part of the roll indicator. If the pilot makes a rudder input, a sideward (yaw) movement of the aircraft is initiated and the beta target moves in the opposite direction, visualizing a side slip.

During the take-off ground run, the beta target also moves according the rudder inputs (to keep the Airbus on centre line), indicating the yaw effect of the input.

In case of an engine out situation (EO), the yaw drift movement into the dead engine is also indicated by the beta target, which changes from **Yellow** to **Blue**.

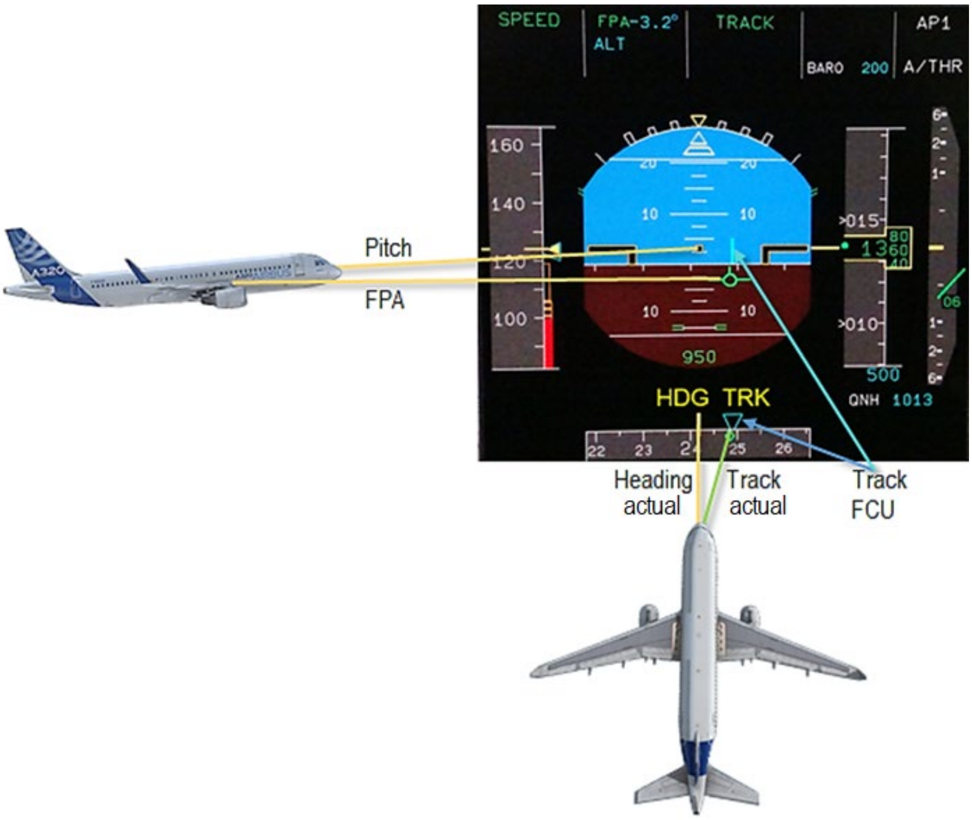
In order to stabilize the side slip, the pilot must provide the required amount of rudder input to centre the beta target (Kick the Target) and to establish an optimum behaviour of the A320.

According to the known procedure „Dead Foot - Dead Engine“ the pilot kicks beta target, in the example the left rudder for a right engine (no. 2) failure.

The rudder trim functions allow the pilot to compensate for the drift without the need to constantly push the rudder pedal (chapter 3).

1.1.2 The Airbus Bird

The Bird, officially called FPV (Flight Path Vector), is an Airbus speciality that was underestimated at first. The indication is especially useful to support manual flying. However, the bird is also an important indicator for non-precision approaches (NPA). The graphic below illustrates the display mode of the bird with its basic functions.



The picture shows the final approach for an NPA with AP1 selected and without FDs.

The vertical indication shows a Pitch of 2.5º and a Flight Path of -2.5º (FPA) or 600 ft/min.

The actual HDG (lateral) is 241°. Because of the wind influence the Airbus is drifting to the right with a Track of 248°.

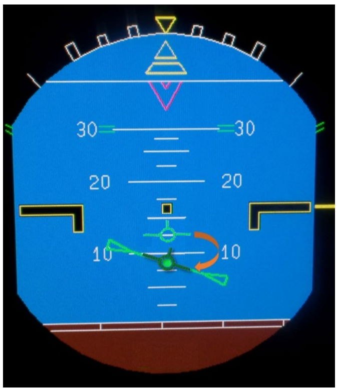
The resulting wind correction angle is 7° (248 – 241). 248º is the course for RWY25C at EDDF.

The **Blue Triangle** represents the Track which has been selected by the pilot via the FCU heading knob. The track compensates for the wind drift, while an aircraft flying a specific heading is influenced by the wind speed and direction (drift angle).

The **Green Diamond** symbol indicates the actually flown TRACK. The selected track (**triangle**) and the actual flown track (**diamond**) are identical in this example and the symbols overlay each other.

Prior to selecting a Track, the pilot needs to switch from HDG-V/S to TRK-FPA and the value shown in the heading window becomes the Track value. To do so, the pilot presses the switch-over button on the FCU. When the pilot switches to TRK-FPA, the bird will automatically be shown on the PFD.

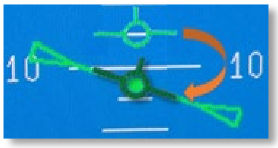
The switch-over button is located in the centre of the FCU just above the AP buttons. If pressed once, the mode changes from HDG-V/S to TRK-FPA. When pressed again, the mode switches back to HDG-V/S.



The flight path director (FPD) is a combination of the bird with a wing symbol and provides a FD-like function. The FPD resembles the wing FD symbol used the 70s before the cross hair became the standard FD symbol.

To use this function, the pilot needs to activate the FD and then presses the switch-over button to select the TRK/FPA, as explained before.

The picture on the left shows a FPD command to execute a right turn (approximately 25º bank), together with a pitch reduction from 12.5º to 8º. The pilot needs to move the **Green Bird** symbol to mask the **Green FPD**, as indicated by the **Dark Green Bird** symbol and the **Orange** bended arrow.



Detailed information about the FCU (Flight Control Unit) is provided in chapter 4.

1.2 The FBW Control

1.2.1 The Flight Control Laws

The Airbus control laws are divided into the following sub routines:

Normal Law: The Normal Law is the normal control regime with all functions and protections available to the pilot. It is further divided into the Ground, Flight and Flare mode. These modes are for the FBW control only and should not be mixed-up with the auto-flight control modes (AFS modes - chapter 4).

This Flight mode uses the full set of functions of the flight control computers to execute commands given by the pilot or the FMGS. The Ground and Flare modes are using the direct law mode (see below), providing a direct relationship between the stick input and the control surfaces. The automatic trim function of the horizontal stabilizer (THS) is an integral part of the control law.

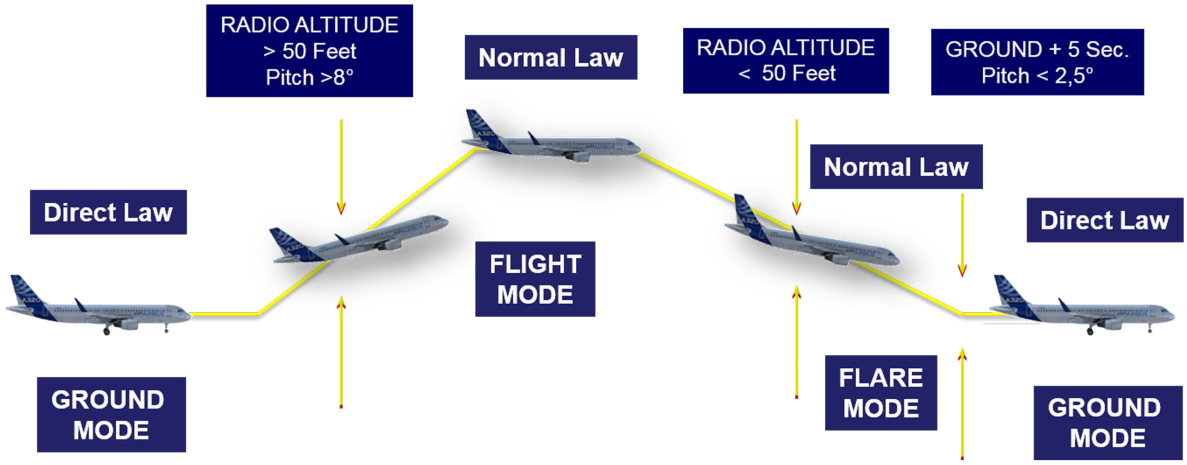
The Airbus cannot stall in Normal Law.

Alternate Law: The Alternate Law provides, as the designation suggests, an alternative set of control functions in case of system malfunctions. The Airbus remains fully controllable but with limited protection functions. Normally the automatic trim function is available, but this depends on the type of the malfunctions that triggered the Alternate Law. Also, the function of some control surfaces can be limited. When the gear is lowered, the Alternate Law automatically changes to the Direct Law.

In Alternate Law the Airbus can stall at any altitude and/or speed.

Direct Law: In case of multiple system functions, the Direct Law becomes active. Neither the automatic trim function nor the protections will be available. The flight controls are direct, like in a conventional non-FBW aircraft. With other words: Stick inputs are transferred to the control surfaces without any processing by the flight computers. Depending on the kind of malfunction the Airbus reacts either sluggish or sharp. The trim function is provided by the manual trim wheels, which are located next to the thrust levers.

To put it into simple words: The different flight laws define the availability of protections and flight control functions. The following picture shows the control law sequence of a typical flight.



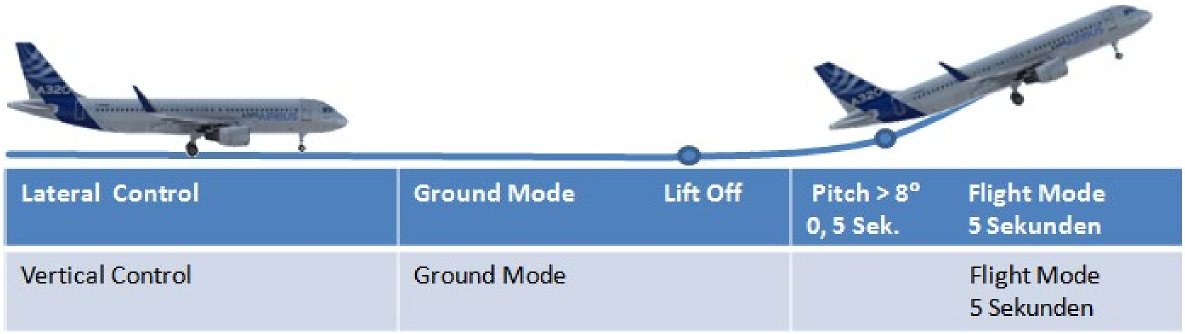
1.2.2 The Ground - Flight – Flare Modes

In order to provide the correct set of functions, the FBW control system needs to know at any time, if the aircraft is on ground or in flight. The actual aircraft attitude is asserted by the flight control modes Ground, Flare and Flight. These control regimes are sub-modes of the FBW control system and determine the transition from ground to flight mode and vice versa. It has to be mentioned again, that these flight control modes have nothing in common with the AFS-modes.

The Ground – Flight Mode Transition

The Ground mode defines, if and when the Airbus is on the ground. Amongst other functions, this mode activates the automatic trim function after take-off. After landing, important systems such as spoilers, automatic breaking and reverse thrust are released by the ground mode.

The Flight mode tells the FBW system, when the Airbus leaves the ground and transitions to flight. Starting from 30 feet or 5 seconds, the flight mode is progressively put into operation and the automatic trim and all flight envelope protection functions are blended in. The mode is fully available between 50 and maximum 100 feet and remains active for the whole flight until 50 feet AGL (above ground level) during approach and landing.



The Flare Mode

The usual pitch attitude during the approach is +2.5º with flaps Full and +3º with flaps 3. The rate of descent is 700-800 ft/min.

The Airbus transitions smoothly from the Flight into the Flare mode when passing 50 feet AGL. At this moment the FBW system takes the actual values for pitch and trim as reference for the Flare mode. The pitch trim is memorized, while the THS (Trimmable Horizontal Stabilizer) is frozen at the actual position.

When passing through 30 feet the FBW control moves the A320's pitch progressively from the actual value to -2º (Pitch Down) within 8 seconds. Therewith, a Nose-Up Input by the pilot is required to initiate the Flare, just like in a conventional aircraft.

After the Flare is established within 30 to 20 feet, the Pitch increases to 5º - 6º to reduce the rate of descent to about 350 ft/min. The vertical control in Flare Mode is performed in direct law, while normal law is used for lateral control.

The Flight – Flare – Ground Mode Transition

1.2.3 The Angle of Attack (AoA)

The AoA value is of utmost importance for the Airbus protection functions. Therefore, a short explanation of the AoA principle may be useful.

What is the Angle of Attack?

The Angle of Attack (AoA) is defined as the angle between the wing chord line and the air flow relative to the wind. The Pitch is the angle between the aircraft's longitudinal axis and the horizon.

The A320 does not feature a specific AoA instrument. However, the AoA can be derived from the PFD using the Bird indication, as shown in the picture above. The AoA is the difference between the aircraft- and the Bird-Symbol.

The picture shows the A320'sattitude shortly after take-off with a Pitch value of 15° and a Flight Path Angle (FPA) of 10º. Therefore, the AoA is 5° (15º Pitch - 10º FPA) and within the normal range.

Contrary to the pitch, the AoA always has a positive value because the air flows directly against the wing. Even though the pitch is negative (e.g. -5º). the aircraft's longitudinal axis remains above the air flow resulting in a positive value of the AoA.

The AoA depends on several factors such as gross weight (GW), speed, gear, flap and spoiler positions. Generally, an AoA value greater than 10 is considered to be critical.

1.2.4 Limitations

The A320 features a range of control mechanism (protections) to provide a stable aircraft attitude within all flight conditions (flight envelop).

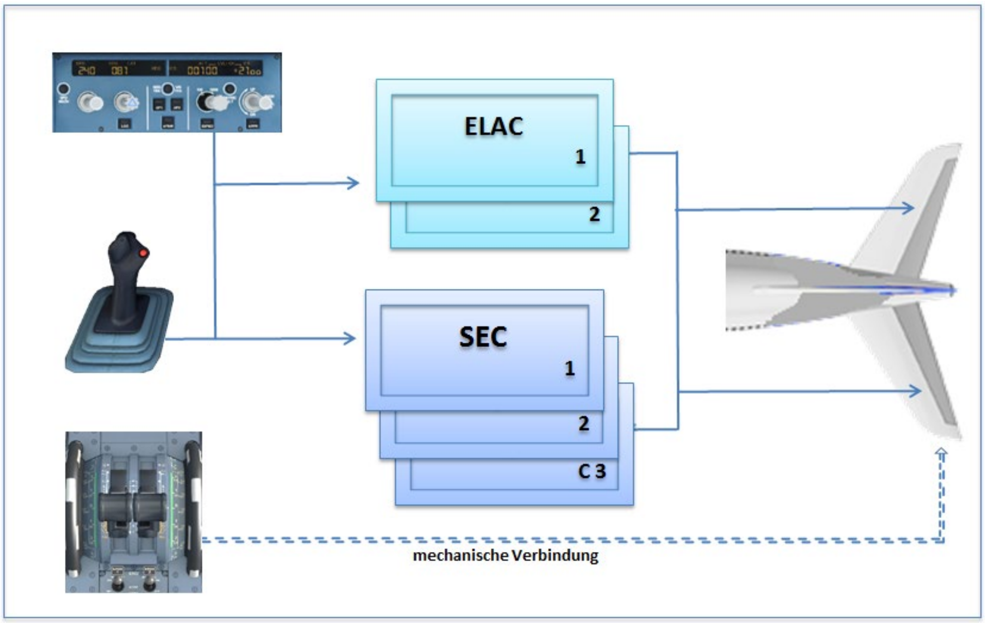
Pitch Control

The A320 Pitch Control comprises of 2 elevators and one stabilizer (THS-Trimmable Horizontal Stabilizer), as part of the stabilizer fin.

During normal operation the ELAC 2 Computer controls the elevators as well as the stabilizer. In case of an ELAC 2 malfunction, the ELAC 1 takes over the control tasks. Should both ELAC computers fail, then the SEC 1 or SEC 2 computer take over to ensure uninterrupted control of elevator and stabilizer.

The stabilizer can further be controlled manually using the trim wheels located next to the thrust levers via the mechanical link. However, the mechanical link still requires at least one hydraulic system to activated the actuators. There is no direct link between the control devices and the mechanical trim wheels.

The mechanical control has priority over the FBW system.

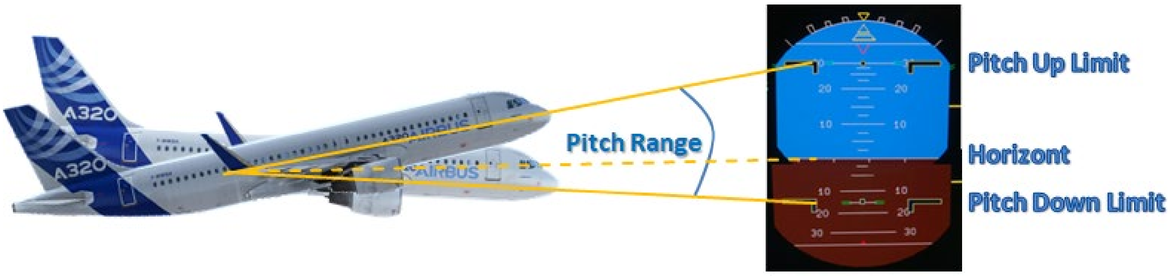


In order to keep the flight envelop within a safe range, the FBW control system limits the pitch in normal law as follows:

- Maximum Pitch - Nose Up +30º
  for flap configuration 0 – 3
  within the low speed range, the maximum Pitch is reduced to +25º
- Maximum Pitch - Nose Up +25º
  for flap configuration Full
  within the low speed range, the maximum Pitch is reduced to +20º
- Maximum Pitch - Nose Down -15º

The maximum deflection of the stabilizers is 13,5º Up and 4º Down.

Airbus calls this procedure Pitch-Attitude-Protection to safeguard the A320 from reaching critical flight conditions.



The Flight Directors are automatically faded out, when the Pitch exceeds 25º Pitch-Up or 13º Pitch-down. They are not switched off and will re-appear again when the Pitch is brought back to a value between 22º Pitch-Up and 12º Pitch-Down.

In Normal Law, Sidestick inputs are executed proportionally by the elevators and the stabilizer, independent from the actual aircraft speed.

The AutoTrim - Function

With the Sidestick in neutral position and the wing horizontal, the FBW control system ensures a Load Factor of 1g within the normal flight envelop. The automatic trim function controls the Pitch regardless of changes in speed, aircraft configuration and wind influence. The automatic trim function is available for manual flight control by the pilot as well as the AutoFlight system.

The value of the automatic trim is frozen under the following conditions:

a. the Pilot makes an input via the manual trim wheel
b. the radio altitude is less than 50 feet or 100 feet respectively with the autopilot active
c. the Load Factor is lower than 0,5 g
d. the Airbus is within the High-Speed or High Mach protection

In case of an AoA activation, the range for the elevator trim (THS) is limited to the value when entering the protection mode and maximum 3,5° Nose Down. Neither the pilot nor the FBW control system is able to command Nose-Up, which would result in an even more critical flight attitude.

The same applies when the A320 flies with a Load Factor greater than 1,25g or with a bank angle beyond 33º.

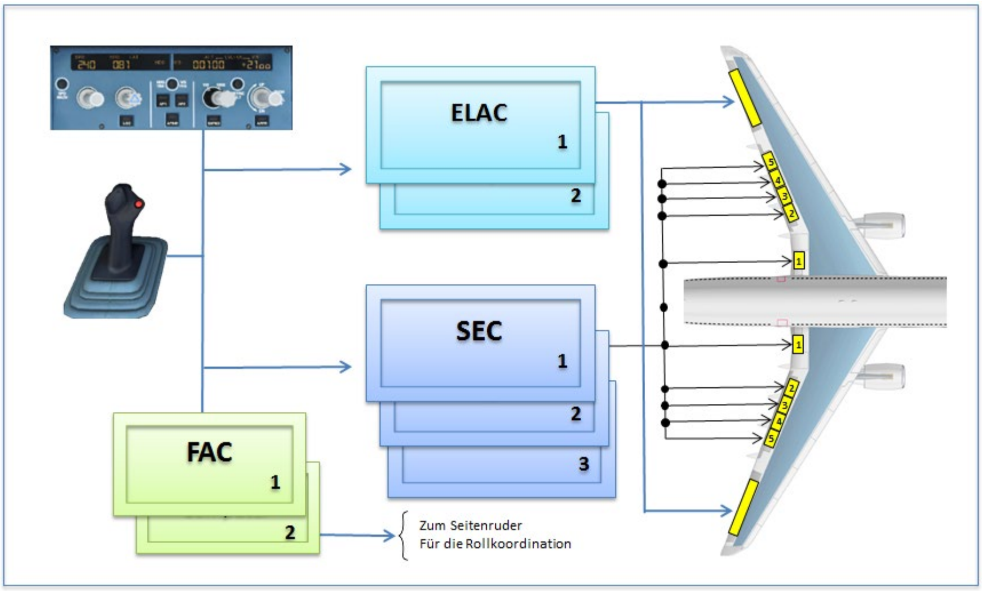
Roll Control

The Roll Control of the A320 is performed by 2 Ailerons that are supported by the spoilers located on top of both wings. With the support of the spoilers the roll rate of the A320 is considerably enhanced. Only the spoiler on the side of the roll movement are used, e.g. right spoilers for a right turn.

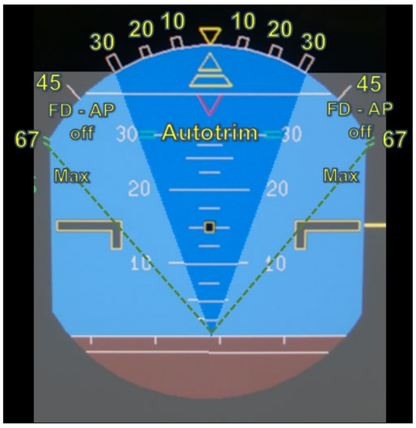
During normal operations, the ELAC 1 controls the Ailerons. The ELAC 2 takes over the Aileron control in case of a malfunction of ELAC 1. Should both ELACs fail, then the Ailerons are set into the damping mode (to avoid aileron flutter) and the SEC computers control the roll. The SEC 3 controls spoiler 2, SEC 1 spoiler 3 and SEC 3 number 5. If one of the SEC also fail, the spoiler concerned will automatically be retracted.

The bank angle limits are as follows:

- Maximum bank right/left Exceeding this value is not possible in Normal Law	67º
- Automatic de-activation of the AP Simultaneously both FDs will be faded-out The FDs re-appear when the bank angle is back to < 45º	45º
- Maximum bank in normal operation, right/left	33º
- Normal bank in AP operations, right/left	25º



Whenever the pilot exceeds the normal bank angel of 33º, the FBW control system temporarily switches-off the pitch and roll stability mechanism. The pilot thus controls the A320 just like a conventional aircraft (stick & ruder) by holding the Sidestick-input in order to maintain the attitude. However, manual trim inputs via the trim-wheel in the centre of the pedestal are still possible.



If the pilot releases the Sidestick (no further input), the A320 will automatically return to the normal bank angle of 33º. Simultaneously, the automatic pitch trim sets in at the current value, which can be either Nose-Up or Nose-Down. Therefore, corrective pitch inputs by the pilot may be required to maintain the required aircraft attitude.

The maximum deflection of the Aileron is 25º. The Ailerons are moving down by 5º when the flaps are deployed, which is known under the term of Aileron-Droop. Newer A320 versions, such as the NEO, have also a so-called anti-Aileron-Droop function. After touch-down, the Ailerons are brought into a slight upright position, to break the lift and support the spoilers in their braking action. The Aileron Droop function, not the Anti-Aileron-Droop, can be checked on the ECAM F-CTR page, see chapter 3.

Spoiler Control

The Spoiler-Speed-brake function is not available (Inhibited) under the following conditions:

- The flaps are in configuration Full for the (A318, A319, A320), or configuration F3 and Full for A321
- The Thrust levers are set further than the MCT detent. In this case, all extended spoilers will automatically be retracted
- The Angle-of-Attack protection is active
- The Alpha-Floor protection is active

Whenever the requirements are met, the Spoilers are automatically retracted. The spoiler lever however, remains in the actual position and must be set to 0 by the pilot. A corresponding ECAM message informs the pilot of the necessary activity.

After the requirements are no longer valid, the spoiler can be extended again after a safety period of 10 seconds. Additionally, the spoiler retraction in the high-speed range is deliberately slowed-down to avoid the risk of stall conditions. If the spoilers are extended at a speed >300 knots, the retraction time is 25 seconds.

The A320 has a different spoiler operation mode compared to A318-A319-A321. Whenever the AP is in operation, the Spoilers only extend half of the possible in-flight range. That means, when passing the half mark, the spoiler lever has no further effect. If the pilot manually flies the A320, then the spoilers can be extended to the full in-flight range.

The A318-A319-A321 provide a uniform Spoiler handling for AP and/or manual flight operation. The maximum available Spoiler deflection is comparable to the A320 AP range. That means, the spoilers of the A320 can be extended further when in manual flight.

As explained under chapter 3, the Spoilers are used as speed (air) brakes as well as roll support. Therefore, it is possible that both functions are commanded simultaneously and may interfere. In this case, the roll has priority over the speed brake function. That means, the spoiler deflection may need to be reduced to comply with the roll support requirement. In order to avoid asymmetric wing conditions, the spoiler deflection on the opposite wing is evenly reduced.

AutoFlight – Yaw Functions

When the AP is switched-on (active), both Sidesticks and the rudder pedals are locked in the neutral positions to avoid inadvertent inputs by the pilots. Usually, the AP is switched-off with the **Red** instinctive disconnect button on the Sidestick, but can also be disconnected by force (sidestick or rudder pedal inputs).

The AP provides yaw control depending on the actual flight conditions:

- Short-term function: During take-off or GA, any thrust asymmetry is counterbalanced by a corresponding rudder deflection, like the pilot would Kick the Target (Ball).
- Long-term function: Afterwards the AP commands the required rudder-trim movement to provide a stabilized flight attitude – centring the Beta Target. The same action would be performed by the pilot if flying manually. In both cases, the trim values are shown on the rudder trim panel located at the pedestal between the spoiler and the flap levers.

The short-term function (rudder deflection) is necessary, because the reaction time of the long-term function (rudder trim) is only approximately 1^0/second that is too slow and would lead to heavy aircraft movement.

1.3 The Flight Protection System

The Airbus A320 incorporates a set of protection functions that improve the safety of the flight envelop and assist the pilot during critical phases of the flight.

The A320 protection system has been divided into 3 categories, which seems to be most appropriate for the Flight-Simulator pilot:

1. Energy-Warning (Low-Energy-Protection)
2. Flight-Envelop-Protection
3. Flap-Overspeed protection

However, the existence of such a protection system does not give a guaranty and must be understood and trained by the pilot.

1.3.1 The Low Energy Warning

The Energy-Level of an aircraft is the function of:

- Airspeed and trend
- Altitude
- Vertical speed or Flight Path Angle – FPA
- Aircraft configuration (Gear, Flaps, Spoilers)
- Thrust

In order to control the Airbus's energy level, all before mentioned parameters need to be controlled by the pilot at any time. However, the pilot must consider that these parameters are influencing each other. Example: If the gear is extended, the thrust need to be increased to compensate for the additional drag and to hold the required air speed.

The low-energy warning will be active before the Alpha-Floor activation, if the speed or the speed trend reaches a critical zone. It is available between 100- and 2000-feet during take-off and landing. Pre-requisite is further, that the flaps are either in configuration 2, 3 or Full. That means there is no low-energy warning above 2000 feet during approach, which is normally before flaps 2 and gear extension.

The low-energy function is a warning but not a protection function of the FBW and also not a pre-stage of the Alpha-Floor activation. It is an independent warning and will be active when a defined energy-level is undercut by the pilot. The warning system determines if the actual energy level, or the energy level trend, is not sufficient to remain within a safe speed range.

The low-energy warning is active before reaching the **Orange VLS** bar on the PDF speed scale. The pilot is warned through an acoustic call-out „*SPEED, SPEED, SPEED*" with a 5 seconds interval.

The recovery is usually done by increasing the engine thrust. Because the warning sounds at a low altitude, reducing the pitch may not be the preferred solution. If the situation permits, a combination of both measures may by the best way out. The pilot needs to take into consideration, that jet engines require a certain response time to produce the necessary thrust.

The low-energy warning is inhibited if TOGA thrust is set or Alpha-Floor protection or GWPS-warning is active. The warning is further not available if both radio altimeter systems are inoperative (INOP).

1.3.2 The Flight-Envelope-Protection

Flight Envelope is the term used to determine the aircraft's performance and design specifications. Amongst other parameters, the aircraft's Flight Envelope describes the safe performance limits with regard to minimum and maximum operating speeds, attitudes and structural strength.

The FBW control of the A320 incorporates a protection system that prevents the aircraft to enter critical flight conditions in case of excessive control inputs by the pilot. Excessive control inputs can, for example, be the result of a surprise reaction to an abnormal situation or severe turbulence.

1. Normal Law Protection

In Normal Law all protections are fully available to the pilot.

Load Factor Limitation

The Load Factor Limitation limits the G-Load as follows:

- In Clean-Configuration (slats and flaps retracted) 2,5 g to -1,0 g
- Slats extended (flaps retracted) 2,0 g to 0,0 g
- Slats and Flaps extended 2,0 g to 0,0 g

The structural limit of the A320 is 2,5 g to -1,0 g.

The pilot can feel the Load Factor Limitation when initiating a Pitch or Roll command. At first, the Airbus reacts firmly to the Sidestick inputs. When the Load Factor Limitation sets in, the FBW control becomes less responsive to avoid over-controlling of the aircraft.

The protection system very much depends on the availability of correct flight data supplied by the various sensors. System malfunctions, false or no data (e.g. icing of the pitot tubes) can lead to erroneous behaviour of the protection system. In such cases, switching to Direct Law and thereby deactivating the protections can be the solution.

Angle of Attack Protection

The Angle of Attack (AoA) protection limits the AoA, not the Pitch to α_{MAX}, provided the Sidestick has been fully moved back (Pitch-Up command). When reaching α_{PROT} +1º, the AP will automatically be disconnected and the FDs are faded-out.

The FBW control automatically commands Pitch-Down, independent from the actual pilot input, to keep the AoA within safe limits (see under AoA). In addition, the pilot should provide additional Pitch-Down Sidestick input to leave the AoA protection and return to the normal flight envelop. The Alpha-Floor protection is further activated should the pilot input be insufficient.

Alpha –Floor (AF) Protection

Starting point to activate the Alpha-Floor (AF) protection is the A320's Angle of Attack (AoA). The AF protection is controlled by the FAC computers and is available from the take-off (Lift-off) to 100 feet RA (Radio Altitude) during landing.

In case of AF activation, AutoThrust (A/THR) TOGA is commanded independently from the actual position of the Thrust levers and the A/THR mode.

The Alpha Floor protection is not available:

→ below 100 feet RA (Radio Altitude)
→ if the A/THR is unavailable (INOP)
→ above Mach 0,53

The AF function is further not available during an EO (Engine Out) condition and if the slats and/or flaps are extended.

The AoA and the Alpha-Floor range are displayed as follows on the PFD speed scale:

The upper edge of the **Orange** bar represents the V_{LS} – the lowest selectable speed.

The **Orange**-**Black** bar defines the $V_{\alpha\ PROT}$, where the Angle of Attack (AoA) protection will be activated. However, before this happens, the protection systems try to counter a high AoA by reducing the Pitch and thus stabilizing the Air Speed.

The **Red** bar stands for the $V_{\alpha\ MAX}$ - Alpha Floor, at which the AutoThrust (A/THR) system activates maximum thrust (TOGA). At this point, the displayed Air Speed is not the trigger but the high AoA resulting from the low Air Speed.

The AF protection is displayed at the PFD-FMA:

The **Green** A-FLOOR notification in the FMA is surrounded by a flashing **Orange Frame** to attract the attention of the pilot. Additionally, the warning message **A-FLOOR** in **Yellow** is displayed in the upper ECAM screen.

The **A-FLOOR** mode is displayed as long as the AF conditions prevail, that means until the AoA is back within safe limits and the Air-Speed is above the V_{LS} mark. Subsequently, the A/THR system changes to the **TOGA-LK** (TOGA LOCK) mode.

TOGA-LK means, the Thrust is frozen at the highest thrust setting (TOGA) and must be deactivated manually by the pilot. The correct procedure is to use the **Red** instinctive disconnect button on one of the thrust levers. Afterwards, the thrust control can be used by the pilot in the normal mode, either manually or with A/THR.

If the pilot presses the **Red** instinctive disconnect button more than 15 seconds, the A/THR as well as the AF protection will be turned-off for the remaining flight. This is in principle an emergency shut-down of the A/THR system.

High-Speed Protection

The High-Speed protection is designed to safeguard the Airbus from leaving its flight envelop during cruise and is active above the V_{MO} + 6 knots or M_{MO} + 0,01. Through lifting the aircraft's nose (increasing the pitch value) the system protects the A320 from a further increase of the Air-Speed (overspeed).

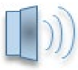
The AP de-activates automatically when the protection is activated and must be manually re-activated by the pilot after the Airbus returned to the normal envelope.

The VMO is indicated by a **Red-Black** bar in the PFD speed scale. The activation trigger for the protection, V_{MO}+6, is displayed by a **Green Double Line =** symbol, like an equal sign.

The pilot is unable to overcontrol the pitch-up command until the Air-Speed is back within safe limits. That means, a pitch-up input by the pilot is only possible when the speed indicator is below the **Red-Black** overspeed bar.

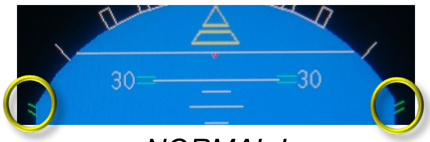
When the VMO-Overspeed is detected, the pilot receives several warnings:

1. The master warning button illuminates with a **Red MASTER WARN** indication. The button is located on the glare shield right in view of the pilot.
2. The acoustic warning – repetitive chime- sounds
3. In the upper ECAM Display a warning message appears: **OVERSPEED ………….. 350 / .82**.

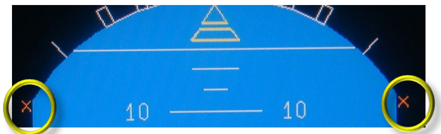


2. Alternate Law Protection

A change from Normal to Alternate Law is indicated on the PFD's artificial horizon. At this stage the **Green Double Line =** at the 67° mark, is replaced by an **Orange x**.



NORMAL Law



ALTERNATE Law

The symbol change is the only directly visible information to the pilot. There is no concerning FMA message. However, a specific system information is provided on the upper ECAM display:

F/CTL ALTN LAW (PROT LOST)

MAX SPEED …………….. 320 KT

In the event of a system failure or operation with limited functionality, e.g. due to missing or incomplete data, the FBW system cannot offer all protections, like in Normal Law. In this case, the FBW provides an alternative (reduced) set of protection features. This is called the Alternate Law and there is nothing more about the term Alternate.

With regards to the Bank Angle Control, the Alternate Law uses a direct relationship between the Sidestick input and the Aileron deflection without further processing by the ELAC computer. As a result, the roll rate is more aggressive as compared to the Normal Law.

The Pitch Control is very much the same as in Normal Law, the automatic trim is normally still available. In Alternate Law the speed scale indications are shown in a different manner:

The upper edge of the **Orange** bar still represents the **V_{LS}** – the lowest selectable speed.

Vα PROT und Vα MAX are replaced by the Stall-Warning-Speed VSW. Hence, the **Orange**-**Black** and **Red** bars of the Normal Law indication are substituted by a single **Red**-**Black** bar.

The V_{SW} is the upper edge of the **Red**-**Black** bar, approximately 114 knots in this example.

The Airbus can STALL in ALTN-Law at any speed.

With the gear extension (Gear Down) the FBW control system switches to Direct Law. The reason is, that Alternate Law does not comprise the Flare mode. Therefore, extending the gear is interpreted as the landing mode by the FBW control.

Consequently, when flying the approach in Alternate Law, the pilot selects the gear down as late as possible but before 750 feet. Otherwise the Gear- alert (Too Low Gear) will be triggered. Extending the gear late will further keep the Load Factor protection and the AutoTrim function available to the pilot.

High- und Low-Speed Protections

In Alternate Law, the High- und Low-Speed protections are substituted by the High- und Low-Speed stability. As with other protection features, the stability functions increase or decrease the pitch attitude in order to maintain the various speed thresholds.

Contrary to the Normal Law, the pilot is able to over-control the stability function at any time.

3. Direct Law Protection

On condition of certain multiple system failures, the FBW control changes straight into Direct Law without the Alternate Law as the intermediate stage. More often however, the change to Direct Law is due to the gear extension when the Airbus is operating in Alternate Law, es mentioned before.

The FMA informs the pilot of the change in the control law with an **Orange** FMA message

Additionally, a specific system information is provided on the upper ECAM display:

F/CTL DIRECT LAW (PROT LOST)

MAX SPEED ……………….. 320 KT/.77

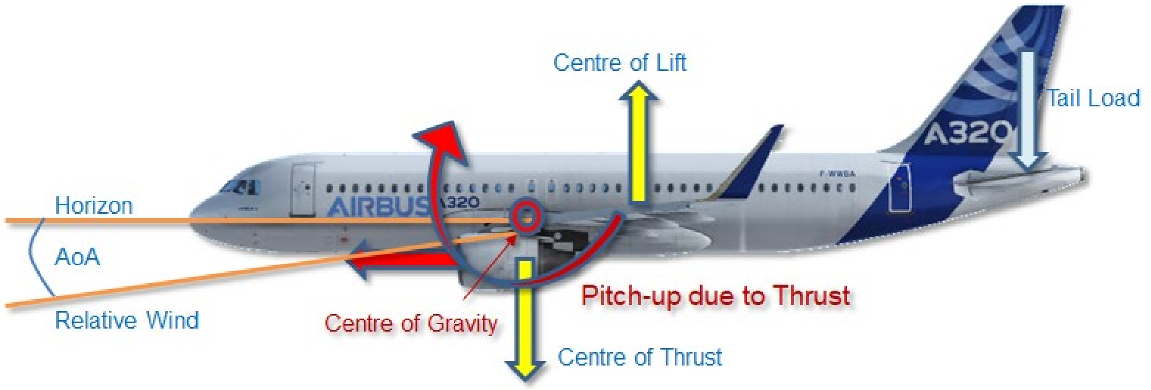
MAN PITCH TRIM ……..….. USE

MANEUVER WITH CARE

When the Direct Law is in operation, the protection system is unavailable. That means all protection features, but also the AutoTrim function, are not at hand for the pilot.

The Airbus can STALL in DIRECT-Law at any speed.

Because of the unavailability of the AutoTrim function, any power/speed change results in a corresponding pitch change. If the pilot moves the thrust levers forward to increase the thrust, the A320 will pitch-up (Nose-up) and vice versa. This effect occurs due to the engines being mounted below the aircraft's wing and the centre of gravity.



In order to correct the aircraft's pitch movement, the pilot needs to apply a corrective Sidestick input at first. Secondly, the pilot uses the trim wheel, located next to the thrust levers, to manually trim the Airbus.

The use of the A/THR is not recommended as it can lead to oscillation. Therefore, the pilot should opt for manual thrust to soften necessary thrust changes.

Direct Law Approach

Flying the approach in Direct law is a daunting task and a stable flight attitude is the pre-requisite for a successful landing. Pitch and thrust changes must be kept to the absolute minimum.

Therefore, the A320 should be in configuration 3 with the gear still up and **F** speed when intercepting the glideslope. It is important to note that Flap configuration 3 is recommended by Airbus for all non-normal landings.

To reduce form **S** to **F** speed, the A320 requires approximately 10 NM, that must be taken into consideration, e.g. asking the ATC for a Long Final.

When the glideslope (G/S) is alive the gear will be selected down and a descent rate of 700-800 ft/min will settle with only slight adjustments by the trim wheel. The increased drag by the gear shall be sufficient to establish the approach speed **VAPP** without large thrust inputs.

Direct Law Go-Around

The pilot flying shall give full attention to a stabile approach to avoid a Go-Around (GA) under non-normal flight conditions. As mentioned before, no AutoTrim function is available in Direct Law.

Flying a GA in Direct Law is indeed one of the most challenging Airbus flight manoeuvres. When the pilot sets TOGA to initiate the GA a tremendous pitch-up movement of the Airbus must be expected. Soft but straight pitch-down Sidestick inputs must be applied to keep the Airbus within its safe flight envelope. No protections are available at this point of the flight.

The gear should be raised as soon as possible, which will bring the A320 back to Alternate Law, if the failure configuration permits. Then, at least the Load Factor protection and the Auto-Trim-function would be available making the control of the A320 much easier.

4. Mechanical Backup

The task of the mechanical backup system is to bridge the time during an outage of the electrical system until the back-up provided by the RAT (RAM-Air-Turbine) is operational. Approximately 8 seconds are required for the extension of the RAT and setting it into operation. During the RAT extension, the batteries take over the electric power supply of the A320.

The mechanical back-up consists of the following provisions:

- Trim wheels (located on each side of the thrust levers) with a mechanical link to the THS (Trimmable Horizontal Stabilizer) on the tail fin.
- Rudder pedals with a mechanical link to the rudder on the tail fin.

The mechanical links operate the actuators of the control surfaces and require either the **Green** (**G**) or **Yellow** (**Y**) hydraulic circuit. There is no direct mechanical link between the trim wheels, the rudder pedals and the control surfaces

The FMA provides the following information:

1FD2

MAN PITCH TRIM ONLY

Special attention must be given to the trim wheel as it reacts quite direct and sensible. This requires a smooth aircraft control on one hand. But on the other hand, the direct trim response helps the pilot in stabilizing the pitch attitude of the Airbus in case of thrust changes.

After the emergency supply of the electric and hydraulic systems is established, the FBW control enters the Direct Law mode for the remaining flight. Experience in the FFS (Simulator) shows, that the A320 is unpretentiously controllable with these limited control devices.

1.3.3 Flap-Protection System

Another important feature of the protection system is protecting the flaps from structural damages due to Flap-Overspeed conditions. The slat and flap operation speeds are illustrated in the following table.

Flap-Lever Position	A318 - A319 Max-Speed	A320 Max-Speed	A321 Max-Speed	ECAM Display
1 *(TO)*	230/215	230/215	230/215	1+F
1 *(APP)*	230	230	230	1
2	200	200	200	2
3	185	185	195	3

Flap 1- Function:

The flap configuration 1 knows two different slat/flap settings according to the actual flight phase (</> 100 knots is the threshold):

→ Configuration 1+F, is the normal flap setting for the take-off. When the pilot sets the flap lever into the position 1, the Slats and the Flaps are deployed to position 1. The ECAM displays the slat/flap symbol 1+F and the term for the configuration is consequently Flaps 1 plus F.

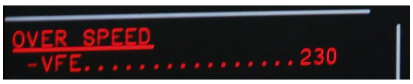
→ Configuration 1, is the first step during approach. When the pilot sets the flap lever into the position 1, the Slats are extended but the flaps remain retracted. The term for the configuration Flaps 1

Take-off-Flaps 1 - Function

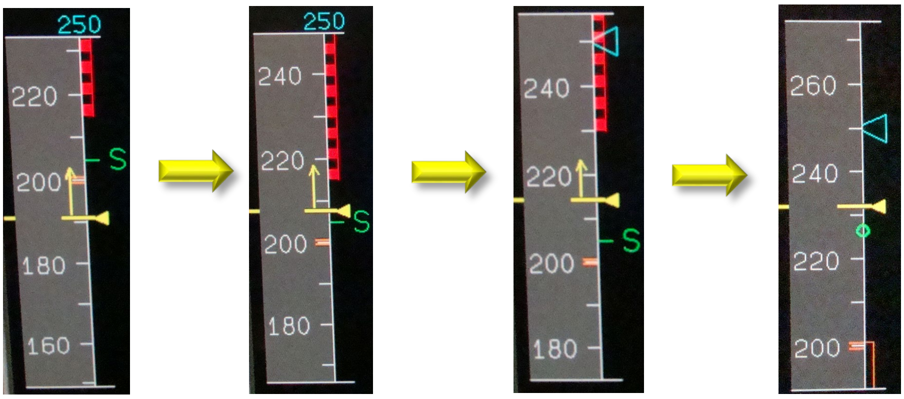
The **Orange Double Line =** represents the VFE (Flap Extension Speed), which is the speed for the next flap setting, in the example to flaps 0, As seen on the right picture, the VFE is about 8 knots above the **S** speed.

The **Red-Black** overspeed bar right on top (230 knots) represents the maximum speed for flaps configuration 1, which is associated with **S** speed. Once the actual aircraft speed is at or above **S** speed, the pilot can select flaps 0 without any operational risks.

In this example the flap configuration 0 has not been selected yet and the Air-Speed is already very close to the **Red-Black** bar, that would trigger the flap overspeed warning.



A high GW take-off with a TOW of 70 tonnes and more requires a special flap retraction procedure, because the **VFE** is below the **S**-Speed. In the following example the **S**-Speed is 206 knots and the **VFE =** is 200 knots as seen on the far-left picture.



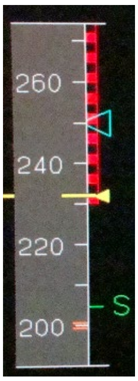
If the pilot would set the flap lever to 0 when reaching the **VFE = marker**, the Airbus has not yet passed the **S** speed. Therefore, flaps and slats would retract before S speed and the Airbus may enter a critical flight attitude.

As usual, the Airbus has a FBW controlled solution to the problem. The A320 FBW control system includes a protection feature which functions as follows:

- Shortly before reaching the **Red-Black overspeed bar**, the flaps will automatically be retracted at a speed close to 215 knots, but the slats remain extended. The ECAM display changes from F+1 to 1 and the flap lever keep staying in position 1.
- Additionally, the **Red-Black** overspeed bar moves from 215 knots (maximum speed for 1+F) up to 230 knots, which is the maximum operation speed of the slats (F1).
- After passing the **S** Speed marker, the pilot sets the flap lever into the 0 position and retracts the slats.

Flap Overspeed Protection

Depending on the take-off weight, the speed acceleration happens fast. If the pilot is slow toto set the flap lever into the 0 position, a flap overspeed situation can easily occur.

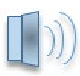


When the A/THR is active, which is normally the case in the climb phase, the A/THR system adapts the thrust to keep the Air Speed just at the **Red-Black** overspeed bar of 230 knots, as shown in the picture.

If necessary, the FBW control commands pitch-up, similar to the High-Speed protection. This pitch-up command cannot be over-controlled by the pilot.

The same protection applies to an F speed situation. In this case the FBW will adjust the thrust to keep the aircraft speed at the maximum flap 2 speed of 200 knots or 185 knots for a flaps 3 take-off.

When the Flap V_{FE} Overspeed is detected, the pilot receives, like for the V_{MO} overspeed, several warnings:



1. The master warning button illuminates with a **MASTER WARN** indication.
2. The acoustic warning – repetitive chime- sounds
3. In the upper ECAM Display a warning message appears: **OVERSPEED VFE 230**

Alpha-Speed-Lock - Function

The α-Lock function prohibits the retraction of the slats, not the flaps, within a certain attitude regime. If the pilot moves the flap lever from 1 or 1+F to 0, the slats are not retracted when the Air Speed is <148 knots or the AoA is >8,5^{o}, but the flaps are moved to position 0. Remember: an AoA of >10 is considered critical.

The ECAM (E/WD) displays **A-LOCK,** which flashes to attract the attention of the pilot.

1.4 Sidestick und Rudder Control

Because the Sidestick is located outside the direct visual field of the pilot, its usage is to a certain extend instinctive. Therefore, the pilot initially tends to overcontrol resulting in a visible oscillation of the A320. After some practice, the pilot's control difficulty will disappear quite easily.

The biggest advantage of the Sidestick is the unobscured view along the flight path as well as to the flight instruments. Especially during IFR (Instrument Flight Rule) operations, the advantage of a free view for the instrument scanning shall not be underestimated.

Pilots also like the extendable table not only for placing meals. It is perfectly suited as a working board for filling-in the flight log, checking navigation- weather charts and preparing for the briefing.

1.4.1 Sidestick Characteristics

In Normal Law, the Sidestick does not provide direct control inputs for the surfaces. The pilot uses the Sidestick to demand a load-factor (pitch) or roll (bank). With other words, he/she tells the flight computer the requested flight path and the flight computer calculates the necessary deflection of the flight control devices. The FBW control further coordinates the aileron and rudder inputs for a stabilized and coordinated turn.

Generally, the A320 is flown with the Sidestick in the neutral (centre) position and the FBW control holds a load-factor of 1g. The pilot's arm is resting comfortably on the stick to react in an instant if necessary.

The Sidestick can be moved in 4 directions and 2 axes:

- forward – Nose-down demand
- backward – Nose-up demand
- right – roll demand to the right
- left – roll demand to the left

The **Red** knob hast wo functions:

1. to de-activate the AutoPilot (AP), when the AP is engaged
2. activating the Sidestick Priority, when the AP is <u>not</u> engaged

The spring-loaded switch in front of the Side-stick (not visible) provides a push-to-talk function (PTT) for the microphone.

The Sidestick can freely be moved around the 4 axes without a rigid steering casing like a car gear-box. The movement profile is progressive. That means, as further the Sidestick is moved the more force is required. Therewith, aircraft induced oscillation due to fast Sidestick inputs shall be prevented.

The same is valid with regards to the reaction time to Sidestick inputs. As faster the Sidestick is moved, as faster the aircraft response is. In this case, the pilot must take care that the demanded load or roll rate is not excessive. Any corrective counter-input can easily end-up in an unwanted and uncomfortable aircraft oscillation.

It is good practise to separate vertical (pitch) and lateral (roll) inputs whenever possible. That means to move the stick either forward/backward or left/right. Especially during the approach, this procedure may not always be possible, Nevertheless, simultaneous inputs over 2 axes shall be kept to a minimum.

Moreover, any Sidestick input will always engage the AutoTrim function. Short and fast Sidestick input can therefore easily result in an aircraft oscillation due to the frequent THS movements.

These procedures are resulting in two scenarios for a coordinated Sidestick input:

(1) As further the Sidestick is moved, as more the aircraft moves in Pitch and Roll (-15 to +30º Pitch and 33º Bank). The maximum roll rate is 15º per second when the Sidestick is fully deflected.
(2) As faster and further the Sidestick is moved, as faster is the aircraft’s reaction. Short and fast inputs shall be avoided.

Whenever the required aircraft attitude is reached, the pilot releases the Sidestick into the neutral (Centre) position, which the Sidestick takes automatically. Both AutoTrim and Roll stability functions are active and keep the Airbus within a stabile flight envelop.

During take-off and approach, it is advisable that the pilot keeps a slight back pressure on the Sidestick. This pressure point avoids a gap between the pilot’s hand and the Sidestick and make an instant control input possible without delay.

If the pilot does not follow this procedure, then the control input may slightly be delayed like a care brake with a pedal gap. The usual pilot react will be to apply a faster control input, which lead to the aircraft’s deviation from the intended flight path.

1.4.2 Sidestick Dual - Input

As already mentioned, there is no physical connection between the two sidesticks. Nevertheless, the Sidesticks are electrically and logically coupled via the FBW control system

In normal operations only one Sidestick is used for control inputs. However, there are cases when the pilot not flying (PNF) must take-over instantly, e.g. in case of incapacitation of the flying pilot or malfunctions.

How does a dual-input affect the FBW system?

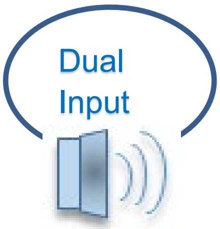
Example: The pilots flying (PF) and non-flying (PNF) simultaneously apply a Sidestick input. Both input values are algebraically added by the FBW control system until the maximum possible control surface deflection.

Captain input full right

F/O input full left

In case of a simultaneous input, both pilots are informed with a **Green** priority light and an acoustic warning „*DUAL INPUT*“. The **Green** light flashes on both pilot instruments as long as a double input is detected.

The pictures below illustrate the message lights on the Captain and the F/O side.



1.4.3 Sidestick Priority

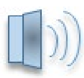
By pressing the **Red** button on the Sidestick, each pilot can de-activate the other Sidestick and take-over the aircraft control (Take-over Button). Pilot inputs on the de-activated Sidestick have no effect on the aircraft control.

The **Red** take-over button (priority button) must be pressed as long as the other Sidestick shall be de-activated. When the **Red** button is released both Sidesticks are active again and the FBW system returns to the normal control regime.

Example: The Captain presses the **Red** priority button and announce the take-over.

The Priority light on the Captain side illuminates with **a Green CPT**. The Captain knows that his Sidestick has now priority.

The F/O Priority light shows a **Red Arrow**. The F/O knows that his Sidestick is de-activated and the Captain has priority.

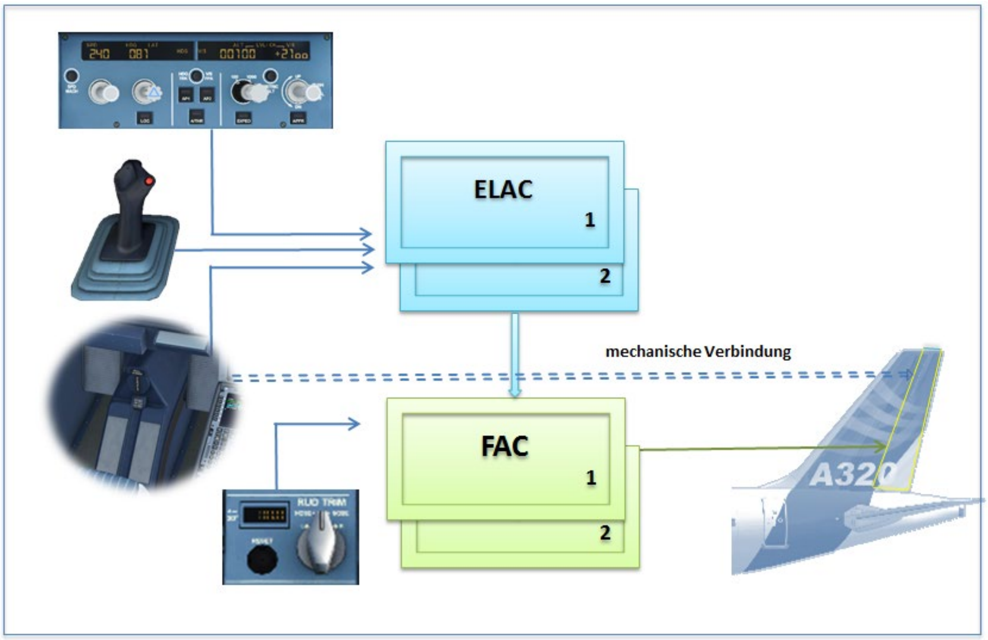
The acoustic voice informs with a „*PRIORITY LEFT*“ call-out. 

If the F/O presses the **Red** button, then his/her Sidestick takes priority. The priority lights show the reverse information, a **Green F/O** and a **Red Arrow** on the CPT priority light. The acoustic voice informs with a „*PRIORITY RIGHT*“ call-out.

If one of the **Red** buttons is pressed longer than 40 seconds, the de-activated Sidestick is permanently disabled (OFF). The Sidestick can be re-activated by pressing the red button again on the initiating Sidestick.

10.4.4 Rudder Control

The rudder (Yaw-Control) located on the tail fin of the Airbus is controlled via two sets of rudder pedals on each pilot side.



Normally, the rudder is controlled by the ELAC und FAC computers. In Normal Law, the 2 ELAC computers calculates the rudder deflection necessary for the Aileron/Rudder turn coordination. The data are then submitted to the 2 FAC computers.

The Flight Augmentation Computer (FAC) is the FBW-Interface for the rudder and the rudder-trim actuators which finally move the surfaces. The FAC receives the control inputs via the ELAC (Sidestick, FCU, AP and Rudder pedals) and the FAC (Rudder trim panel).

The A320 is flown with Sidestick inputs and manual rudder input is only required for a cross-wind landing (de-crab) and in engine out (EO) conditions. Yaw Damping and – auto-turn coordination is provided by the FBW control, with no input required by the pilot.

The amount of the rudder deflection is limited depending on the speed of the aircraft to avoid excessive rudder movement and critical flight conditions. Heavy rudder movement can also lead to structural damages to the aircraft’s fin and stabilizer surfaces. Some examples: With an Air Speed of 160 knots, the rudder deflection is limited to 25º, with 350 knots to 1,4º onA320 and 2,9º onA321. Please refer to chapter 3 (Yaw Control).

Mechanical control of the rudder is possible at any time and has priority over the FBW control system. Like the Pitch-Trim wheels, the Rudder Pedals also have a mechanically link to bridge an outage of the electrical supply until the RAT (Ram-Air Turbine) is operational.

If the AutoPilot (AP) is active the rudder pedals are locked like the Sidesticks and the Trim panel is inactive. Moving the rudder pedals with force will disconnect the AP in the same way as per the Sidesticks.

1.5 The Aircraft Configuration

1.5.1 The Centre of Gravity (CG)

The correct Centre of Gravity (CG) calculation is a pre-requisite for a safe and stabilized flight. The aircraft's weight and lift create a pitch movement, that must be balanced through load distribution (Load sheet) and stabilizer setting (THS).

The CG has a significant impact on the performance, particularly on the handling characteristics of the A320. As further ahead the CG is set, as larger the balancing movement of THS and the corresponding drag increase is. An A320 with a forward CG is heavier to rotate (top-heavy) with a lower initial climb rate. The pilot flying will feel the aircraft heavy and slow to rotate.

General rule: A top-heavy CG affects the performance negatively.

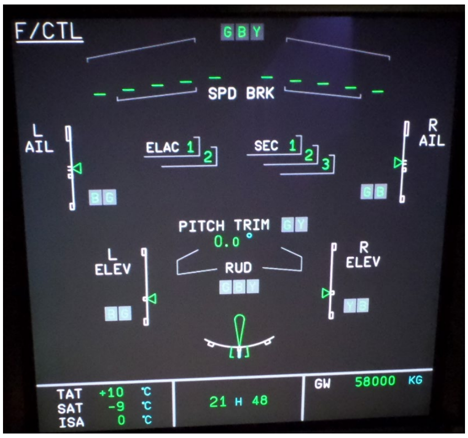
The CG is further important for the stability of the aircraft in flight. An aircraft is considered stable when it returns to the starting position after a gust-induced (turbulence, wind) pitch movement without pilot intervention.

Generally, a slightly aft CG is preferable.

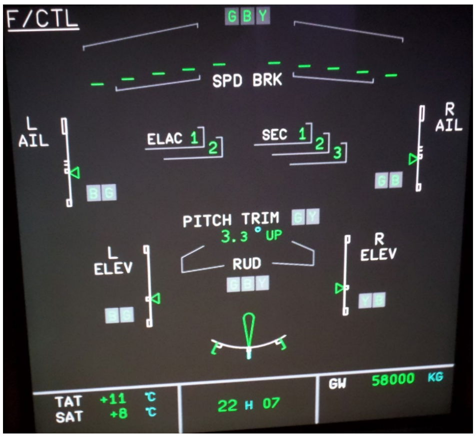
When calculating the CG two important facts must be considered:

- The A320 must be easily manoeuvrable on ground and during rotation.
- A sufficient ground clearance to avoid a Tail Strike must be observed.

The take-off GC setting for the A320 is usually 0 to 0.8 Up, which is slight Nose-up and therefore easier to rotate. After touch-down the FBW control always re-sets the trim to 0 independent form the actual weight. The following pictures display the trim settings for take-off and landing.

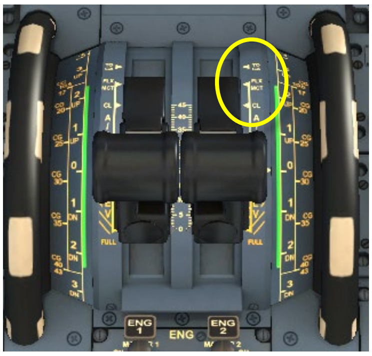


ECAM wheel page with take-off trim setting



ECAM wheel page with trim setting for final approach

The CG must be set once by the pilot before the take-off and the AutoTrim function adapts the setting according to the flight phase. As seen above the trim setting is 0 for take-off and 3.3 Up for the final approach. During cruise flight (horizontal flight) the FBW control moves the CG slightly aft to reduce the induced drag and in turn the fuel consumption



Part of the thrust quadrant are the trim wheels with the trim scale that is used by the pilot to manually select the THS trim value.

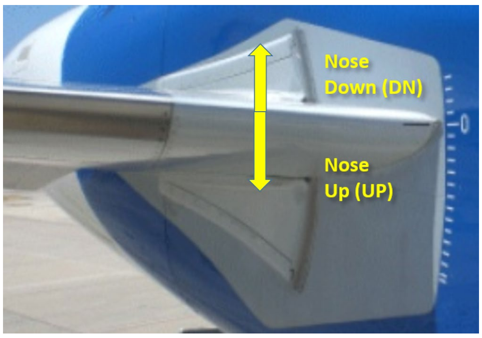
The manual trim position has priority over the FBW setting.

On top of the thrust lever quadrant, three physical detents (TOGA, FLX/MCT and CL) are located. They are used for the take-off and climb power setting.

The left picture shows a trim setting of 0.8 UP as well as the **Green Trim Area** from +2,3 (Up) to -2,3 (Down), which marks the allowable area for take-off.

If the trim wheel is rotated forward, the trim pointer moves backwards and vice versa.

For a slight aft trim setting the trim wheel is moved backwards (Nose-UP) and the pointer moves forward (THSUP), see chapter 3.



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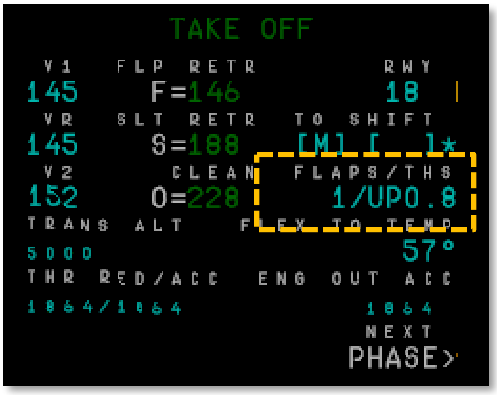
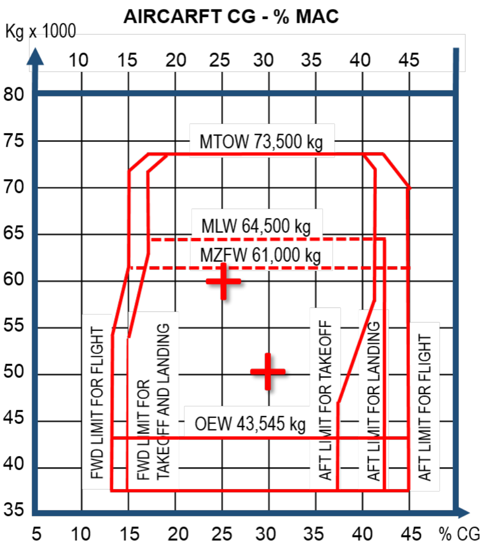
The pilot enters the trim value into the PERF-TO-Page. This data is one of the few MCDU insertions that have no effect on the FBW control.

The same is valid for the insertion of the flap configuration setting. For the configuration 1+F only the number 1 is entered in the TO-Page.

Both entries are used for the briefing and before take-off check.

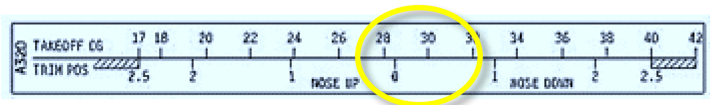




The diagram on the left shows the trim range of the A320 family. The standard value is 28% MAC corresponding to a THS trim setting of 0, based on the MTOW.

Two examples are shown in the diagram. For a TOW of 60 tonnes a setting of 0,8 UP (25 MAC) has been considered. The slight aft CG shall support the pilot during rotation.

For a TOW of 50 tonnes a setting of 0.2 DOWN (30 MAC) has been defined. The slight forward setting shall avoid an early rotation due to the light GW

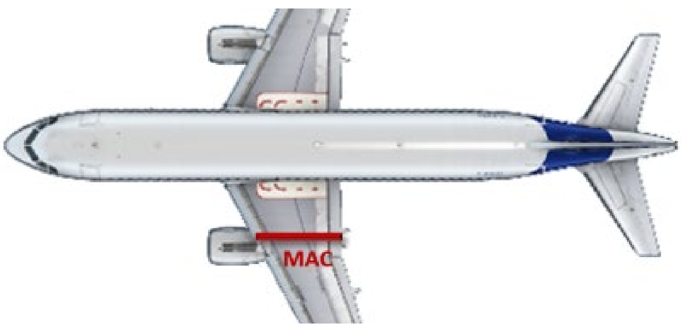


What is the MAC:

MAC means - Mean Aerodynamic Chord (middle chord of the wing) - and defines the CG area of the aircraft. This value is pivotal for the definition of the THS setting, as seen in the diagram above.

Generally, the CG setting very much depends on the load and passenger (Pax) distribution in the cabin. The load sheet is the final information for the pilot which includes all relevant load and Pax data as well as the proposed trim setting.

The Pax cannot discretely change their seats after boarding but need to request for with the cabin crew. A slightly loaded A321 can easily reach an „Out of Trim Condition". That means, the CG may no longer be within the **Green band** of the allowable CG area.



10.5.2 The Load-Sheet

The load sheet is prepared by the flight operation department of the Airline. The sheet is still provided in printed form and must be signed by the Captain. It contains all important information for a safe operation of the flight, including the trim setting for the take-off. A load sheet example is shown in the following table.

DOW	43170	Dry Operating Weight in Kg	
DOI	27.50	Dry Operating Index	
LOAD	9.4	Load in tons	UNLD - unload, disposable load
ZFW	52.6	Zero Fuel Weight	*MAX 61.0*
TOF	14.8	Take-off Fuel in tons	
TOW	67.4	Take-off Weight in tons	*MAX 73.5*
LAW	55.6	Landing Weight in tons	*MAX 64.5*
LIZFW	34.6	Loaded Index Zero Fuel Weight	*+22.2/+57.2*
ZFCG-TOGC-TRIM		ZFW-CG	TOCG 25.0TOW-TRIM 1.0 UP
CREW	2/4	2 pilots, 4 cabin crew	
Version	C24M132	Aircraft version	C 24 Business, M 132 Economy
PAX ACT	C15/M67	Actual Pax	C15- Business, M 67-Economy
		T 82 – total Pax	
LOAD ACT		Distribution of load to cargo bay 1, 4 und 5	
1/957 4/269 5/168			

Load includes Pax luggage. The LIZFW considers Pax-behaviour and assumes that Pax distribution is not even within the cabin. The Zero Fuel Weight includes freight and luggage, Pax and service load, but excludes fuel.

When compiling the load sheet, the flight operations centre takes care that all important weight limitations such as ZFW (Zero-Fuel-Weigh) and TOW (Take-off Weight) are not exceeded. The TOW is essential for the take-off calculation, yet the ZFW is crucial for the speed calculation in flight by the FAC.

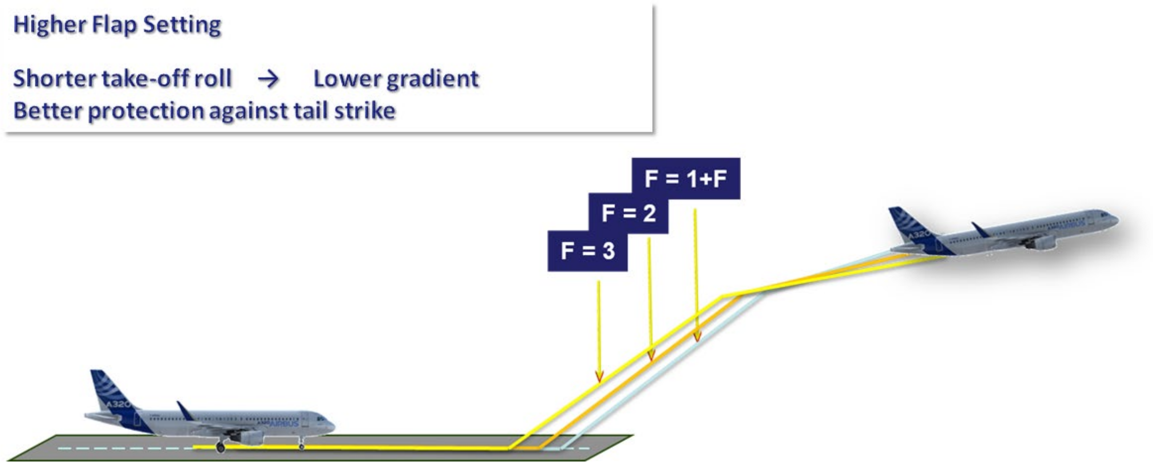
1.5.3 Defining the Flap Configuration

Due to various operation conditions different flap configurations are considered for take-off. These conditions include:

- Short runways
- High take-off weight
- High temperature
- High-elevation Airport
- Obstacles within the Airport environment, etc.

The standard flap setting is 1+F. If a shorter take-off roll (earlier rotation) is required the preferred flap setting is configuration 2 or 3.

The higher flap setting results in a shorter take-off run, providing additional obstacle clearance in the first phase after take-off. However, after passing the ACC-ALT, the pitch change is greater to build-up the speed for the slats/flaps retraction. The result is an initially higher obstacle clearance traded-in against a lower climb gradient over the take-off segment.



Beside a shorter take-off run, a higher flap setting reduces the take-off speed and provides a faster lift-off. Following tables gives an example for the A320.

Airport Elevation	Runway Length	TOW	Flap Config.	Take-off Speed knots	Take-off Run
300 feet	4000 m Example EDDF	65T	1+F	V_1 138 V_R 138 V_2 140	approx. 1200 m
1500 feet	2000 m Example LOWI	65T	2	V_1 130 V_R 132 V_2 135	approx. 1100 m

The V_1 at LOWI (Innsbruck) is considerably lower due to the shorter runway and the reduced stop margin in case of an engine failure.

A320 Flap Schedule

As further explained in chapter 3, maximum flap operation speeds must be observed to avoid structural damage to the slat/flap system. For A320 the following speeds prevail:

Position	Slats	Flaps	Max- Speed	Flight Phase
1+F	18	10	215	TAKEOFF
2	22	15	200	TAKEOFF
3	22	20	185	TAKEOFF

If these speeds are exceeded a master alarm is triggered requiring the immediate corrective action by the pilot. However, the A320 provides some flap overspeed protection which is explained in this chapter under section Flap Overspeed Protection.

Above the stand-by instruments, a placard informs the pilot of the most important flap (V_{FE}) and gear (V_{LE} / V_{LO}) speeds. They are also called the placard speeds.

The V_{FE} speeds are equal for take-off and landing with the exception of flap configuration 1+F. This flap setting is for take-off only.

1.5.4 Ground Clearance

Another important aspect for take-off and landing is the ground clearance, the space between the Airbus's tail and the runway. Ignoring this limitation can easily result in an expensive tail-strike incident.

All Airbus aircrafts, except the A318, are geometrically limited. That means, the pilot's Sidestick input can demand a pitch attitude leading to the tail touching the runway before the A320 is lifting off. This is particularly true for the A321 with its long fuselage.

As mentioned before, only the A318 can be rotated with full Sidestick back-pressure pitching up straight to the recommended 15-17,5° Pitch without the risk of a tail strike.

Ground Clearance - Takeoff

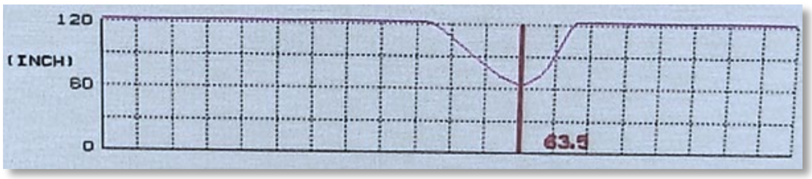
Position of the main wheel	Pitch attitude leading to tail strike		
Fully extended	A319 15,5º	A320 13,5º	A321 11,2º
Fully compressed	A319 13,9º	A320 11,7º	A321 9,7º

Ground Clearance – Landing

	Geometrical Limit	Pitch attitude at V_{APP} (Vref+5Kts)	Pitch attitude Touch Down	Ground clear-ance
A319	15,5º	3,4º	7,7º	7,8º
A320	13,5º	3,3º	7,6º	5,9º
A321	10,8º	2,4º	6,6º	4,2º

Approximately 25% of Tail Strikes happens at take-off and 65% at touch down.

The flap 2 or 3 setting for take-off reduces the tail strike risk because of the higher lift component produced by the larger wing area of the slat/flap extension. Therefore, the Airbus lifts up earlier and faster thus reducing the risk. The picture below shows the take-off diagram taken from the APT.



The space between the A320's tail and the runway is 63,5 Inches or 160 cm (1,6 Meter) at the rotation.

The take-off took place with a V_R of 148 knots and an initial pitch of 8°.

The rotation rate was slightly below the recommended 3°/second. This explains the more than sufficient ground clearance during the rotation.

Wing Tip and Engine Scrap

Beside the pitch attitude, also the bank angle must be considered during take-off and landing. Otherwise, the risk of touching the runway/ground with the wing or engine may occur.

The following bank angles for A319-A320-A321 will definitely lead to a ground contact:

Bank angle - Main wheel not loaded	18º	(gear struts not compressed)
Bank angle – Main wheel loaded	16º	(gear struts compressed)

The official bank limit at touch down is 7°. If the flying pilot exceeds this value, the pilot non-flying must provide a corresponding call-out – bank angle.

1.6 Defining the Power Setting

1.6.1 TOGA (Take-off Go-Around)

Take-offs with full power (TOGA) are nowadays the exception. Runways at international Airport provide enough TORA (Take-off Runway Available) to safely take-off with a reduced engine thrust.

Nevertheless, the following Airport conditions will require a take-off with TOGA thrust setting:

- High temperature.
- High Airport elevation.
- High take-off weight.
- Short runway. Weather conditions such as, crosswind, contaminated runways, etc.
- A combination of these conditions.

Especially under the above-mentioned weather conditions a short take-off run is favoured to get off the ground as soon as possible. On the other hand, jet engines produce less power with increasing temperature or field elevation making TOGA the preferred choice.

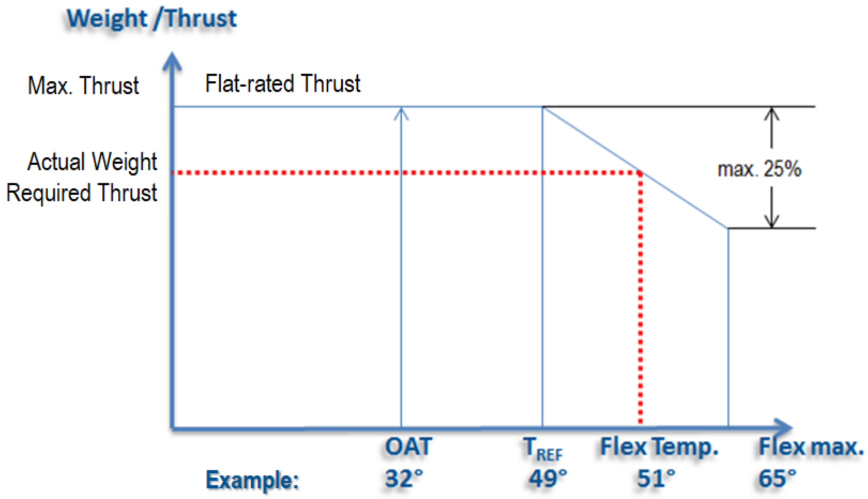
1.6.2 Flex-Temperature (FLEX)

International Airports usually have got long runways and maximum take-off power is not absolutely necessary. Therefore, pilots calculate the lowest possible power setting for a safe take-off, thus accepting a longer take-off run. A lower power setting, called Flex take-off, saves, extends the engine life cycle and reduces noise. Flex take-offs are nowadays the standard procedure and an important aspect for the Airline to optimize their operation costs.

Another important reason for using a Flex take-off setting is the lower power setting in case of an EO condition. Through the lower power setting, the aircraft's yaw moment is lower and easier controllable during this critical procedure.

When calculation the Flex take-off data, the assumed outside temperature is the key data and not a certain percentage of the available engine power. This calculation method is called De-rated Take-off power and is not available with the A320 family. Because engines are producing less power with an increasing temperature, this behaviour is the key factor for the Flex temperature procedure.

The aircraft manufacturers are providing specific temperature/power tables for each aircraft variant. The following graphic shows the general principle of the Flex TEMP operation.



After calculation, the Flex temperature is entered into the MCDU-PERF-Page and accepted with LSK4R, right picture.

This data is then used by the FADEC (Full-Authority Digital Engine Control) to command the required engine output when the pilot moves the thrust levers into the FLX/MCT detent of the thrust quadrant, see chapter 3.

At any time, the pilot is able to select full power by placing the thrust levers into the TOGA detent. Just for completeness: After a de-rated take-off power is set, the pilot cannot apply full power, the de-rated power output is the maximum power available for the take-off.

Airline operators have specific computer programs on hand to calculate TOGA, Flex or De-rated take-off data. The A320 family does not provide De-rated thrust setting.

In order to support the Flightsimulator-pilot, take-off data for popular take-off weights are included in this book.

1.6.3 Cost-Index

The Cost Index (CI) is an important tool for Airlines to operate as economical as possible. Through the CI, Speed/Mach Profiles (thrust settings) are determined for the various flight phases such as climb and cruise.

Generally, the following rules apply:

- Whenever the fuel consumption is the decisive factor, the CI value is mean. CI 0 = maximum range, lowest fuel consumption.
- Whenever the flight time is important: the CI value is high. CI = 999 – minimum flight time, highest fuel consumption.

Therefore, the Cost-Index is the relation between the flight time and the fuel consumption in percent (%).

$$CI = \frac{\text{Flight Time Costs in € }/hour}{\text{Fuel Costs in € }/tons}$$

The CI is individually calculated by the Airline and depends on the aircraft performance and the route profile. Therefore, the CI is always a compromise between fuel consumption and flight time. Typical CI values are 20 and 30.

Should the flight situation require, e.g. the flight is delayed or to avoid a holding at the destination Airport, the pilot can adapt the CI at any time. To do this, the pilot enters the new CI factor into the MCDU INIT- or PERF-Page. A higher CI increases the aircraft speed whereby, for example, a delay due to heavy head wing can be avoided. Such adaptions and the additional fuel consumption are usually considered for the flight planning.

1.7 The Fuel Calculation

The fuel calculation follows a standardized procedure using so-called trip-fuel-tables. The calculation example is based on the following assumptions:

Take-off	TOGA – maximum take-off power
Climb Profile	250kts/300kts/M 0.78
Cruise	M 0.78
Descent Profile	M 0.78/300kts/250kts
Approach and Landing	Visual landing

Average fuel consumption in still air:

Aircraft type	Approach and landing	Average consumption cruise	
A319	110 kg for 6 minutes IFR	40 kg/min	2,4 tonnes/hr
A320	120 kg for 6 minutes IFR	40 kg/min	2,4 tonnes/hr
A321	140 kg for 6 minutes IFR	50 kg/min	3,0 tonnes/hr

ISA Standard-temperature	for each degree above the ISA the following correction is required: 0.015 x ∆ ISA (in ºC) x Air Distance (NM).
Centre of Gravity:	CG 33% MAC
Air-Condition A/C:	Normal
Anti-Ice:	OFF
Reference GW:	A319 50 tonnes / A320 50 tonnes / A321 60 tonnes

NM	A319	A320	A321	Flight Time
200	1550	1630	1770	38 min
225	1700	1715	1930	42 min
250	1830	1920	2080	45 min
300	2115	2215	2390	51 min

All values are rounded. The flight time corresponds to the cruise phase.

The fuel consumption includes all fuel required from brake release at the gate until landing and taxi to gate at the destination Airport. Additionally, the following adaptions must be considered:

Condition	A319	A320	A321
A/C Econ	-0,5	-0,5	-0,6
Anti-Engine-Ice ON	+2	+2,5	+2,5
Anti-Ice ON / All *	+4	+4,5	+5

* *Anti-Ice All = Wing and Engine*

Additions according to the standard fuel calculation model:

Taxi Fuel:	200 kg for A318, A319, A320 and 300 kg for A321
APU Fuel:	250 kg
Alternate Airport:	approx. 100 NM (in Europa)
Holding:	20 minutes
Reserve:	Final Reserve is always 30 minutes, e.g. for a Holding at the Alternate Airport in 1.500 feet.
Contingency:	Usually 5 percent of the trip fuel

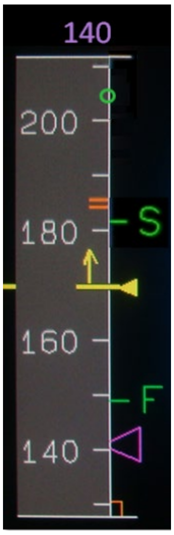
Note: all fuel consumption data are based on flying in still air. Adjustments must be made according to the weather conditions (headwind > tonnes/hr, tailwind < tonnes/hr).

1.8 The Take-off and Landing Speeds

1.8.1 The V-Speeds

GD, **S**, **F** - Speeds have different meanings for take-off and approach.

Take-off Speeds



F - Flap Speed - minimum Speed, where the flaps can be retracted, or set to the next position, e.g. Flaps 1 for a Flaps 2-takeoff.

S – Speed - minimum Speed, to retract Flaps and Slats to position 0 (Up).

GD – **Greed Dot** (**o**) Speed - speed with the best drag/lift ratio after an engine failure, also known as Clean-Speed. Therefore, **GD** is the target speed after engine failure.

= VFE – speed for the next flap lever position. The pilot sets the flap lever into the next position. The **Orange =** VFE symbol moves according to the actual flap position and speed (F, S). During take-off, the VFE symbol represents the latest moment for the next flap position.

V_2 – safe climb Speed and is displayed by a **Magenta-Triangle**. As long as the speed value is outside the speed tape, the V2 is indicated as a **Magenta Value (140)** on top of the speed tape.

Approach Speeds

GD – Speed - target Speed, where the Flaps are extended from 0 to 1.

S – Speed - target Speed for Flaps extension to position 2.

F – Speed - target Speed for Flap configuration 2 und 3.

= –VFE - speed for the next flap lever position. The pilot sets the flap lever into the next position. The **Orange =** VFE symbol moves according to the actual flap position and speed (F, S, GD). During approach the VFE symbol represents the earliest moment for the next flap position.

VAPP – is the Approach Speed for Flap configurations 3 or Full. It is always slightly less than the **F** – Speed and displayed by a **Magenta-Triangle**. As long as the speed value is outside the speed tape, the VAPP is indicated as a **Magenta Value (140)** below the speed tape.

VLS - Lowest Selectable Speed. The speed corresponds with the upper edge of the **Orange Bar**. The **VLS** is actually the lowest speed that can be flown with the A320. But on the FCU, the lowest speed selection is 100 knots, which is always lower than the **VLS**.

VMAX - maximum speed for the current aircraft configuration. The **Red/Black** speed band represents the maximum value of:

- VFE max for the current flap setting, left picture
- VMO or MMO (Mach Max Operating speed) which is defined by a **Green =** symbol (+ 6 knots of the VMAX band), right picture

VLE - Gear Extension Speed

VFE - Flap Extension Speed

Cruise Speeds

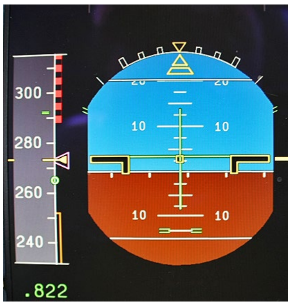
ECON Speed – is calculated by the FMGS using the Cost-Index (CI) – and is the most economical cruise speed, usually Mach 0.78.

The usual CI is 20 or 30, which is a good compromise between low fuel consumption and an adequate cruise speed. However, if the flight is behind schedule a CI of 99 is often used to speed up the flight and avoid a delay.

Mach – IAS switch-over

Up to FL 270 (27000 feet) the speed is shown in knots and above in MACH. As of FL270 the TAS in knots decreases with rising altitude and the MACH value increases. The reasons are atmospheric conditions and the different measuring methods (Pitot-tube and Mach meter).

The picture on the right also shows the notorious Coffin-Corner. The margin between the maximum speed (**VMO**) and the **VLS** is just 40 knots. However, a Stall would only occur at a speed lower than the **VLS**.



The MACH number 0.822 in **Green** is the actual TAS corresponding with 275 knots. The photo was taken on an A330 at FL360.

1.8.2 The VFE Speeds

VFE (Velocity Flap Extension) is the maximum flap extension speed, as indicated in the table below. They are marked on the PFD speed scale with a **Red**-**Black** bar.

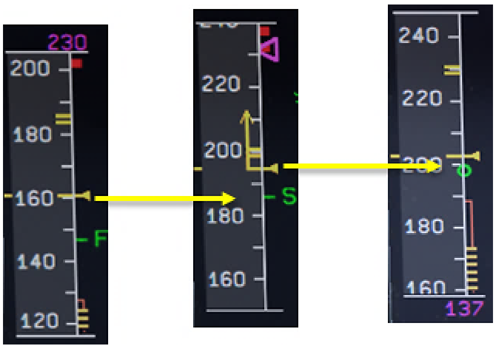
VFE-next is the corresponding speed at which the pilot selects the next flap configuration. It is marked on the PFD speed scale with an **Orange Double Line =**.

Both speeds have fixed values, which are defined by the structural limitations of the flap system. On the contrary, **GD**, **S**, **F** and **VAPP** are variable depending on the aircraft's GW.

Flap-Lever Position	A318 - A319 Max-Speed	A320 Max-Speed	A321 Max-Speed	ECAM Display
1 *(TO)*	230/215	230/215	230/215	1+F
1 *(APP)*	230	230	230	1
2	200	200	200	2
3	185	185	195	3
Full	177	177	190	Full

Similar to the GD, F and S speeds, VFE and VFE-next have different meanings for take-off and approach. VFE and VFE-next are indicated whenever the Airbus is below 20.000 feet (FL200).

Take-off Flap-setting sequence



On the left picture, the VFE-next for the next flap configuration 1 during a F2 take-off is 185 knots. That means, the pilot selects the next flap configuration _latest_ at the VFE-next speed marker.

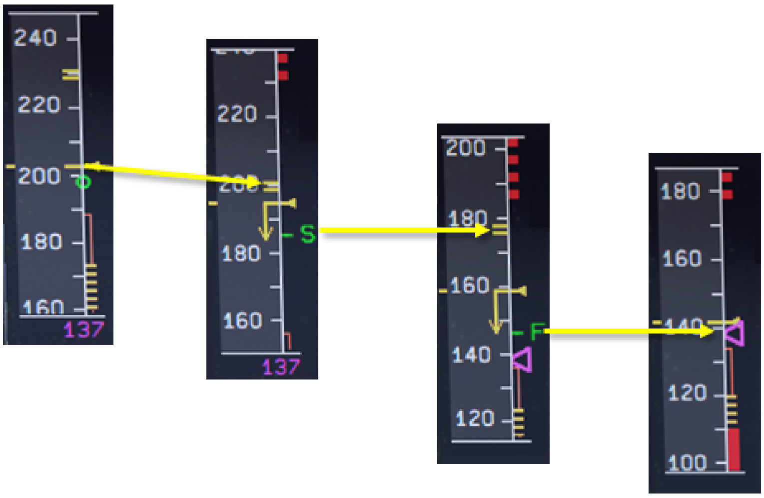
The **Red-Black** bar on top of the speed scale is the VFE, the maximum speed for the current flap configuration 2, which is 200 knots.

For a take-off with flap configuration 2, the pilot retracts the flaps to configuration 1 when the Airbus climbs above **F** speed, at the earliest. In the example F1 is selected at 160 knots. The speed scale indication changes to **S** speed with the VFE-next of 200 knots and VFE of 230 knots.

In the centre picture the Airbus climbs at 195 knots which is above the **S** speed and just below the VFE-next. Once the actual speed is above **S** speed, the pilot can retract the flap UP (configuration 0). In the right picture the new target speed is **GD**.

Approach Flap-setting sequence

Configuring the Airbus for the approach starts with the activation of the APPR-phase (activating the PERF-APPR-page). At first, the APPR-phase commands **GD** speed and the speed decreases to 195 knots, far-left picture.



The pilot can extend the flaps to position F1 when the speed is below the VFE-next marker of 230 knots.

The speed scale indication changes to **S** speed with the new VFE-next of 200 knots. When the Airbus flies below VFE-next, the pilot extends the flaps to configuration F2.

The speed scale indication changes to **F** speed with the VFE-next of 180 knots.

When the Airbus flies below the VFE-next of 180 knots, the pilot extends the gear followed by flap configuration F3. The speed scale indication changes to **VAPP** speed, no further VFE-next is shown. When the pilot selects F-Full, the speed decreases to **VAPP**.

It is important, that the pilot observes the VFE-next indicators, otherwise a flap overspeed situation may arise, as seen in the right picture.

1.8.3 The Take-off Speeds

Calculating the take-off speeds is a complex issue for the FS-pilot, while Airlines pilots are using specific computer programs as part of the EFB (Electronic Flight bag). The FS-pilot usually does not have such comfortable support on hand.

The calculation of the take-off and landing speeds depends on the following factors:

- Take-off weight (TOW)
- Available and usable runway length (TORA)
- Actual air pressure at the Airport (QFE)
- Airport elevation (QNH)
- Flap configuration (1+F, 2 or 3)
- Environment conditions (Temperature, Wind, Cloud-base, Runway)

The take-off and landing speeds are roughly the same within the A320 family (A319-A320-A321) for a given gross-weight (GW). This should be acceptable for the FS-pilot, but it would not be sufficiently accurate in real operation.

Overview of the important Take-off Speeds

V_1 is the speed where the take-off cannot be rejected anymore. The remaining RWY would not be sufficient for a safe stop. Therefore, the V_1 depends on the available RWY length beside take-off weight, Airport elevation and actual temperature.

V_R is the rotation speed. The PNF calls out „Rotate“ and the PF lifts-off by applying back pressure on the Sidestick. The rotation speed is calculated based on the same factors as before.

V_2 is the safe climb speed in case of an EO (Engine Out) situation. After lift-off, the aircraft must be able to safely overfly an obstacle of 35 meters. V2 + 10 is the target speed after rotation until the acceleration altitude (ACC ALT).

S is the speed at which the flaps can be retracted from position 1 to 0. Usually the pilot calls for flaps 0 shortly after passing the **S** speed marker, e.g. **S** + 10 knots.

F is the speed at which the flaps can be retracted to position 1 from position 2 or 3 depending on the take-off configuration. The PF calls for Flaps 1 when passing the **F** speed marker, e.g. + 10 knots. Only one **F**-Speed marker is displayed for both flap settings, 2 and 3.

GD (**Green Dot o**) is the speed with the best lift/drag ration and the target speed in case of an engine-out situation (EO).

The following tables contain a selection of take-off speeds for various flap configurations. These speeds are valid for take-offs under ISA standard temperature and Airports with an elevation up to 1400 feet MSL (Mean Sea Level).

A320 Take-off-Speeds with Flaps 1+F setting

Gross-Weight (GW) tons	V_1 knots	V_R knots	V_2 knots	Roll distance Meter	RWY cond.
50 TOGA FLX 65°	115 115	120 122	125 125	700 800	dry
60 TOGA FLX 65°	125 130	132 135	136 136	1.250 1.500	dry
65 TOGA FLX 63°	130 142	138 143	141 143	1.500 1.700	dry
70 TOGA FLX 65°	140 148	148 153	152 155	1.700 1.900	dry

Take-off-Speeds with various Flaps settings

A320 / A319 60 TOGA F1+F F2 F3	 125 120 115	 132 125 120	 136 130 125	 1.250 1.100 1.000	 dry
A321 70 TOGA F1+F F2 F3 FLX 60 F1+F	 125 125 120 145	 136 128 122 150	 145 135 130 155	 1.500 1.350 1.200 2.000	 dry

Selected GD – S - F Speeds

Gross-weight	Speed in knots < FL200			> FL200 - FL280
tonnes	O Dot	S	F	O Dot
65	215	192	150	223
60	205	185	145	213
55	195	178	140	203
50	185	168	130	193

For each 1000 feet above FL200 /1 knot has to be added – for FL280 = 8 knots
Take-off -Speeds are taken from the APT and rounded.
Take-off roll distances are partly rounded.

As already mentioned, take-off speeds are calculated by the pilot using a specific program (EFB) and entered into the TO-PERF-Page.

Additionally, the FMGS automatically generates the other important operating speeds, such as **F**. **S** and **GD**-speed. Pre-requisite are correct data in the FUEL-PRED-Page.

Take-off with high Take-off Weight

Airport elevation and the actual air temperature have a significant impact on the definition of the maximum allowable take-off weight. As higher the Airport elevation and the air temperature as lower is the maximum take-off weight. The reasons are, that jet engine produce less power with increasing elevation and/or temperature and the lower air density requires a higher rotation speed for the take-off.

It is standard procedure to switch-off the packs (air conditioning system) for take-off to generate additional engine power of approximately 4%. Generally, the packs are regulated as follows:

A/C	Max actual PAX number	PACK Flow
A319	115	LO
A320	115	LO
A321	140	ECON

During the start-up, the Packs are automatically switched-off when the starter switch is set to IGN/START. Once the engines are running, the Packs are automatically switched-on when the starter switch is set back to NORM.

1.8.4 The Landing Speeds

Contrary to the take-off speeds, the landing speeds are calculated by the FMGS and the FAC, see also under V_{LS}-check.

Selected Landing Speeds

Landing weight	Speed in knots				
tons	O Dot	S	F	VLS / V_{APP} 3	VLS / V_{APP} Full
60	205	185	145	135 / 140	130 / 135
55	195	178	140	130 / 135	125 / 130
50	185	168	130	125 / 130	120/ 125

The Landing -Speeds are taken from the APT and rounded.

The difference between the V_{LS} and the V_{APP} is usually 5 knots.

These speeds are displayed in the APPR-PERF-Page. Pre-requisite are correct data in the FUEL-PRED-Page. Detailed information about the system pages is provided under chapter 4.

Landing Distance

Airport elevation and air temperature also play an important role for the landing. For a landing in configuration Flaps Full, the following values apply for the A320

Landing weight	Required Landing Distance (RLD) in meter		
tonnes	Manual braking max	AutoBrake Medium	AutoBrake Low
60	1.030	1.320	1.900
55	980	1.270	1.850
50	930	1.220	1.800

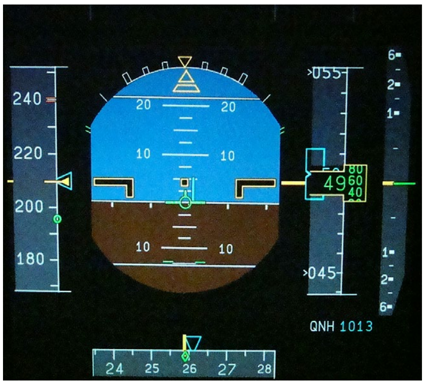
The values are valid for a landing in configuration-Full and dry runway conditions

1.9 The Basic Flying Techniques

1.9.1 Flying with Raw Data

Flying with Raw Data means, only the basic (unprocessed) flight information data such as Attitude, Speed, Heading, Altitude are available for manoeuvring the Airbus.

The Raw Data, that are entered into the FCU windows are displayed on the PFD in **Blue**. The data for speed and heading is further displayed in form of a **blue** triangle, also called BUG.



In the left picture the **Speed-Bug** is set to 210 knots, which corresponds with the actual speed. No pilot action is required.

The **Heading-Bug** is set to 262º which is slightly to the right from the actual heading. The Actual heading is defined by the **Yellow Bar** in the centre of the compass cut-out. A slight right turn is required to line-up with the heading bug.

No selected altitude is shown on the PFD, because the Airbus is in level flight.

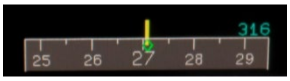
As mentioned before, the selected Raw Data for speed, heading and altitude are entered into the FCU windows using the corresponding dial knobs.

The FCU data for speed (180) and heading (266) are shown on the PFD as **Blue Triangles** like in the example before.

The selected altitude **18000** (**FL180**) is above the current altitude and displayed as a **Blue Value** above the altitude scale. It will be shown below the altitude scale, if the selected altitude is below the actual aircraft altitude.

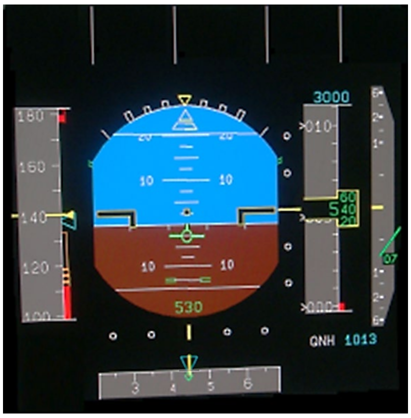
Changing the QNH from 1013 to STD, will alter the altitude information from **18000** to **FL180**.

If the heading bug **266º** is displayed on the left side of the actual heading, **Yellow Bar**, the pilot must steer to the left to fly the requested heading and vice versa.

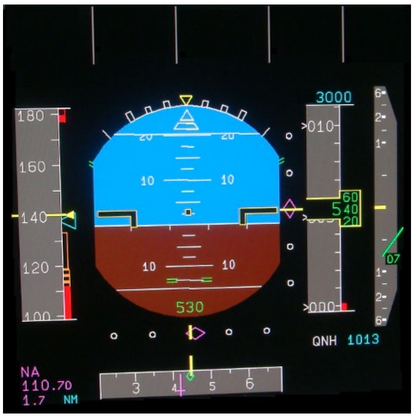


If the selected heading is outside the course scale, then the heading bug is shown as a value. In the example the pilot must execute a right turn to fly the requested heading of **316º**. Once the actual heading is less than 295º the **Blue Value** will be replaced by the **Blue Triangle**.

Visual APPR with Bird



Raw-Data ILS



The above picture on the left shows a visual raw data approach to RWY04R at LFMN (Nice) with the corresponding **Bug Setting**. The bird has been selected as an additional information for the flight path angle. Consequently, the HDG bug is the aircraft track.

The above picture on the right illustrates the same approach using ILS Raw Data, with the **Magenta Rhombuses** for the localizer and glideslope deviation. The **Rhombuses** only tell the pilot the position of the Airbus in relation to the localizer and glideslope, but no flight control command is provided.

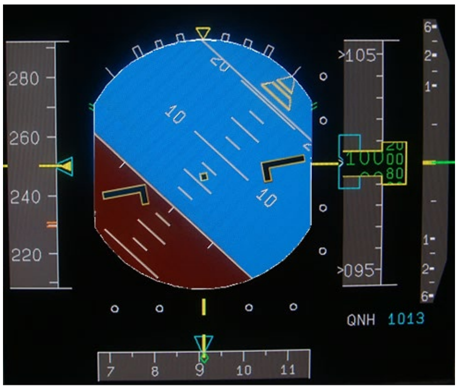
Without the FD, the pilot has to determine by himself/herself how much control input and in which direction is required to fly a stabilized approach.

1.9.2 Flying a Steep Turn

The pattern training is not well suited to integrate steep turn training due to the low altitude of the traffic pattern. The turn is best practised at a height near to FL100 to stay within the training Airport vicinity

Up to a bank of 33º, the AutoTrim will hold the A320 level, even though some pitch correction may be necessary due to jerky turn manoeuvres by the pilot or under strong wind conditions. Flying a turn with a bank angle greater than 33º, the pilot needs to hold level by holding the Sidestick aft, like a conventional aircraft.

The PFD picture shows a turn with 45° Bank to the left. Starting point is a horizontal flight at FL100 with a speed of 250 knots. With a GW of e.g. 60 tons, the A320 requires a power setting of approximately 62% - N1.



When passing the 30° marking, the pilot must apply back pressure on the Sidestick to prevent the nose from dropping. The pitch will increase from 2,5° (level) to 5-6º and simultaneously the power setting from 62% to 70% (+12% - N1), to keep the target speed.

After finishing the turn, the pilot must bring the pitch back to 2,5° and reduce the power setting to 62% - N1.

This training procedure should be conducted without A/THR to get a good feeling about the sensitivity of the thrust levers.

1.9.3 Pitch and Power Flying

Modern jet-aircraft are flown according to Pitch and Power, independent from the size and type (e.g. A320 or Business Jet).

With other words: The Pitch und Power values are the decisive references for the pilot, especially when flying on Raw-Data as discussed before.

Whenever these two values are in proper relation (e.g. Pitch 2.5º, 60% N1 power), all other important parameters such as V/S (0 ft/min) and Speed (250 knots) are automatically in agreement. The relation is only good for a specific scenario, in the example a horizontal flight with a gross weight of 60 tonnes.

Selection of important Pitch and Power Values for the A320

Flight Phase GW 60 tons	Configuration	Speed	Pitch	Power N1
Take-off	F-1+F	V_R	15°	98% TOGA 88% FLEX
Climb ACC-ALT	F-1+F	V_2+10	15°	TOGA / FLEX
Climb < FL100	F-0	250 knots	10,0°	83% = CLB-THR
Climb > FL100	F-0	300 knots	7°	83%= CLB-THR
Level FL100	F-0	250 knots	2,5°	60%
Cruise FL250	F-0	300 knots	2,5°	70%
Cruise FL300	F-0	M 0,78	2,5°	76%
Descent > FL100	F-0	300 knots	-0,5°	IDLE (ca. 30%)
Descent > FL100	F-0	270 knots	0,5°	IDLE (ca. 30%)
Descent < FL100	F-0	250 knots	0°	IDLE (ca. 30%)
Approach (Level)	F-0	G-Dot	5,0°	54%
Approach (Level)	F-1	S	7,5°	56%

Approach (Level)	F-2	F	8,5°	58%
Approach (Level)	F-3	F / GD	7,0°	63%
Landing (Final - 3°)	F-3	F / GD	4,0°	54%
Landing	F-3	V_{APP}	3-4°	50% = GW-15%
Landing	F-Full	V_{APP}	2,5°	54% = GW-10%

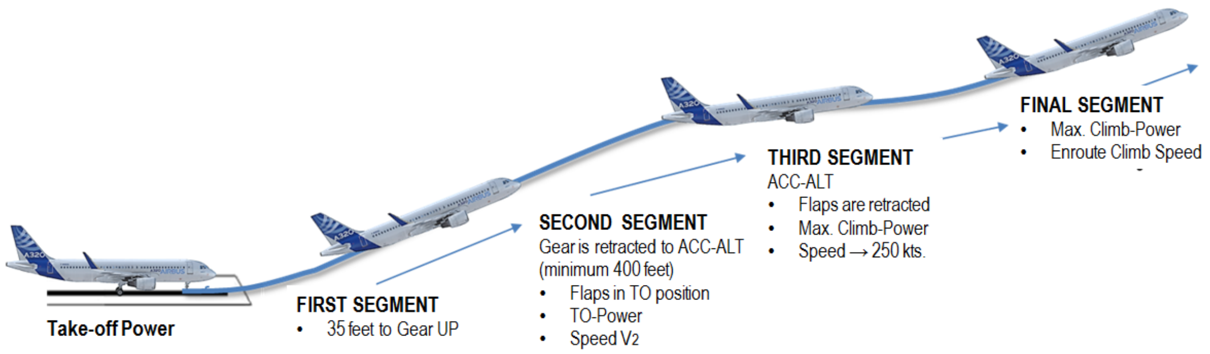
The above values have been compiled during training sessions in the APT. As an example, they are sufficiently accurate as a round figure for the FS-pilot.

1.10 Take-off Training

The take-off procedure is generally divided into four segments, which are shown in the picture below.

This classification is the basis for the calculation of the climb gradient. What is the difference between climb gradient and climb rate?

- Climb Rate is the actual rate in feet per minute regardless of the distance covered.
- Climb Gradient is the distance covered by the aircraft in relation to the height gained in percent (%), like the slope of a mountain road (e.g. 10%, for a steep road).



For the certification by aviation authorities, any twin-engine Aircraft must demonstrate a minimal climb gradient necessary to safely pass a 35 feet obstacle after the take-off in case of an engine failure. The performance criteria must be met independent of the take-off weight and other factors such as temperature, field height and so on.

Gross Gradient: is the climb performance that is demonstrated during a test based on typical (good) conditions.

Net Gradient: is the climb performance that is demonstrated during a test based on the worst known conditions. These tests are especially important to determine the maximum allowed take-off weight.

A twin-engine Aircraft like the A320, must comply with the following minimum gradients:

First Segment Gear-Up	Second Segment minimum 400 feet	Third Segment	Fourth Segment
Positive (ca. 0.2 %)	2.4 % / 1.6 % (Gross / Net)	1.2 % / 0.4 %	1.2 % / 0.4 %

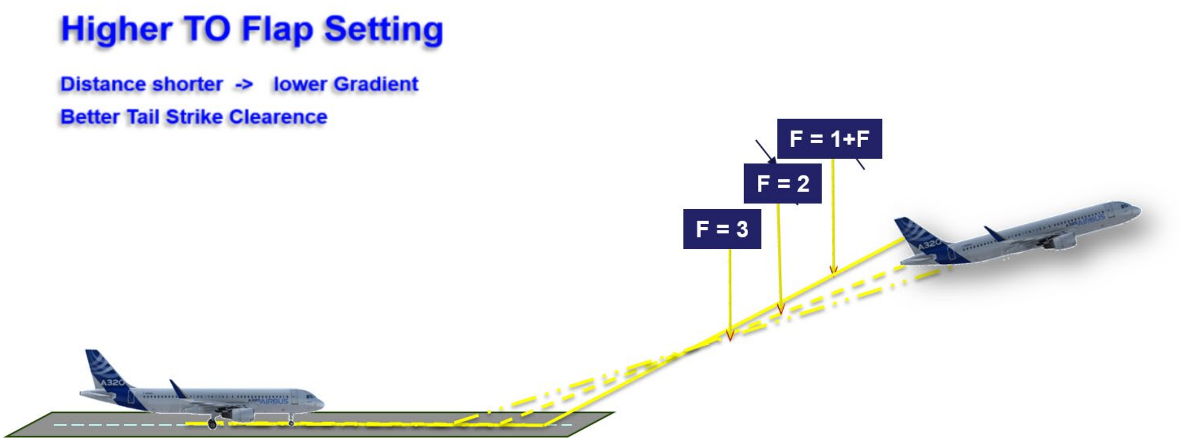
In the third segment the Aircraft energy is used for acceleration and flap retraction on a more or less level flight. However, for certification a minimum gross gradient must be demonstrated.

An A320-211 with CFM-5A engines (25.000 lbs) only achieves approximately 300 ft/min on high GW with one engine out (EO). The version A320-214 with CFM-5B engines (27.000 lbs) is able to climb with 500 ft/min and more on high GW. Even though, the difference in engine power seems marginal, the performance gain is substantial.

The climb gradient further depends on the flap configuration.

- With the flaps in 1+F, the A320 rotates later but climbs steeper. Therefore, the distance covered is shorter for a certain height. But because of the longer take-off run the 35 feet obstacle clearance may just barely be overflown.
- With a flap configuration 2 or 3 the procedure reverses. The A320 rotates earlier and will clear an obstacle at a greater gap. However, the climb gradient is shallower and the distance for a certain height is longer. This can create challenges in a mountainous environment where other obstacles are located in the distance.

The following picture gives an overview of the climb gradient in relation to various flap settings.



The Take-off

The take-off distance, which is the way from setting the take-off power until rotation, is calculated by external programs. Following the A320 data for a TOW of 60 tonnes:

TOW tons	V_1 knots	V_R knots	V_2 knots	Distance meter	RWY cond.
60 TOGA	125	132	136	1.250	Dry
FLX 65°	130	135	136	1.500	Dry

From these take-off speeds, the data for the RTO (Rejected take-off – RTO) can be derived as shown in the next picture (taken from the ATP with super-imposed details).

The **green** marked area defines a runway width of 60 meters. The dashed **Orange** area shows a runway width of 50 meters.

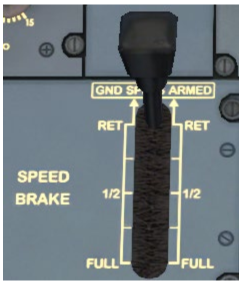
The RWY 26L in EDDM with a **TORA** of 4.000 m (**T**ake-**O**ff **R**unway **A**vailable) and a width of 60m served as the test RWY.

In these examples the RTO has been initiated just before reaching V1. AutoBrake was set to MAX as per SOP (Standard Operating Procedure) and full reverse thrust has been applied. The reverse thrust was deactivated before reaching 60 knots and manual brakes applied.

The RTO Stop Margin (buffer) after a FLEX take-off is 2.400 m. A TOGA take-off increases the Stop Margin to 2.500 m. A take-off with TOGA and flap configuration 2 instead of 1+F improves the margin further to 2.700 m.

For the take-off, the Auto-Brake will be set to MAX and the spoilers armed by pulling the spoiler lever.

In case of a rejected (aborted) take-off, the full braking force of the AutoBrake system will instantly be activated.



More and detailed information on the automatic braking system (AutoBrake) is provided in chapter 3.

The Take-off Thrust setting

The setting of the take-off thrust is done in two steps:

Step 1: The thrust levers are moved forward until a N1 value of 50% - 1,05 EPR is shown in the upper ECAM E/W display, see also chapter 3.

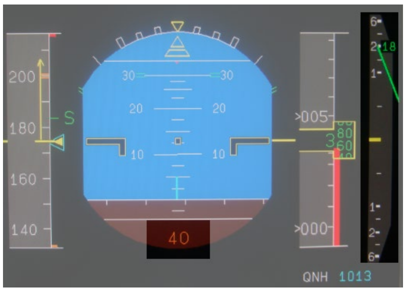
Step 2: Then, the thrust levers are moved into the TOGA or FLX-MCT detent, depending on the take-off variation, see also chapter 2.

In the event of a cross-wind take-off, the power setting is done in three steps:

Step 1: The thrust levers are smoothly moved forward to command an N1 of 50%.

Step 2: Then the thrust levers are moved fast to a position of 70% N1.

Step 3: Finally, the thrust levers are set into the TOGA or FLX-MCT detent.



As soon as a positive climb is achieved, the gear will be retracted. Positive Climb means, that not only the V/S indication shows a positive value/trend, but also the altimeter. Only then are the criteria accomplished to retract the Gear Up.

In the left picture the V/S scale shows a positive rate of 1800 ft/min and the altitude is 40 feet. Now it's ok for the PNF to call positive climb and for the PN to command gear up.

It is common and good practice not to initiate a turn below 500 feet AGL. The next PFD picture shows 730 feet AGL and an altitude of 1000 feet MSL. In the example, the FCU altitude has been set to 1800 feet to fly the pattern at 1500 AGL. Frankfurt Airport has an elevation of around 300 feet.

After initially climbing with 15° to 17,5° and approximately **3000** ft/min, the pitch is brought back to 10° and **1900** ft/min. The initial climb speed is V2+10 max. +25.

At the ACC ALT of 1000 feet AGL, the thrust levers will be set into the CL detent to command climb thrust.

All these activities happened within just 1000 feet that confirms the dynamic of the take-off procedure.

Initial Climb Altitudes

For the initial climb two altitudes are of utmost importance, which are the THR RED and the ACC ALT respectively.

What is the difference between the two altitudes?

- The THR RED ALT is the Thrust Reduction Altitude. It is the altitude at which the take-off thrust is reduced to the climb thrust (e. g. from 98% TOGA to 88% CLB). There are two reasons for this: First, the engines should not be operated at full power for more than 10 minutes, due to wear and tear. Secondly, for noise reduction, which is a hot issue nowadays.
- The ACC ALT is the Acceleration Altitude. This is the altitude where the acceleration to the initial climb speed of 250 knots. (up to FL100) begins. In this phase the A320 uses 70% of the energy to accelerate and 30% for climb (gaining altitude). This is the reason, why the pitch is substantially reduced after passing the ACC ALT until the climb speed of 250 knots is reached.
- Usually both altitudes are equal, as practised for the training flight (see chapter 6, PERF pages).

Engine Out (EO) Considerations

Even though the book does not include malfunctions, some general information may be of interest. However, it must be stated that the following is not a complete EO procedure.

The take-off thrust setting has a direct influence of the Aircraft behaviour:

1. Setting TOGA will reduce the take-off distance but the yaw effect towards the dead engine will be high, due to the maximum engine thrust.
2. Setting FLEX will result in a longer take-off run, but the yaw effect will be less because of the reduced engine thrust. Therefore, whenever possible Flex take-off shall be used. It will also reduce engine tear and wear.
3. In case of an EO after V1 the pilot rotates to 12.5º followed by 10º is soon as practicable. If the EO occurs during climb, pitch need to be reduced from about 15º to 10º immediately.
4. After the Airbus has been stabilized with the rudder input, it is advisable to engage the AP. The AP is best suited to trim the Aircraft and correct the yaw effect. At or after rotation the rudder trim value is 11-13º, in level flight at **GD** speed around 5º.

At a high take-off GW, the climb rate of the A320 is substantially limited. As mentioned before, the EO climb rate of the A320-211 will be around 300 ft/min while the A320-214 can achieve 500 ft/min and more, even at maximum take-off-GW.

With the limited climb performance, it may not be possible to follow normal departure routes (SID), due to the MDA (Minimum Descent Altitude) within the terminal area. Specific engine out departure routs (EO-SID) are provided at international Airports. Another reason for the EO-SID is, that the limited Aircraft performance may have an impact on the traffic separation and thus of the Airport traffic capacity. In case of absence of an EOSID, the pilot must carefully carry-out the EO traffic pattern.

Moreover, the A320 has no fuel dumping facilities and an overweight landing need to be exercised in case of system failures, e.g. EO. Especially under high temperature and/or at high elevation airports, an A320 near or above the maximum LAW may not be able to hold the circuit altitude.

Neglecting important activities when initiating the take-off is not uncommon, but the Airbus is well prepared to warn the pilot accordingly:

- He/she forgets to release the Parking Brake before moving the thrust levers to the take-off position. The upper ECAM will display a warning message supported by the warning sound (repetitive chime).

  CONFIG PARK BRK ON

- The flaps are not set in the take-off position (1+F, 2 or 3) or are not extended due to a malfunction. Again, the pilot receives an ECAM warning message and the warning sound.

  CONFIG
SLATS NOT IN T.O CONFIG
CONFIG
FLAPS NOT IN T.O CONFIG

- The Pilot does not move the thrust levers into the correct take-off detent (FLX/MCT instead of TOGA). The pilot will get an ECAM caution message (**Orange**) together with the caution sound (single chime). In this example, the thrust levers are moved into the FLX/MCT detent, without a valid MCDU-FLEX input. The **Blue** message informs the pilot to move the levers forward to **TO/GA**.

  ENG THR LEVERS NOT SET
- THR LEVERS . . . . . . TO/GA

  If a FLEX temperature has been entered and the levers are set into the TOGA detent, then only an alert sound (single chime) is given but no warning ECAM message.

1.11 Approach and Landing Training

1.11.1 General Procedures

The Final Approach

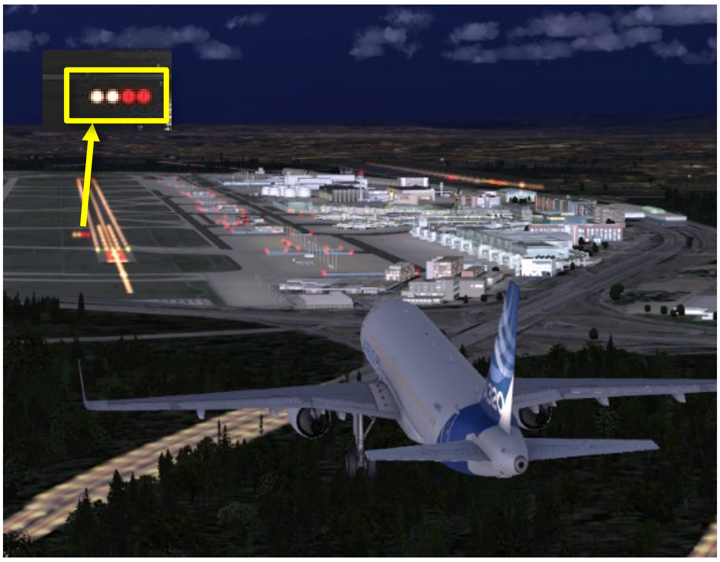
The Final Approach starts at around 1000 feet (AGL).

During the Final approach, the pilot rotates his view between the flight instruments and the outside view, which requires some practise. It is a normal that the pilot concentrates too much on one of these activities until a certain level of proficiency is achieved. At 100 feet, the pilot increases the proportion of the outside view and at 50 feet his/her view is outside only.

Starting with two thousand five hundred (2500 feet AGL), the pilot receives automatic altitude call-outs to assist him/her in flying a stabilized approach. Sequentially, the next is at one thousand five hundred (1500 feet) followed by one thousand (1000 feet).

Glideslope Correction

All Airports suitable for the A320 provide a vertical guidance support called VASI or PAPI. On the following picture, the Airbus is perfectly on the glidepath with 2 **Red** and 2 White indications.



The VASI - Visual Approach Slope Indicator – consisting of two units, each with two **Red** or White lights and is accurate until 200 feet AGL. The VASI has mostly been faced out at international Airports.

The PAPI - Precision Approach Path Indicator- consisting four light units with four **Red** and White lights, as shown in the left picture. It is usually installed left of the runway and is accurate until 50 feet AGL.

Both methods are simple optical systems without complex electronics.

If the Airbus is above the glidepath (3 or 4 white), then the sink rate must be increased, e.g. from 700 ft/min to 1.000 ft/min. When the Airbus descends below the glidepath (**3 or 4 Red**), then the sink-rate must be reduced. Two methods can be applied for the correction:

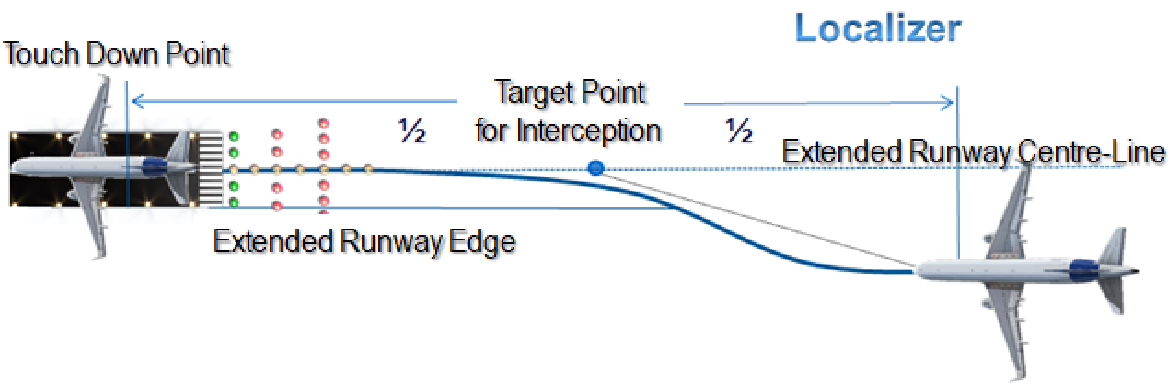
1. Reduction of the sink rate from, e.g. 700 ft/min to 500 ft/min.
2. Level off for a short horizontal flight until the PAPI shows 2 White and **2 Reds**.

When the Airport is located within a hilly environment (e.g. Zurich), method one may not be safe, because the Airbus already flies below the optimal glidepath. Continuing below the optimum glidepath, even with a reduced sink rate, still involves the risk of getting too close to obstacles.

In order to avoid this risk, it may be advisable to go for method two, break the descent and level-off with no loss of height. The pilot than steers the Airbus back to the optimal glidepath from underneath, similar to an ILS interception. After 2 White and **2 Reds** are shown again, the approach continues with 700 ft/min.

Runway Course Correction

Contrary to vertical guidance, the pilot must find his/her own method to correctly line-up the Airbus. Having said that, there is off-course a hands-on method available to the pilot.



If the Airbus flies offset the runway, the pilot defines a target point on the extended runway centre-line, about half-way between the runway touch-down point and the actual aircraft position. Then the pilot aims for the target point and shortly before reaching them, he/she initiates a turn towards the runway centre-line, as shown in the picture below.

Such as for the take-off, pilots may also fall into known traps when approaching the Airport. Late flap setting and extending the gear too late, rank among the most common mistakes.

An acoustic call-out „*TOO LOW FLAPS*“ sounds, if the flaps are not moved into the full-position. In addition, „*TOO LOW FLAPS*“ sounds for a flap 3 landing, if the Flap-3 button on the GWPS Overhead panel is not selected.

In case of a delayed gear extension the acoustic call-out „*TOO LOW GEAR*“ will sound and the ECAM warning message appears.

The Auto Brake System (AB)

Independent from the runway length, the pilot must brake immediately after touching down. Even though the A320 is a FBW aircraft, it requires a firm use of the pedals to provide the required braking force.

The pilot is supported by two functions:

1. The Anti-Skid function, to prevent the brakes of the main wheels from locking, much like the ABS in modern cars.
2. The Auto-Brake System.

The A320 Auto-Brake system offers three push-buttons for three brake level settings: LOW, MED and MAX. Only LOW and MED can be selected in- flight while MAX is dedicated for a Rejected Take-off (RTO). Even though, MAX setting cannot be selected in-flight, it is possible on ground after touch-down. This is however, not an official procedure and will overheat the brakes.

The AB push-buttons are located just below the gear indication lights. When pressed, the corresponding AB button illuminates with a **Blue ON**.

AB-MED is the used brake application, as shown in the left picture.

After touch down, the AB, if selected by the pilot, will automatically be activated by the FBW control. The AB activation follows a similar logic as the spoiler deployment and require the spoilers being armed during the approach preparation. Once the touch down criteria are fulfilled (e.g. both main wheels are depressed) the AB is activated and a **Green DECEL** indication (Deceleration) confirms the braking. The AB is usually de-activated through manual brake application (pressing the rudder pedals) by the pilot.

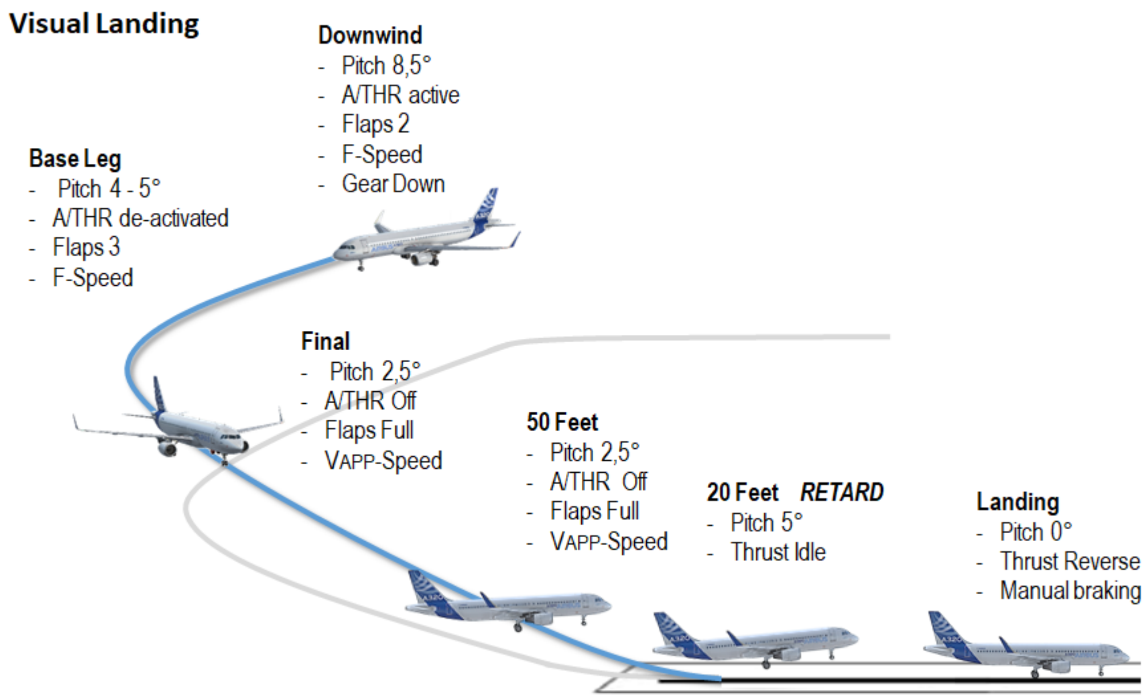
One of the advantages of the AB system is, that the braking action sets-in instantly with the touch-down of the main wheels. Afterwards the pilot may take-over the braking at any moment at his/her discretion.

After a full-stop landing, the brakes need some time to cool down to less than 150º. This process can be speeded-up by using the brake fan (BRK FAN), but brake fan cooling increases the brake wear. The switch for the BRK Fan is installed next to the AB buttons and LDG gear indication lights.

1.11.3 The Landing Training

The Flightsimulator-pilot is supported by the well-known synthetic approach call-outs, starting at 2,500 feet. The following sequence is: 1000 – 500 – 400 – 300 – 200 – 100 – 50 – 40 – 30 – 20 – RETARD – and 10. In case that the approach is very flat, then even a 5 call-out may sound.

Passing 100 feet, the pilot must be attentive because the approach corridor to the runway narrows rapidly. The **VAPP** up to a maximum of **VAPP** + 10 must be maintained with a correct power setting requiring only minimum thrust lever adjustments by the pilot. Attention must also be given to the bank angle to avoid excessive aircraft movement as well as a wing tip strike. Especially during the last 100 feet, the bank angle should not exceed 5º.



When passing 50 feet, the FBW control takes the actual pitch attitude as reference and freezes the THS position, the trim position is now fix. The pilot should avoid inputs when passing through 50 feet, because the new THS position may limit the elevator authority. Between 50 and 30 feet the Airbus is trimmed for speed by the elevators which may further limit their authority.

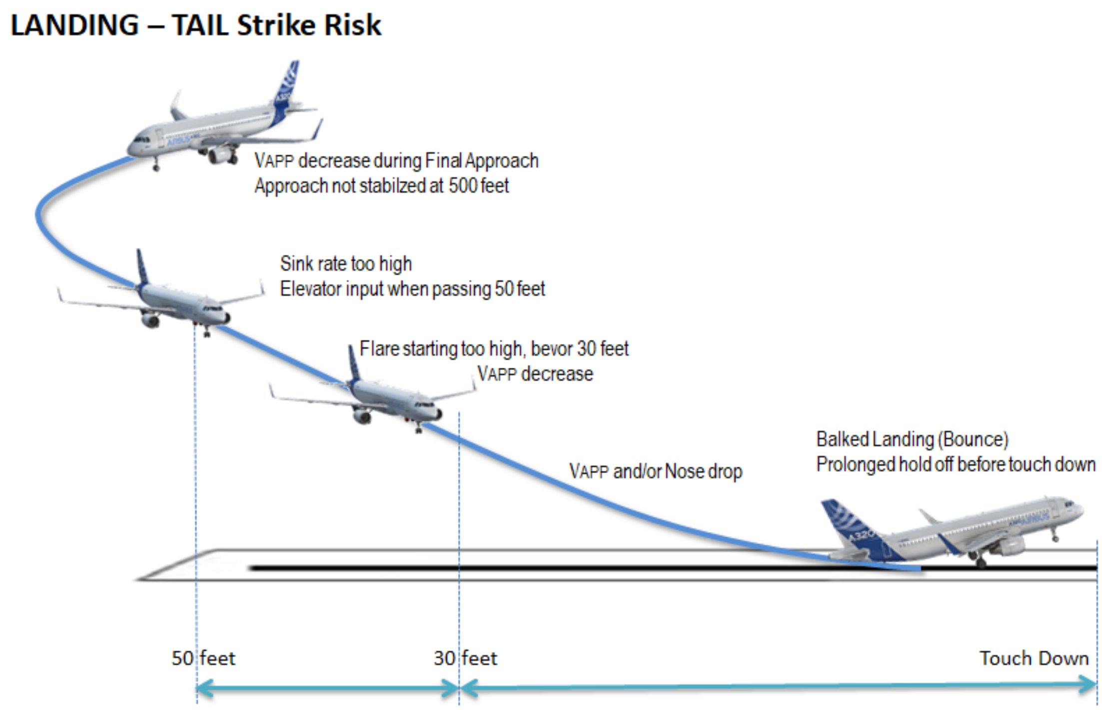
The combination of all these factors has an impact on the aircraft behaviour during Flare. Therefore, even for a similar landing profile, the A320's flare behaviour may feel substantially different, often the reason for a hard landing.

Thirty (30) is the point when the pilot raises the nose from 2,5 ° to 5º (max. 8°) to break the sink rate from the actual rate of 600-800 ft/min to approximately 300-350 ft/min and to initiate the Flare. At 20 feet, the call-out „***RETARD***“ sounds to remind the pilot to bring the thrust levers back to idle. If the A/THR was in use, it will be switched-off automatically when the thrust levers are set into the idle position.

When passing 30 feet the Airbus is in the Flare mode and reduces the pitch attitude to -2,5º over 8 seconds by means of the elevators. This behaviour of the FBW control forces the pilot to provide back pressure on the Sidestick to initiate the Flare, just as it is done in a conventional aircraft.

The pilot must hold the back pressure on the Sidestick until touch-down to keep the pitch at the correct position and avoid a nose drop. The Airbus is now in Direct Law without AutoTrim function. Eventually, the pilot may adjust the back pressure at 10 and 5 feet. After touch-down of the main wheels the Sidestick must immediately be released to the neutral position followed by some slight back pressure adjustments to smoothly set the front wheel on the runway.

If the pilot holds the Sidestick aft when touching down, the nose may rise and the acoustic warning „*PITCH, PITCH, PITCH*“ sounds. Now it is of utmost importance to lower the nose immediately, because the risk of a tail strike is imminent.



In case of a bounced landing (the aircraft becomes airborne again), the pitch should not be increased. This would inevitably result in a tail strike. It is better to touch down with the actual pitch even if it leads to another hard landing.

After landing the Airbus needs to be on ground for more than 30 seconds, to allow a normal take-off procedure. If the pilot sets take-off power within 30 seconds, the FMGS considers the action as a Go-Around at ground level and activates the GA modes and GA-PERF-page respectively.

A safe landing procedure requires the correct calculation of the landing distance. Several factors affect the landing distance, which are:

- Altitude of the Airport.
- Approaching height and approach speed over the threshold.
- Landing and Flare Technique.
- Delay in nose wheel touch down.
- Delay in braking or insufficient braking action.
- Insufficient use of braking support devices such as spoiler and reverse thrust.
- Runway conditions, e. g. wet, slush, snow, ice and visibility.
- Wind conditions, e. g. tail Wind and crosswind.

During the test phase the Aircraft manufacturer generates so-called „Demonstrated Landing Distances“. However, these landing distances are the result of test runs by test pilots under optimum conditions. Consequently, the landing distances under normal airline operations are slightly longer, depending on the pilot’s actions.

The table shows the typical approach data for a landing weight of 60 t and flaps Full:

Landing Weight	Speed in knots				
Tons	O Dot	S	F	VLS /V_{APP} 3	VLS /V_{APP} Full
60	205	185	145	135 / 140	130 / 135
Landing Distance	Manual	AB Low	AB MED	*AB=AutoBrake*	
	1.430 m	2.000 m	1.500 m		

The following contingencies need to be considered when calculating the landing distance:

- Plus 10%, if the Airport elevation is >1000 feet.
- Plus 300 meter/1.000 feet, if the Airbus crosses the threshold at 100 instead of 50 feet.
- Plus 20%, in case the approach speed is 10% higher as calculated (APPR PERF page).
- Plus 30%, for a prolonged Flare.

- Wind corrections for tailwind of 10 knots:
  - Dry runway + 14%
  - Wet runway + 15%

It is further important that the touchdown of the main bogies occurs exactly at the touchdown area, 300m / 1.000 feet after the threshold.

Landing example Geneva:

Runway length: 3.900 meter

Demonstrated landing distance, A320 with 60t 1.250 m dry runway
1.440 m wet runway

Calculation:

50 feet too high, meaning 100 feet over threshold + 300 meter

10 knots over V_{APP} = +10% + 125 meter

10% for delay of braking action + 125 meter

Landing distance on dry runway ***1.800 Meter***

Stop margin 2.100 meter

Landing distance on wet runway ***2.000 meter***

Stop margin 1.900 meter

At certain Airports, a tail wind landing may be unavoidable or is the better of two poor choices. Salzburg (LOWS) or Innsbruck (LOWI) with their mountainous surroundings are such examples.

Addition for every 5 knots of crosswind	+ 120 meter
Final maximum landing distance	***2.120 meter***
Remaining runway available	1.780 meter

In case of an additional prolonged flare, even the nearly 4.000-meter runway of EDDM can barely be enough, leaving only low margins. Airports like Innsbruck must therefore be approached very carefully and in adherence with the standard operation procedures (SOP).

Therefore, when flying a manual approach all limiting factors should be considered, including possible deficiencies by the pilot.

The following table gives an overview of the final approach criteria, the pilot shall not fall short. In case of deviations or exceedance from standard parameters the pilot non-flying (PNF), if available to the FS-pilot, must provide the pilot flying (PF) with correcting call-outs.

Parameter	Deviations / Exceedance	Call Out by PNF
IAS	VAPP -5/+10 knots	Speed
V/S	>1000 ft/min	Sink Rate
Pitch	>10º -2,5º	Pitch
Bank	>7º	Bank
LOC	> ¼ dot	LOC
G/S	> 1 dot	Glide

Another not very well-known Airbus landing speciality is the trim setting for the approach.

- When the A320 passes through 50 feet, the THS (trimmable Horizontal Stabilizer) is frozen and the actual pitch is memorized.
- Between 50 and 30 feet the elevators are used to trim the A320 for speed.
- Passing 30 feet, the elevators command the pitch form the memorized value to -2º within 8 seconds.

The combination of all these factors have an impact on the Aircraft behaviour during Flare. Therefore, even for a similar landing profile, the Aircraft's Flare behaviour may be substantial different, often the reason for a hard landing.

There are three distinct landing methods:

1. Manual sidestick and manual thrust.

2. Manual sidestick and A/THR ON. This method is approved by Airbus but not a standard procedure for many international Airlines
3. Automatic Landing with AP and A/THR ON.

Some typical landing mistakes

- Below 100 feet, the aircraft nose drops and the sink rate increases.
- The pilot starts the Flare too early, before 30 feet.
- After 30 feet, the nose-down trim (-2,5°/8 seconds) is not managed properly, e.g. when the counter stick input has been interrupted.
- The approach is too shallow with less than 700 ft/min. If the pilot increases the pitch by 2°, a horizontal flight instead of the flare can be the result. Because the thrust levers are already at idle the speed decreases with the result of a hard landing.
- Wind changes either in speed or direction are always a key factor in landing problems. An increase of the headwind can result in a considerable rise of the **VAPP**. As a counter reaction the pilot may put the thrust levers too early at idle followed by a hard landing. A decrease of the headwinds causes a decrease of the **VAPP** and an increase of the sink-rate. If the pilot sets the thrust lever to idle because of the „*RETARD*" call-out, then a tail strike is unavoidable.
- During a crosswind approach, the de-crab (lining-up the nose with the runway centre-line) may be commanded too early or too strong. It is recommended to apply rudder pressure with care during the flare (approx. 20 feet).
- Any approach with tail wind is very tricky. Because of the higher ground speed, less engine thrust (N1) as normal will be required. If the pilot reacts too slow to wind changes, undershooting the **VAPP** may be the result.
- The biggest threats for a safe landing are the height and speed over the threshold. Both must be at the correct values, 50 ft height at **VAPP**.

This list of selected mistakes during the approach highlights how fast a stable approach can turn into an unstable landing.

1.11.6 The Crosswind Landing

There are two officially recognised methods for flying a cross-wind approach.

The Low Wing (Sideslip) Method

The pilot uses Cross Control of Aileron and Rudder to bring the Airbus into the desired low wing attitude.

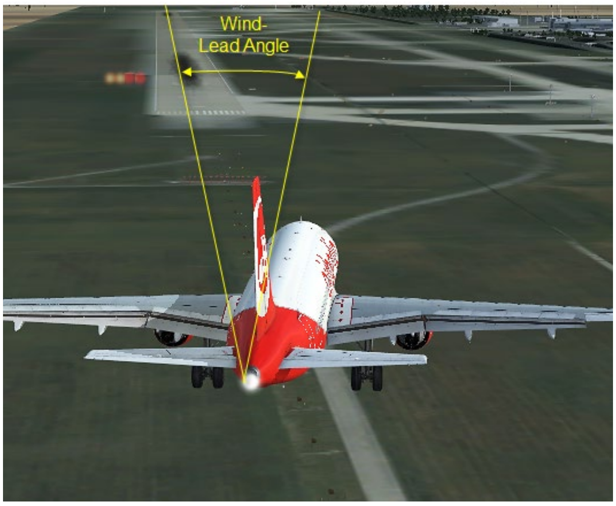
First, the Aileron is used to steer the Airbus into the wind, let's say to the right to counter a right-hand wind. This action also results in a corresponding bank angle and a low wing towards the wind. Secondly, the rudder is commanded left to avoid a turn and keep the Airbus on the runway centre-line. Aileron to the right and rudder to the left make-up the cross-control.

This method has the disadvantage of the low wing, which reduces the ground clearance of the wing and engine during flare and landing. It is also not comfortable for the Pax, even though this issue is not relevant for the Flight-Simulator pilot.

Because of the roll stability of the A320, it is not the preferred choice by the Airbus pilots.

The Crab-Angle Method

This method is named after the Crab, which runs with a sideward slip. Likewise, the Airbus flies the approach with the nose pointing sideward into the wind, called the wind correction angle or wind lead angle.



Due to the roll stability of the Airbus, no rudder input is required to keep the A320 in line with the Runway.

Pilots flying a conventional aircraft, must fly the approach with a permanent Rudder input and Aileron cross-control.

For the Airbus pilot, the FBW control corrects wind influence without pilot input, only some adjustments with the Aileron may be necessary.

Contrary to the Sideslip Method, the Airbus is steered into the wind with the only use of the Sidestick. A conventional aircraft requires some cross-input with Aileron and Rudder to counter a slight bank angle. The following picture shows the A319 approaching EDDM RWY 08L with a strong cross-wind from the right.

The following example is a cross-wind landing at EDDF RWY 25R with the following approach conditions:

- → Runway course 248°
- → Wind from 202° with 19 knots (wind from the left)

TRK (Track) is the heading (HDG) compensated by the wind influence.

The ND picture shows the wind lead angle and the Airbus pointing into the wind.

In order to compensate for the wind a HDG of 242° is required. The corresponding wind lead angle is 6º (TRK 248° – HDG 242° = 6°).

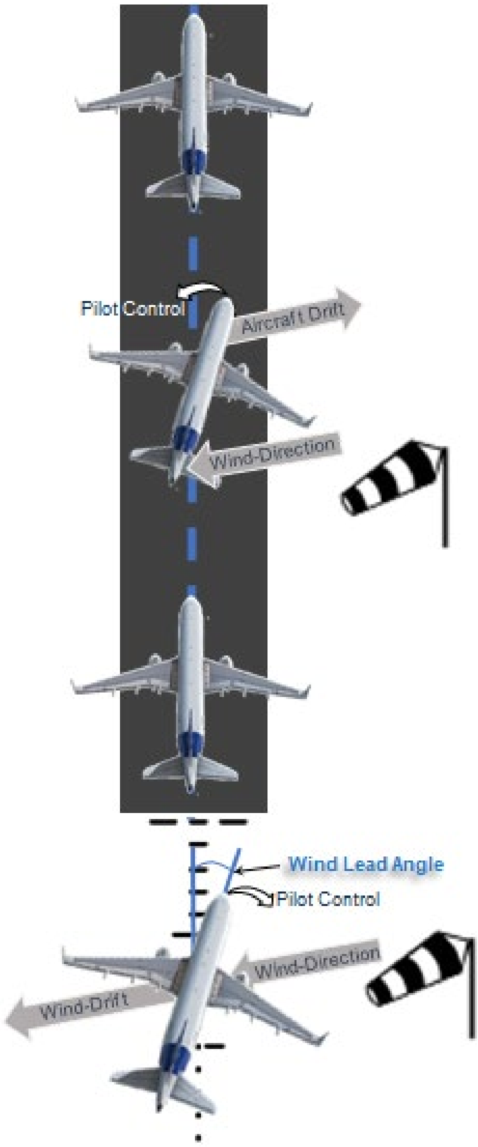
Usually the Rudder is only used for the de-crab to line-up with the Runway. Only for exceptionally strong cross-winds, the Airbus is flown with some rudder input. In this case, the pilot may use the rudder trim function to trim the Airbus laterally.

It is recommended to apply rudder pressure with care during the flare (approx. 20 feet). After touch down the rudder should be held in the de-crab position to counter the weather vane-effect and avoid additional opposite rudder application.

During de-crab the aileron shall only shortly be applied with a maximum half of the sidestick deflection. This will prevent the into-wind wing from raising, which could lead to the wing edge touching the surface (Hamburg Kirill incident). A sidestick deflection with more than half of its range and a prolonged activation will raise the spoilers and command a high roll rate with an additional tendency to turn into the wind.

Under strong crosswind conditions, touching down with a residual crab-angle of 5º is acceptable. In case of a snowy or contaminated Runway, a touch down with a slight rest crab-angle is preferred as it increases the tire friction.

The following graphic shows another example of a crosswind landing in the normal course of events. EDDF is again the training airport, but the wind direction changed from 202 º to 270º, but the same wind speed of 19 knots.



Now the A320 is properly lined-up with the runway centre line.

The pilot must initiate a corrective action by applying rudder in the opposite direction.

However, the wind still blows against the aircraft's tail. Hence, through the leverage of wheel friction and tail force, with the main wheel axis being the pivot point, the aircraft's nose moves into the wind; wind vane effect.

After the touch down the friction of the main wheels prevent the aircraft from drifting further sideward.

Shortly before the touch-down the pilot applies left rudder input to align the Airbus with the Runway centre-line - de-crab.

Simultaneously, some right Aileron input prevents the Airbus from raising the wing due to the wind force underneath the wing.

At the same time, the pilot also applies Sidestick back pressure to initiate the flare.

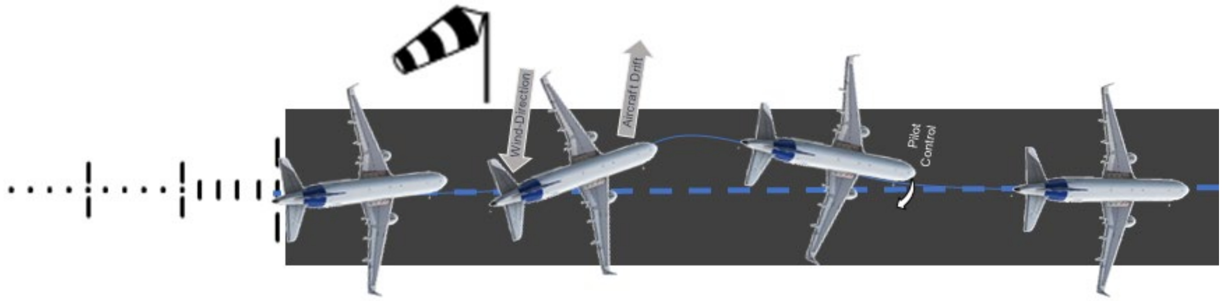
The Airbus flies with a right Wind Lead Angle toward Runway 25R. The Wind blows from 270° with 19 knots.

During the approach the rudder trim can either be set to neutral (00.0) approximately when passing 50 feet. Or the pilot may opt to land with the active rudder trim, which will assist him/her to counter the wind vane effect.

In order to reset the rudder trim, the RESET button is pushed one time and the Airbus will smoothly reduce the trim to neutral (0). The RUD TRIM console is located at the pedestal between the Spoiler- and Flap- levers, next to the PARK BRK- lever.

If the pilot activates the reverse thrust while the aircraft is not yet lined-up with the runway, the aircraft will move into the wind, similar to the wind vane effect. The Airbus must then be stabilized as follows:

1. De-activate the reverse thrust
2. Release the brakes
3. Line-up the Airbus with the rudder pedals (bring back to centre-line)
4. Re-activate brakes and if required reverse thrust



A320 Cross-wind Limitation

For take-off and landing, the actual ATC wind information are the reference values for the pilot's decision making.

1. Headwind
   Max. headwind for CAT II or CAT III Autoland (Landing and roll-out) - 30 knots.

2. Tailwind
   Max. tailwind for take-off and landing on dry or wet Runways – 10 knots
   Max. tailwind take-off and landing on contaminated Runways– 5 knots

3. Cross-wind – dry and wet Runways
   Max. cross-wind for take-off and manual landing – 30 knots, gusts up to 38 knots
   Max. cross-wind for Autoland – 20 knots
   Max. cross-wind for take-off with a RVR < 200 m – 10 knots
   Max. cross-wind for take-off with a RVR < 800 m – 10 knots
   (RVR = Runway Visual Range)

4. Crosswind limitation for take-off and landing on contaminated Runway:

Braking action	good	25 knots	
	good-medium	20 knots	
	medium	15 knots	(slash, snow)
	medium-poor	10 knots	(slash, snow)
	poor	5 knots	(dry/wet snow, standing water)

Note: for landing with a RVR < 800 m the maximum wind component is 10 knots.

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Chapter 2

Content

2. The Basic Jet-Training – Part 2

In part 2 the basic Airbus training continues, covering the standard procedures for both manual and instrument flying.

So-called Standard Operating Procedures (SOP) are a set of procedures/regulations, which are tailored to the specific operation environment of an airline. They include non-type-related (general operation) policies and type related (airplane operation) matters. The standard procedures in this chapter are part of the type-related section. Furthermore, SOPs contain instructions for the crew members by assigning tasks; who is doing what, when and in which sequence.

The goal of this chapter is to allow the Flightsimulator-pilot to single-handle the A320, which is certified as a two-crew aircraft. Therefore, the procedures are based on the technical/systems process and no work/task sharing between crew members is envisaged. SOPs including CRM (Crew Resource Management) may be considered for the planned volume two.

The procedures contained in this chapter are based on the following main characteristics:

- Airbus cockpit philosophy and communality.
- Airbus specific aircraft systems.
- Optimum use of the aircraft features.

Pre-requisite for the understanding of the standard Airbus procedures is a basic knowledge of the AutoFlight modes and the MCDU (**M**ulti-functional **C**ontrol and **D**isplay **U**nit) functions.

The Flightsimulator-pilot who is not familiar with these procedures may consult chapter 4.

In chapter 7, the acquired knowledge of the Basic Jet Training (part 1 and 2) is put into practice by means of a short training flight.

2.1 The Take-off

2.1.1 General Technique

The first step is to check the check the cockpit according to the SPIT procedure.

S System check on the Overhead panel

P Programming the FMS

I Instrument check - EFIS (PFD, ND, FCU, ECAM)

T Take-off Briefing and performance check

The FS-pilot should consult the Add-on manual and follow the described procedures.

The Engine Start is part of the push-back procedure with the following sequence:

1. As preparation for the start-up procedure, the APU is switched on to provide the necessary bleed-air. To start the APU the pilot presses the APU Master Switch to ON and after 5 seconds the APU Start Push-button ON.
   The run-up time for the APU is approximately 45 seconds and can be monitored via the ECAM-APU page. The START indication changes from **ON** to **AVL** (available). Then, the APU Bleed Push-button on the overhead is selected ON.
   Electric power is normally supplied by the external power unit connected to the A320. The FFS and the Aerosoft Add-on allows to shorten the APU start with a specific start-up procedure.

2. After ATC clearance for engine start-up is received, the IGN knob is set to IGN Start.

Engine master switches.

Rotary ignition switch (IGN.

The Packs for the cabin pressurization are automatically switched OFF.

3. During the push-back, the engine master switch of engine No 2 is set to ON. Engine No 2 is always started first because it charges the Emergency Brake ACCU. This procedure ensures brake pressure even in case of problems with the braking system.
4. When Engine No 2 runs (19% N1, check ECAM), the master switch of engine No 1 is set to ON.
5. When both engines are running, the A320 is ready for taxi and take-off.

The ramp-agent gives the thumbs Up when the push-back truck and external power are disconnected. By showing the **red** strip, the agent confirms that the NWS pin has been removed.

Now the PNF calls ATC for the taxi clearance followed by the before take-off check list.

Following, the flaps are set into the take-off position, usually F = 1+F.

Before taxi, the engine parameters must also be checked (ECAM) as part of the take-off check.

CFM		N1 - 19%	N2 - 60%	EGT - 520ºC	FF 320 kg/h
IAE	EPR – 0,990	N1 - 22%	N2 - 60%	EGT - 470 ºC	FF 420 kg/h

Before commencing the taxi to the RWY, the IGN knob is set back to NORM and the Packs are automatically switched ON again.

The Taxi to Runway

The Taxi speed is usually within the range of 25 to 30 knots and should not be exceeded. When steering a tight turn, a speed of 9 to maximum 12 knots has proven to be a good choice.

The Nose Radius of all A320 family members is good enough for a complete 180º turn on the runway, even with the long A321. Making a 180º turn on the runway is frequently necessary at regional Airports, because taxi ways very often enter at the middle section of the Runway or short of the Runway end.

A319	16,5 m
A320	18,5 m
A321	22,5 m

The rudder pedals with a deflection range of 6º are not good enough for steering tight turns, e.g. entering the runway on a sharp angle or to make a turn on the Runway.

For this purpose, a steering device called Tiller (handwheel) is installed on both pilot sides, just next to the Sidestick. It can be moved in two directions and provides a nose wheel deflection range of 75º to the left and right.

The push-back truck-nose wheel connection (NWS pin inserted) allows turns of up to 90 º.

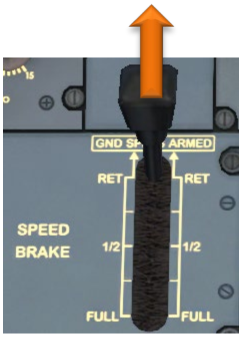
Above a Taxi-Speed of 20 knots it is not advisable to use the Tiller for steering the Airbus. This may result in a rocking motion due to the large deflection range of the tiller. The rudder pedals with their limited deflection range are perfectly suited to be used for taxi above 20 knots.

It is further important to check the brake temperature before starting the take-off roll. The temperature should not exceed 150 degrees, which can easily be the case. If the turn-around time was too short for cooling, using the brake fan (if simulated by the Add-on) during taxi may be sufficient. If not, ATC should be informed and the take-off delayed.

Otherwise, in case of a rejected take-off (RTO) the brakes may not function as required due to the high brake temperature.

For the take-off, the Auto-Brake will be set to MAX and the spoilers armed by pulling the spoiler lever.

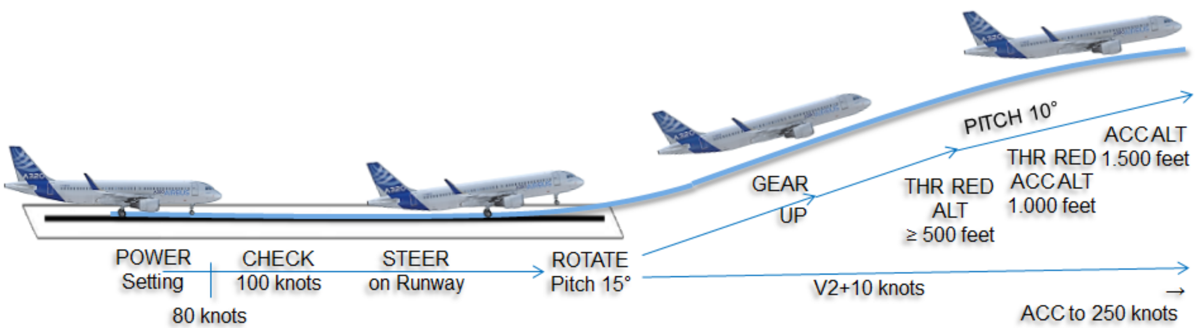
If the brake fan is required, the corresponding button can be found next to the gear indications (three lights).



When the take-off power is set, the Sidestick is moved half-forward until 80 knots and continuously released to be neutral at 100 knots. Hence, the Airbus will be prevented from raising the nose when full take-off power is set. During a take-off run on a rough or bended runway it may even be necessary to hold some forward stick pressure until rotation to keep the nose wheel on ground. Under Cross-wind take-off conditions, the Sidestick is moved fully forward until 100 knots and then released into the neutral position.

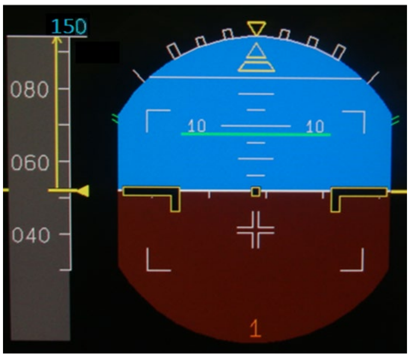
However, there are different opinions with regards to the cross-wind take-off procedure. Some may opt to apply half Sidestick input into the wind. The problem with this procedure is, that the spoilers will deploy to support the Ailerons, which may affect the aerodynamic efficiency of the wing. In the worst case the wing stalls. Therefore, it may the better choice to refrain from using the Ailerons.

The following picture highlights the standard procedure for the take-off.



2.1.1 Take-off without Flight Director

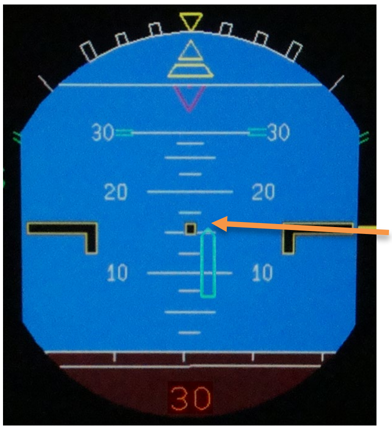
The following Take-off is conducted without Flight Director (FD), using raw-data only.



In the left picture the Airbus commence its take-off roll and the cyan bar shows 8° pitch the pilot should not exceed during rotation. Afterwards 15° or 17,5° pitch is the target depending on the TOW.

The **Blue 150** on top of the speed scale represents the FCU speed bug selection and will be replaced by a **Blue Triangle** once the 100-speed mark is visible.

Speeds for the TOW of 60 tonnes:
Rotation - 132 knots. V2 - 140 knots. V_2+10 - 150 knots.



When the Airbus passes through 100 feet, the pilot can release the back-pressure on the Sidestick. The AutoTrim function is now active and the AP could also be activated.

After Rotation the pitch target is 15º. In the left picture, the Airbus climbs through 30 feet slightly left of the runway centre line, which is indicated by the **Green** slender rectangle.

The runway deviation symbol is shown during the take-off roll but subject to the availability of a F-PLN and/or an ILS signal for the guidance.

Attention must be given to apply a proper rotation technique of 3º/second. Because the Airbus shall be rotated to 15º, the procedure will take 5 seconds (3º x 5 seconds = 15º). It may be of help to the pilot to start counting to 5 when applying Sidestick back pressure for the rotation.

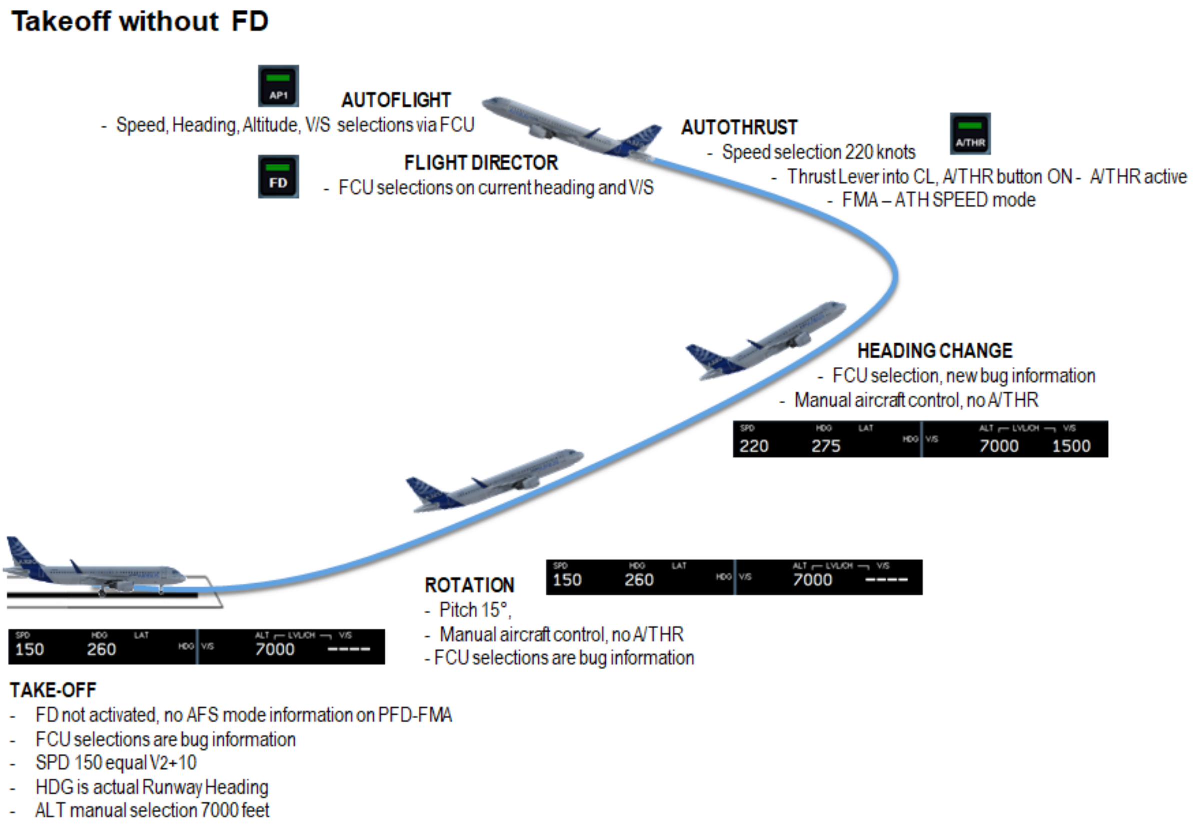
If the rotation is too slow or shallow (e.g. to avoid a tail strike), the pilot may release the Sidesticks too early resulting in a plunge of the Aircraft on to the runway. Then the next rotation attempt will to a great extend end-up with a tail strike.

A shallow rotation will further produce a higher speed then V_2+10, which implies the risk of a flap overspeed condition. In any case, the climb speed must be monitored because, depending on the TOW, the pitch may need to be increased to 17,5° to fly the target speed.

With both FD-OFF, the FCU shows the following information:

- 100 for Speed and Altitude
- Actual heading
- Dashes for V/S
- The V/S dashes may be replaced by a 0 value, depending on the actual status

Take-offs without the FD are only endorsed for training purpose, or in case of system malfunction. Even for a training flight, the checklist must be carefully completed to make sure that both default values are altered. A no-FD take-off is usually performed with maximum engine thrust (TOGA-**T**ake-**O**ff, **G**o-**A**round).



2.1.2 Take-off with Flight Director

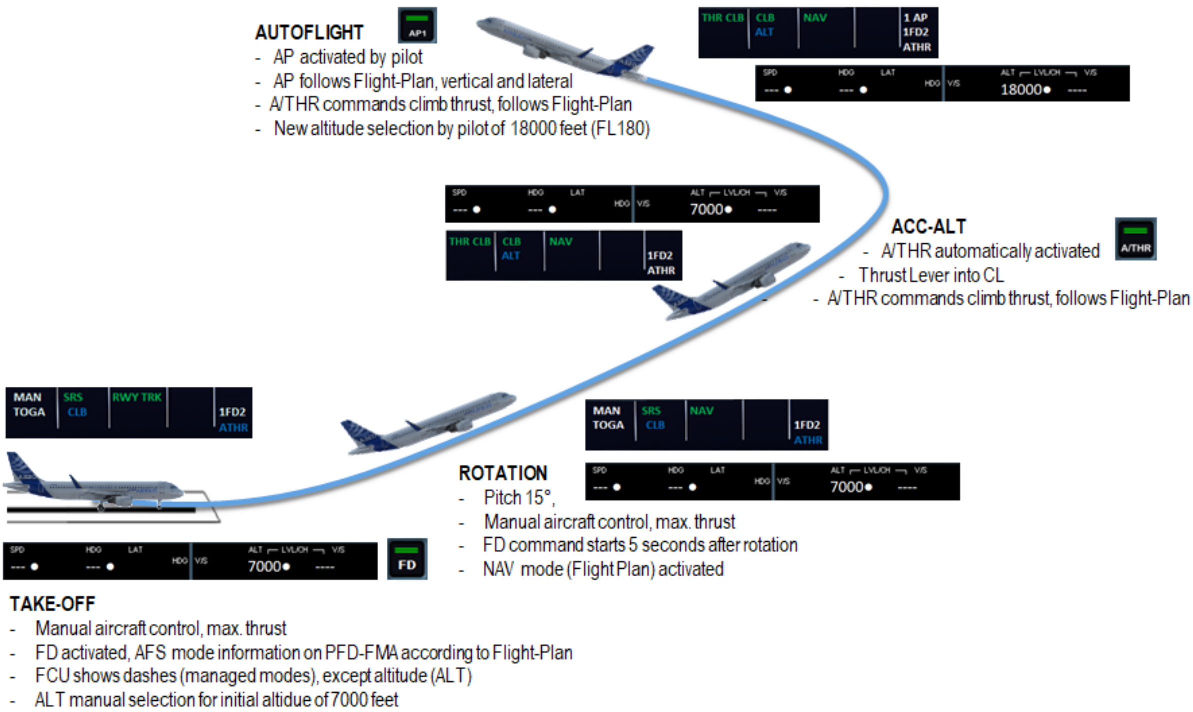
In line operation, the FD supported take-off is the standard procedure. However, it is well accepted, that the pilot flying (PF) may conduct part of the climb manually.

The following flight data must be entered into the FMS via the MCDU (multi-functional control and display unit):

- Initiation data – INIT A page. The data include the city pair, cost index, calculated flight level and the flight number (the flight number will be used by the transponder and sent to ATC for identification).
- Performance data – PERF page, including the take-off speeds (V_1, V_R and V_2), Acceleration Altitude (ACC ALT), Thrust Reduction Altitude (THR RED ALT) and the EO ACC ALT (Engine Out). Flap configuration and CG data (THS) are not mandatory but important for pre-take-off cross checks.
- Weight and Fuel data – INIT B or FUEL PRED page.
- Flight Plan data – F-PLN page.

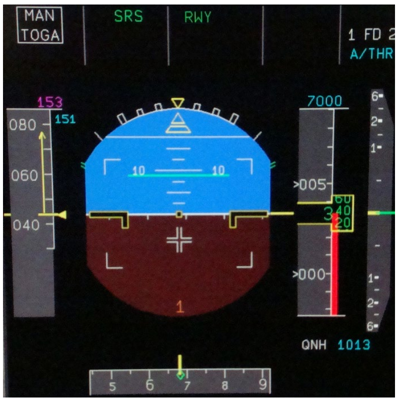
Most important for the correct progress of the flight is the input of a complete Flight Plan (F-PLN) covering the city pair, SID, STAR, all WPTs and CSTR (Constraints). F-PLN controlled flights are usually flown in the managed modes **CLB** / **NAV** and A/THR-**THR CLB**, thus requiring the Cruise Altitude and Cost Index data.

Takeoff with FD

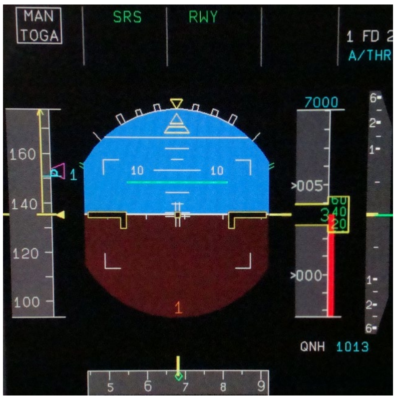


This example reflects a typical take-off for a commercial flight. Therefore, the TOW (take-off-weight) is much higher compared to a training flight. Consequently, regarding the take-off V-speeds higher values have been calculated.

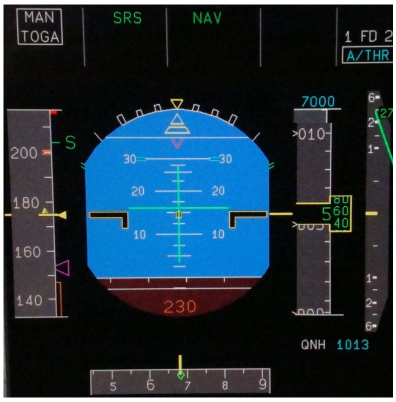
The following pictures illustrate the process of a standard take-off.



The Airbus starts its take-off roll. The selected TO-Speeds are shown on top in figures.
V1 – 151
V2 – 153
VR is not shown.



Once the 100 marker comes into view, the TO-Speeds are indicated by symbols.
V1 – 1
VR – o
V2 – ◁

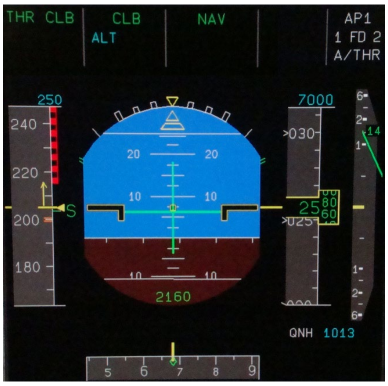


The A320 is established on the first part of the climb. The gear is retracted.
The pitch is slightly above the FD indication. Therefore, the speed increase is a bit slow.
The vertical navigation changed from RWY (runway) to NAV (Flight-Plan).

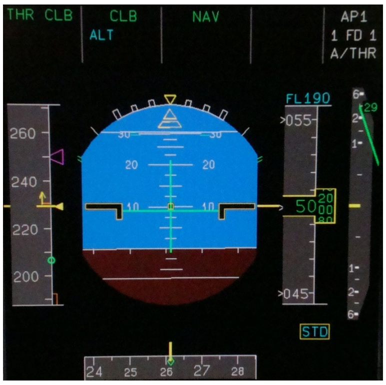
The second part of the climb includes the THR-RED (**Thr**ust-**Red**uction) and ACC-ALT (**Acceleration Alt**itude). Usually, both altitudes have the same values, as it is in the example. The ACC-ALT is 1.500 feet, however, in Germany it has recently been reduced to 1.000 feet.

THR-RED and ACC-ALT have different heights, if a noise abatement procedure is in place.

After passing ACC-ALT, the thrust changed to climb. The pitch is reduced to 10° to compensate for the reduced thrust.
The speed trend indicates an increase towards **S**-speed.



When the A320 flies above **S**-speed it is time to retract the flaps to 0.
Because of the high take-off weight, the **red overspeed bar** is uncomfortable close to the actual speed.



After cleaning-up the aircraft, the speed indication shows the **GD**-speed (**o**).
The QNH has been set to STD and the selected altitude (ALT) is now shown as FL (Flight Level) instead of feet.

2.2 The Climb

The real climb commences with the segment four, when the Airbus accelerates to the SPD LIM of 250 knots. (SPD – speed limit), as shown in the above picture (on the far right). Until FL100 the speed is limited to 250 knots. Subsequently, the target for the climb is 290 - 300 knots, depending on the flight distance/altitude and the aircraft weight.

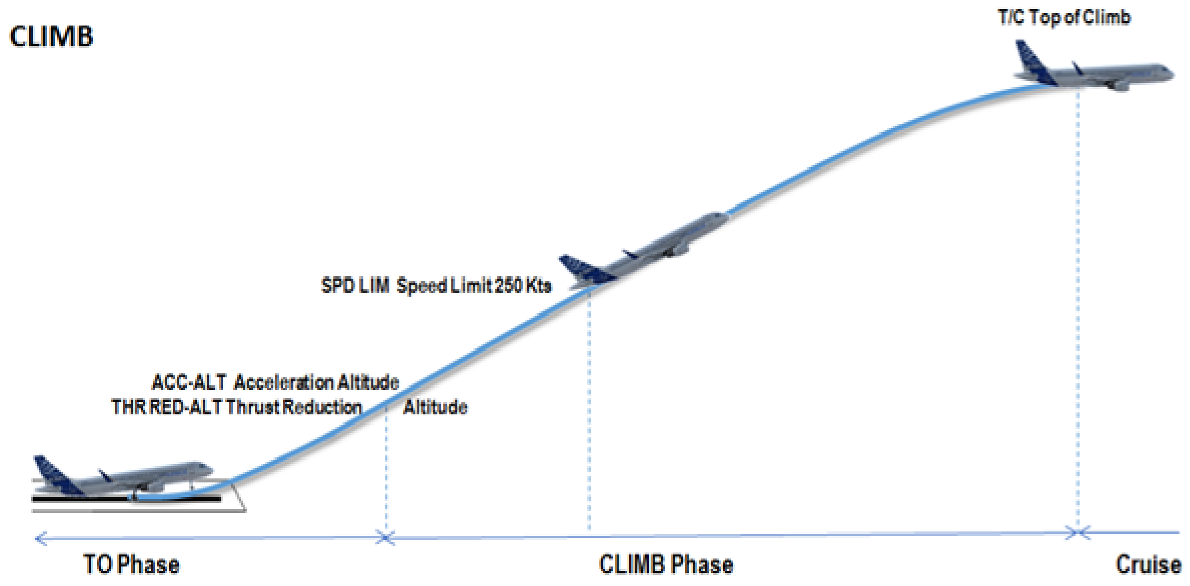
In case of an engine failure, the target speed for an immediate return or diversion to the alternate airport is the **GD**-speed.

*Remark: The speed after a Go-Around (GA) is also **GD**.*

The planned altitude of the training flight EDDM LOWS is only FL100 or FL110 because of the relative short flight distance (60 NM) and the climb speed is approximately 290 knots. For other flights like EDDM LSZH with a distance of 140 NM, the climb or ECON speed is 300 - 320 knots (ECON stays for Economy) with an optimum FL250.

When the Airbus crosses FL100, the crew performs the following tasks:

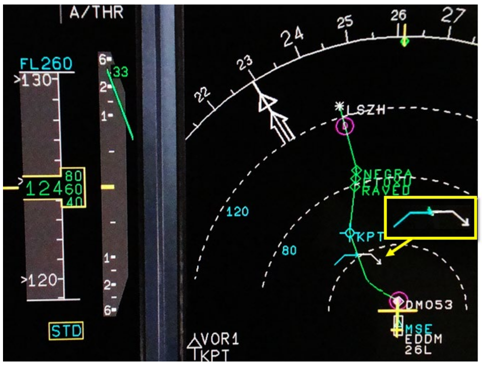
- Landing Lights – OFF
- Seat Belt Sign OFF
- Check NAV data in the RAD NAV page.



The top of climb (T/C) is permanently calculated by the FMGS and shown in the ND display. It is a so-called pseudo waypoint initiated by the FMS and part of the active F PLN. The MCDU F-PLN page shows the T/C data usually after SPD LIM which is also a pseudo waypoint.

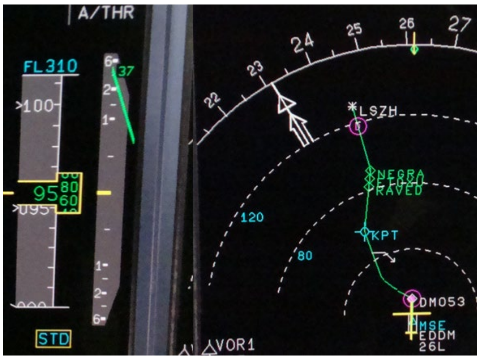
When calculating the T/C the FMGS takes the planned CRZ Flight Level (FL) as inserted by the pilot (INIT page) into consideration. Any change of the CRZ FL value prompts the T/C symbol to move either closer to the destination (higher FL) or further (lower FL).

Instructions by the ATC can further influence the T/C and the pilot needs to manually alter the CRZ FL in the MCD PROG page (Progress page). However, wind and speed effects also have an impact on the T/C calculation. This is one of the reasons why the T/C moves on the ND without any input from the pilot.



For a flight from Munich to Zurich (EDDM LSZH), the maximum flight level is FL260, as shown in the left picture. T/C and T/D (white and **blue** arrow) are at the same geographical position making the flight a ballistic flight with only a climb and descent segment.

This does not mean, that FL260 is the optimum FL, which is calculated by the FMGS and shown in the PROG page.



Assuming the pilot inserts 31.000 feet (FL310) in the FCU for example, then only the T/C is shown on the ND (white arrow). No T/D is displayed because from this altitude the destination airport cannot be reached with the FMGS profile.

2.3 The Cruise

With the change from climb to cruise (level flight) also the AFS modes change from **CLB /OP CLB** to **ALT*** and further on to the **CRZ ALT** mode.

Pre-requisite for the **CRZ ALT** mode to become active is that the FCU ALT is equal or higher than the Altitude inserted into the INIT page. Otherwise the **ALT** mode will be activated as the FMGS assumes a step climb. The FMGS stays in the climb phase and the MCDU shows the climb pages. No switch to the cruise pages is performed by the FMGS.

If the pilot initiates a descent while in ALT mode, no switch to the descent pages will take place. The FMGS will again consider a level change and not a descent initiation. For this reason, the cruise altitude must be altered via the PROG page. Two techniques are available to the pilot:

1. The pilot types the new cruise altitude into the scratchpad and transfers it to the CRZ field by selecting LSK1L.
2. The pilot types the figure 1 into the scratchpad and selects LSK1L. In this case the actual altitude will be written into the CRZ field. This method has the advantage that is first faster and secondly less error prone.

Airways heading West (180° to 359°) use even and odd levels towards the East (0° to 179°).

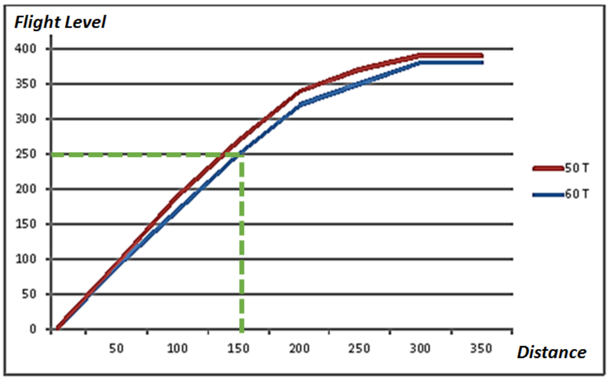
2.3.1 Optimum Flight Level

Any flight plan contains vertical (Cruise Altitude) and lateral data (Waypoints, Airways, Airports). The cruise altitudes (flight levels) are arranged in even or odd altitudes according to the heading/course of the airways. The vertical clearance between flight levels is 1.000 feet (300m), see chapter 5.

The optimum flight level is limited by the air distance (as shown before in the ND screenshots) and calculated by means of the following assumptions or data respectively:

→ Distance from Brake Release to Landing
→ Climb profile 250/300/M0.78
→ Level flight conditions for eat least 5 minutes
→ Descent profile M0.78/300/250
→ Approach and Landing

Example of an OPT FL calculation:



The picture shows the OPT FL for a typical A320 medium range GW of 50 or 60 tonnes. For a short distance flight of 150 NM (EDDM LSZH) it is FL250.

This is 1.000 feet lower as the maximum FL as shown in the example before.

2.3.2 Soft Altitude

Airbus has further introduced a so-called Altitude Soft mode, which allows altitude deviations of +/ 50 feet without immediate corrections. The mode is automatically enabled 2 minutes after reaching the cruise altitude, when **CRZ ALT** and **MACH** modes are active.

Through the Soft mode marginal fluctuations of the cruise speed (CRZ Speed) are accepted to avoid permanent power changes, resulting in less fuel consumption and better passenger comfort.

2.3.3 The Altitude Alert System

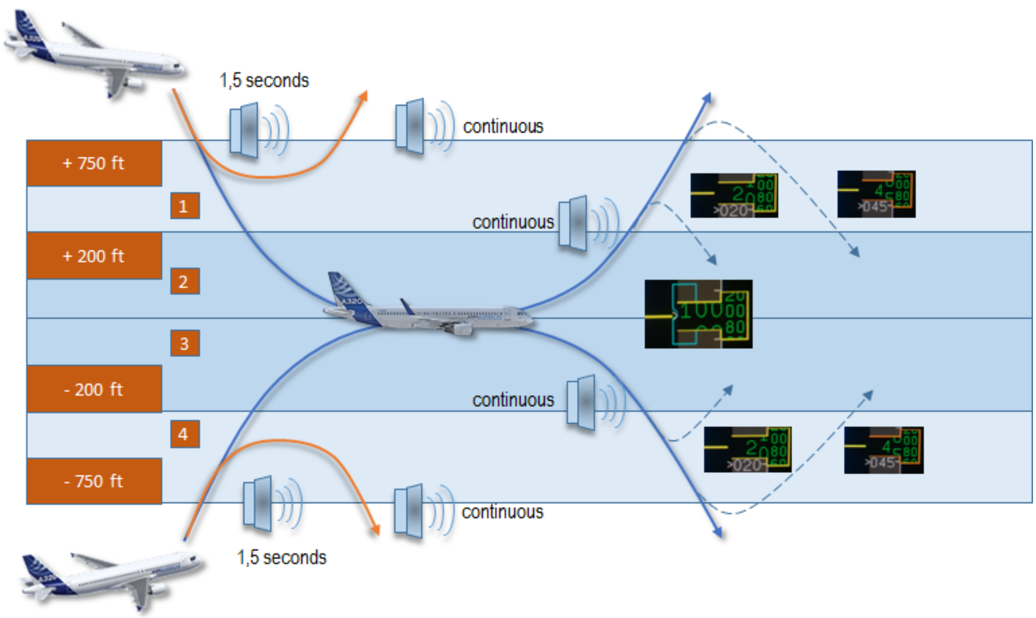
Like any other commercial airliner, the Airbus incorporates a range of warning and support systems to assist the pilot in his/her task for the correct adherence of altitudes.

The Flight Warning Computer (FWC) generates aural and visual warnings in form of special tones (C Chord) and coloured markers in the PFD ALT tape. To do this, the FWC compares the FCU selected Altitude with the altitude information of the ADIRS system.

***Remark**: ADIRS is the Air Data Inertial Reference Unit and generates, beside others, raw data for speed and altitude.*

After levelling off at the FCU ALT, altitude deviations of +/ 200 feet are neglected (earlier systems +/ 250 feet). The altitude warning is active by deviations of +/ 750 feet.

If the Airbus approaches the FCU ALT a short alert tone (1.5 seconds) is given when entering the 750 feet envelop. Same tone sounds when the Airbus is leaving the envelop.



An altitude warning tone is provided for the following flight conditions:

1. If the pilot enters the 750 feet envelop and leaves it before reaching the FCU ALT a continuous warning tone is generated by the system. The Pilot has to re-enter into the 750 feet area again or change the FCU ALT to stop the warning tone.

2. If the pilot leaves the 200 feet area but remains within the 750 feet envelop, the same continuous warning tone will sound and additionally the **yellow** markings of the ALT window is blinking.
   The ALT window pulses and changes to **orange** (Amber) if the pilot leaves and re-enters immediately 750 feet envelop and the continuous tone sounds.

The continuous warning tone can be switched off by means of two methods:

1. A new FCU ALT is selected that is outside the 750 feet envelop, as already mentioned before.
2. By pushing the Master Warning button, which is located above the ND. This method is used for a TCAS Alert to suppress the continuous tone which can distract the pilot. Flying the TCAS procedure means leaving the FCU ALT.

The altitude warning is suppressed, when:

- at least the Slats are extended (Flap Configuration 1)
- on the approach when the pilot flies on the glideslope (ILS Approach)
- the gear is extended

The Coffin Corner

As higher the altitude as thinner is the air is. Consequently, air resistance as well as the engine power are becoming less. If these conditions are put into relation to each other, the speed window that generates sufficient lift shrinks.

At an altitude of 38.000 feet (FL380) the speed window is just 40 knots, as shown in the picture on the left. When the **Orange VLS Bar** moves up with altitude, the speed range is adapted. The higher the GW, the more the bar moves up and limits the speed range.

This speed window is called ***Coffin Corner***, because the usual consequence is a stall and, in most cases, a fatal accident when the Aircraft leaves the window.

2.4 The Descent

2.4.1 Descent Approach Preparation

In normal operations, a Flight Plan (F-PLN) from the departure to the destination Airport is available to the pilot with the Top of Descent (T-D) calculated by the FMGS. However, the Flight Simulator Pilot may like to fly a route using Raw-Data (VOR Navigation), for example from LSZH (Zurich) to EDDM (Munich). So, the question arises when to start the descent to reach the IAF (Initial Approach Fix) at the correct altitude.

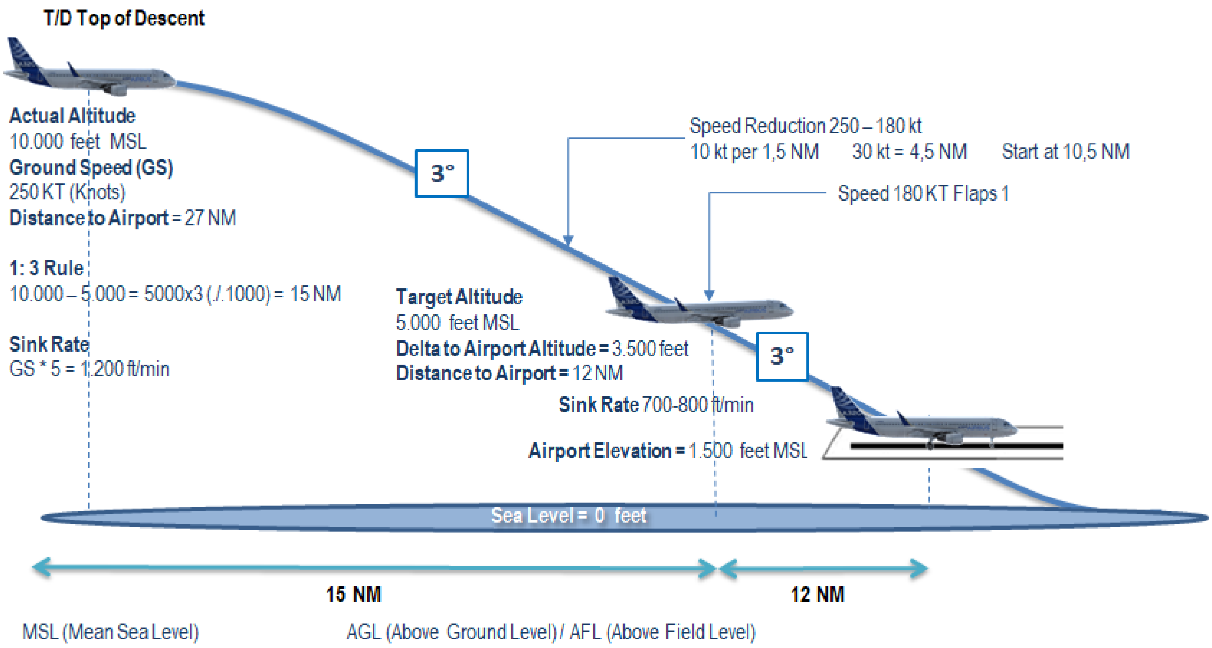
The left picture indicates, the Airport is not visible to the FS-Pilot at a distance of 32 NM, but at 27 NM, the Airport appears in the distance.

Three conditions must be considered to determine the best point to start the descent:

1. At what distance must the descent be started.
2. What is the required descent rate?
3. How far is the Airbus actually away and in which direction from the Airport.

Calculating the descent distance

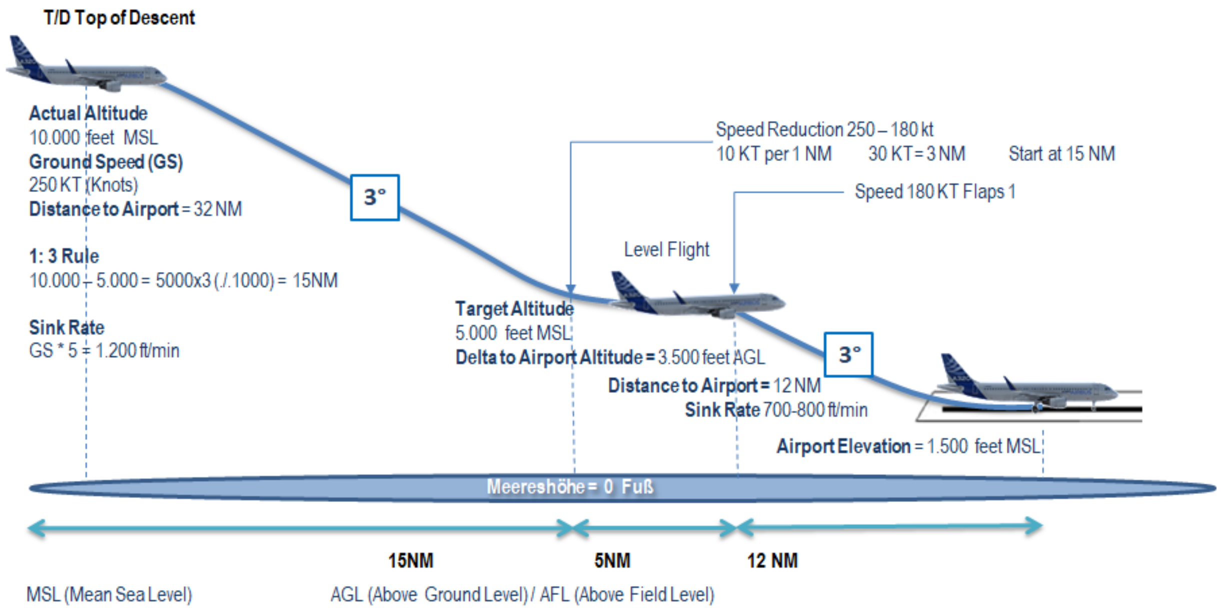
The graphic shows a straight descent from FL100 via the IAF of 5.000 feet down to the Airport height of 1.500 feet. The distance to the IAF is 15 NM followed by 12 NM from the IAF to RWY08R. All together the distance for the descent has been calculated at 27 NM.



In the first section of the descent, the Airbus usually descents with some thrust, depending on Aircraft GW and wind conditions. However, during speed reduction and Aircraft configuration (flaps, gear), the descent rate, Aircraft pitch and power setting change accordingly. In order to fly a 3° descent, the PFD and ND indications need to be changed from the HDG/V-S to TRACK/FPA, see chapter 9.

Reducing to VAPP (Approach Speed) is a complex task when performing a straight-in descent and the usage of speed brakes (spoilers) may be necessary. During the level flight, for 10 knots of speed reduction 1 NM is required, while during the descent 1,5 NM are necessary for a 10 knots reduction.

Therefore, a short level segment of 5 NM may be included to support the speed reduction to S-Speed of approximately 180 knots (Decelerated Approach - Flaps 1, Gear Up). The corresponding 1:3 Rule calculation is shown in the following graphic.



Calculating the descent rate

The required descent rate is a function of the actual aircraft speed. The calculation uses the ground speed because it is already compensated by the wind influence.

The descent rate = ground speed x 5.

Example 250 x 5 = 1.250 ft/min

Defining the distance and direction to the Airport

There are two methods to find-out how far the Aircraft is from the destination Airport.

1. If a VOR or DME (Distance Measuring Equipment) is available, the distance of e.g. 27 NM is shown on the ND in the lower corners (VOR 1-left, VOR 2-right).
2. The ND range circle allows to roughly calculate the distance by interpolating the Airport location between the ND range cycles. The Airport EDDM (**Magenta Star ***) is located 2/3 between the 20 and 30 circles equal to approximately 27 NM.

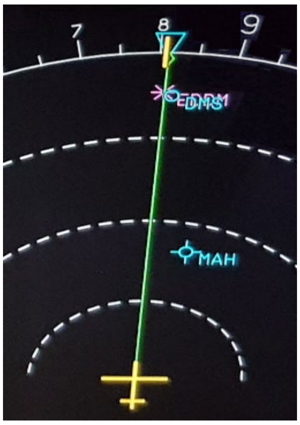
The Airport indication on the ND (Navigation Display) (**Magenta Star ***) always corresponds to the centre of the Airport area. Because the Runways at EDDM are both 4.000 meters in length, half or 2 NM have to be added to define the Runway thresholds.

The same applies to the DME-**DMS** which is located at the half-way point of the south Runway (DMS = DME Munich South, DMN = DME Munich North).

When the **Green** TRACK line overlaps with the **Magenta EDDM *** or the **blue DMS circle O**, the Airbus will fly the correct track towards the Airport, with wind compensation.

Either of the two pictures clearly indicates, that the A320 is on the track towards the EDDM Airport.

The MDH (Minimum Decision Height) should not be less than 1.000 feet AGL.



If the FS-Pilot has entered the Destination Airport data into the MCDU-F-PLN page, then the selected Runway is graphically shown on the ND. This presentation greatly enhances the situational awareness and the lateral navigation.

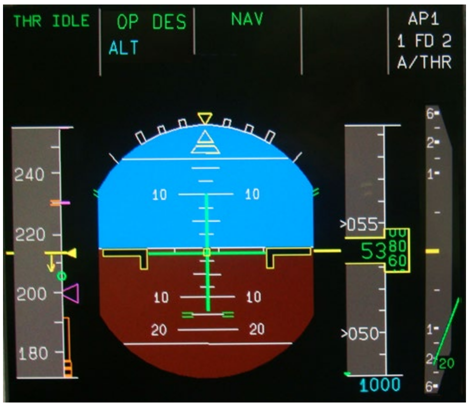
Nevertheless, the vertical navigation still needs to be calculated using the 1:3 Rule. In the following picture the A320 is on final approach to EDDM08R with an FPA of -3.2° (-800 ft/min) and a track of 082°. The actual Radar-Altitude is 920 feet, shown in the lower brown part of the artificial horizon.

The Distance to the Runway is approximately 2.8 NM as the Runway symbol is shown between the 2.5 and 5.0 ND circles. Cross-check: 1 NM per 300 feet / 3 x 920 feet AGL = 2.8 NM.

The FPV (Bird) sits exactly on the -2,5° bar, indicating an FPA of around 3°.

The FMA column 5 indicates, that the FD of the F/O (FD2) is switched ON.

Another method available to the FS-Pilot is the Open Descent Approach (**OP-DES**), but the descent rate will be more than 3°. As a reminder: **OP-DES** is a descent with **IDLE** thrust, which usually results in a descent rate of 2.000 ft/min or more.



An approach initiation with **OP-DES** at the 27 NM point (first graphic) will lead to a short level flight due the greater descent rate. Again, this section can be used for speed reduction, similar to the second graphic.

However, the last segment starting with the Aircraft configuration must be flown with both FDs switched OFF to make sure, that the A/THR is in **SPEED** mode.

Latest at 1000 feet AGL the **OP-DES** mode and consequently **IDLE-THR** is not permitted.

See also chapter 4-AFS modes for the **OP-DES** mode and chapter 9-Approach Procedures.

2.4.2 Descent Initiation

The Descent (DES) must always be initiated by the pilot. There is no automatic FMGS procedure when reaching the T/D (TOD - Top of Descent).

The Descent Preparation starts no later than 80 NM before the T/D (approx. 10 minutes). The actual flight time to the T/D can be read on the PERF PROG page.

Following are some examples of the relationship between the speed reduction and the required flight distance:

Speed Reduction	Time	Distance
320 → 280 Knots	1 minute	6 NM
300 → 250 Knots	1 minute	5 NM
320 → 210 Knots	2 minutes	10 NM
280 → 210 Knots	1 minute	4 NM

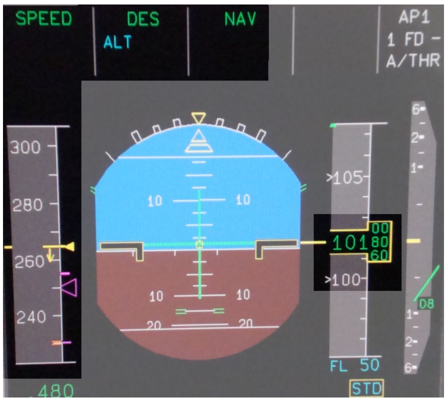
The next table shows some descent reference values:

Altitude	Distance	Speed	Configuration
26.000	80 DME	M 0.76	0
15.000	45 DME	280	0
10.000	30 DME	250	0
6.000	20 DME	250	0
3.800	12 DME	210	F1
2.500	8 DME	180	F2
2.000	6 DME	180	F2 / GD*
1.500	4,5 DME	160	F3
1.000	3 DME	V_{APP}	Full

GD – Gear Down

The Airbus descents from FL350 a standard descent speed of M.78/300 knots is flown. From FL 250 and lower, the descent speed is approximately 270 knots. Passing the FL 100 the descent speed is 250 knots.

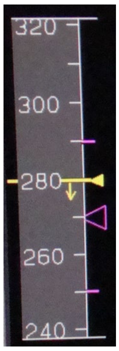
The descent speed calculated by the FMGS also varies according the aircraft weight and atmospheric conditions (e. g. wind, if inserted into the wind pages). The descent speed calculation always includes a certain speed range to avoid constant changes between **THR IDLE** and **SPEED** mode.



The right picture shows a descent speed of 270 knots with a speed margin ranging from 290 to 250 knots.

In the left PFD example, the descent speed decreases to reach 250 knots at FL 100. During this phase the A/THR may require some power and the A/THR changes from **THR IDLE** to **SPEED**.

The speed margin ranges from 255 knots to 230 knots. The small deviation of 5 knots is accepted.



When passing FL100 some important crew actions are performed (like in the climb phase but in reverse order: Landing Lights - ON, Seat Belt Sign - ON, Landing System - ON (LS button on EFIS controller) and the check of the descent profile (distance to destination). It is also a good moment to check the Navigation- and meteorological-data in the RAD NAV page and enter NAV-data if necessary.

In case the descent is carried out in the **OP-DES** or **V/S** mode (together with **HDG** or **TRK** mode) the **Green** Energy Circle is displayed in the ND.

If required, the spoiler can be used to increase the descent rate.

Half Spoiler (50)	Descent Gradient	+ 50%
Full Spoiler		+ 90%

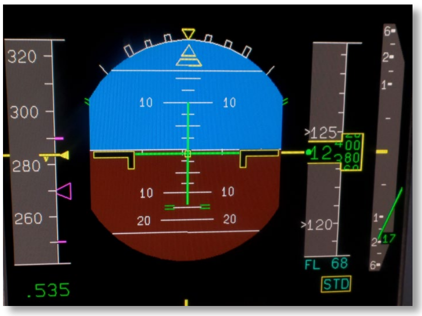
The target is, to reach an altitude of 9.000 /10.000 feet approximately 30 NM before the destination runway with a speed of 250 knots.

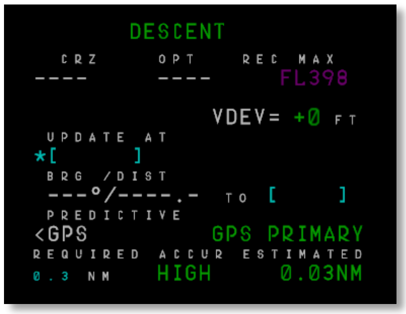
2.4.3 Descent Monitoring

The FMGS permanently calculates the descent profile and displays it on the ND and the F PLN page. A **Blue** arrow on the ND defines the point where the Airbus will level off after the descent at the FCU ALT, see also under chapter 5. On the F-PLN-page, the pilot can read the predicted altitude at each waypoint (WPT), see also under chapter 5.

In case restrictions (constraints) are to be observed at certain waypoints, they are shown on the ND and in the F PLN page. More details are included in chapter 6 and 8. The FMGS takes all constraints (altitude, speed) into consideration when calculating the descent profile.

To ensure that the Airbus is reaching the approach gate 1.000 feet (AGL) at the correct distance, the pilot should visually monitor the descent profile. Beside the mentioned indications the pilot has one more reference on hand, the **V/DEV**.



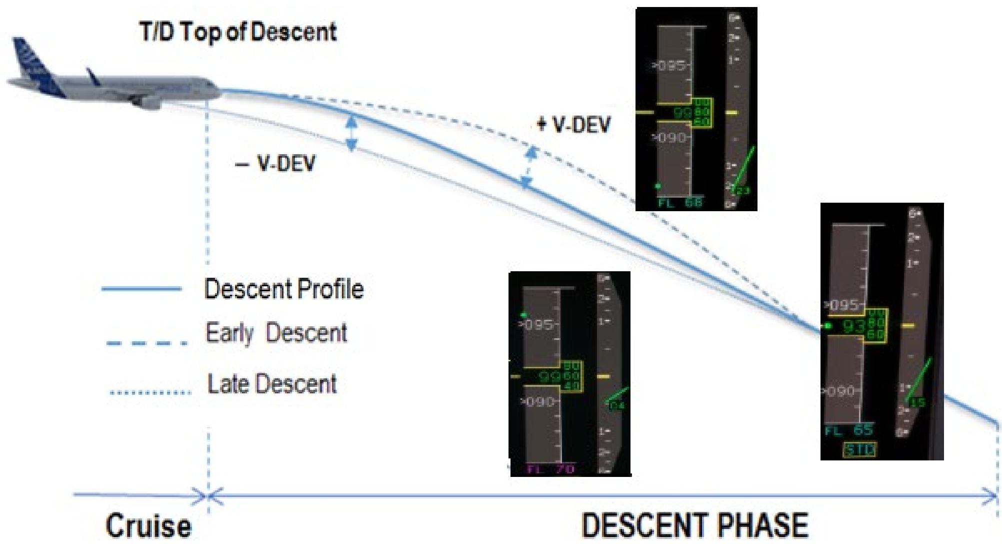


The **V/DEV** or Vertical Deviation works similar as the ILS G/S indication.

The **V/DEV** is represented by a **Green Dot** (●) on the altitude tape.

Remark: *Depending on the aircraft variant, the EIS may show V/DEV with a* ***magenta dot*** *(●).*

According to the screenshots above (PFD and PROG page), the Airbus flies exactly on the calculated descent profile. The **Green Dot** on the PFD is right in the centre of the altitude tape and the PROG page shows **+0** feet.



The **V/DEV** indication is not based on a certain descent rate but solely on the pre-calculated descent profile. The information is available from the Top of Descent (T/D) until the MAP (Missed Approach Point).

2.5 The Approach

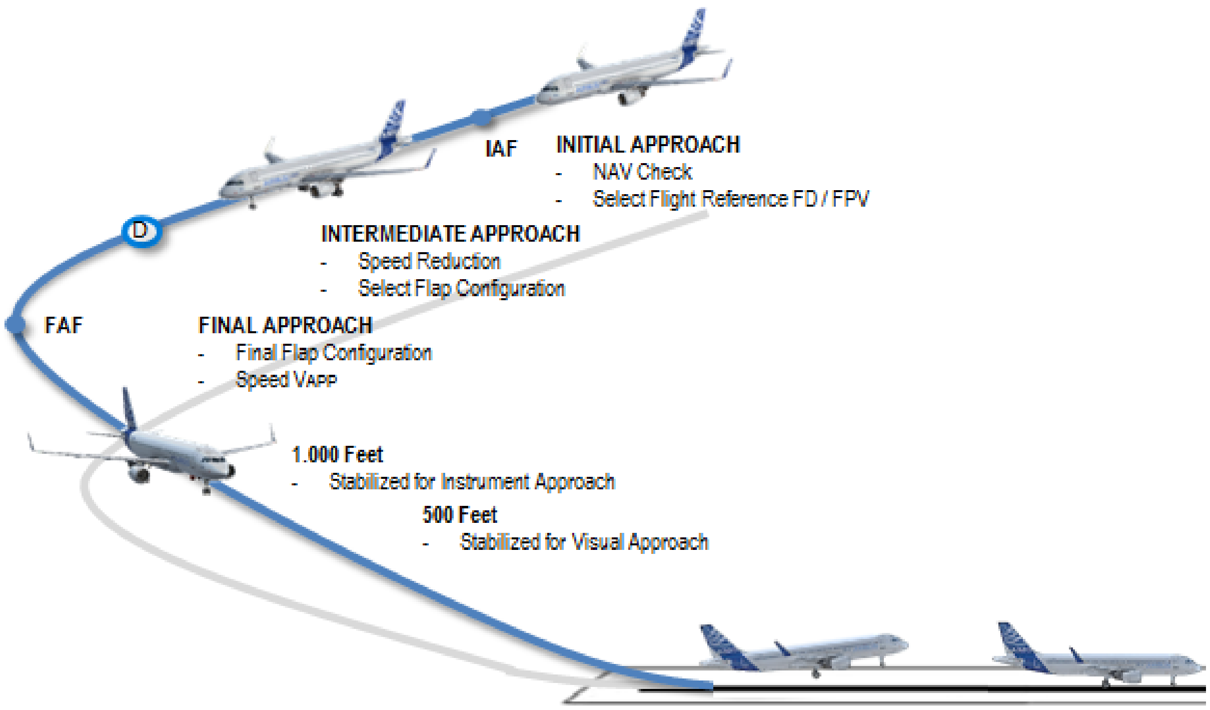
The approach is divided into 3 segments:

1. The Initial Approach starts at the IAF (Initial Approach Fix) about 15 NM from the destination Airport.

   If the **NAV** mode are active, the MCDU PERF-APPR-page is automatically activated when the Airbus passes the **DECEL** Point. However, the pilot must press the MCDU-PERF function key to display the APPR page, if not already selected.

   As soon as cleared for final approach (ILS or Managed NPA Approach), this is the right moment to press the APPR button to arm the APPR Modus.
   In case of an ILS Approach the LS button (Landing System) must also be pressed if not already done. For a Managed NPA Approach the LS button is not selected.

   The IAF is also often used as a Holding Point, like SBG on the approach to Salzburg (LOWS). Following some standard holding speeds as a reminder:
   → 230 knots / FL140
   → 240 knots / FL200
   → 265 knots above FL200



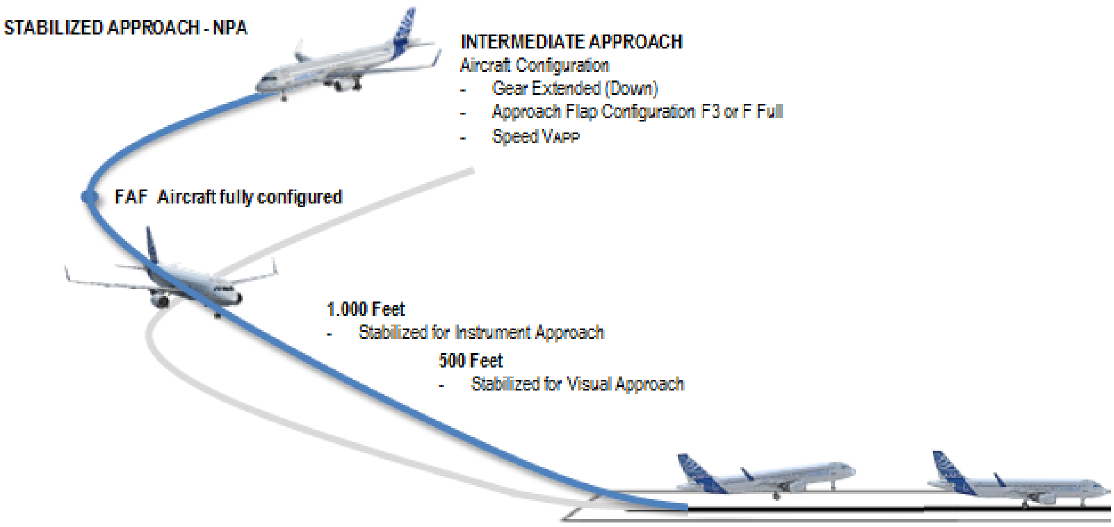
2. The Intermediate Approach guides the Airbus from **DECEL** Point to the FAF (Final Approach Fix). In this segment the speed is reduced from 250 Knots to VAPP (Approach Speed) and the Airbus aligned with the runway centre line (Localizer Interception).
   It is normal practice that ATC advise the pilot to hold 170 Knots until Middle Marker.

3. The Final Approach begins when passing the FAF leading to the decision height/altitude. The FAF is located 10 NM from the runway threshold in 3.000 feet AGL and marks the start of the final approach (Glideslope Interception).

Approach Procedures

There are two distinct approach procedures:

1. ***The Stabilized Approach Technique:***
   This approach technique is used for non-Precision Approaches (NPA). The pilot configures the A320 full (flaps 3 or full) with gear down. Reaching the FAF the correct approach speed VAPP should be established.

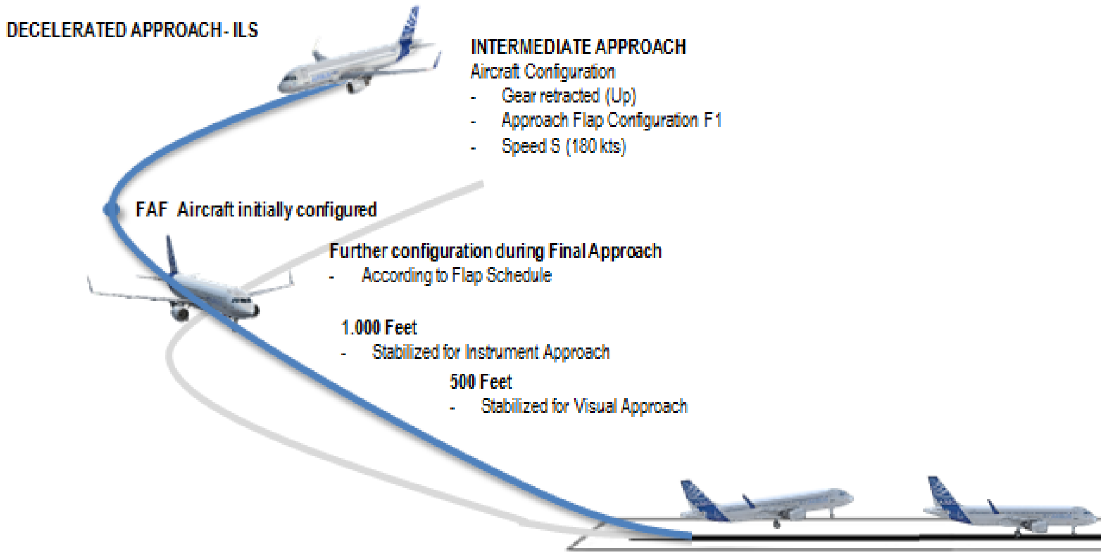


A fully configured and stabilized aircraft enables the pilot to concentrate his/her full attention on flying the correct lateral and vertical profile during the final approach.
A disadvantage of this technique is, that the A320 flies the VAPP early and the approach is consequently slow. This makes the separation of the arriving aircrafts more challenging for ATC.

Therefore, some Airlines fly the NPA like any ILS approach with the decelerated approach technique.

2. ***The Decelerated Approach Technique:***
   This approach technique is used for Precision Approaches like the ILS. The Airbus reaches the FAF with the Flaps in configuration 1 or 2 and at **S** Speed, depending on Airline SOP. The speed reduction to VAPP and the further flap configuration takes place while on glideslope during the final ILS approach.

   Under visual flight conditions (VFR) the Airbus must be stabilized by latest 500 feet (AGL) and under instrument flight conditions (IMC) by 1.000 feet (AGL). In case the pilot is unable to meet these gates, a Missed Approach (MA) or Go-Around (GA) must be initiated.



During an approach in **OP-DES** and **THR-IDLE** mode the A/THR must be changed to **SPEED** mode latest by 1.000 ft. This is usually done by switching off **both** FDs, or by pulling the FCU SPD knob. The pilot must make sure that **both** FDs are switched off. In case only **one** FD is set to OFF, then the **OP-DES** / **THR-IDLE** modes remain active.

Pulling the SPD knob will revert the A/THR to selected **SPEED** mode and the actual speed becomes the target speed. Any other desired speed must then be selected manually be dialling the value with the SPD knob. If a manual landing is planned, then the A/THR may be disconnected latest by 1.000 feet.

2.5.1 The Final Approach

During final approach when the Airbus passes 3.000 feet the A/THR's sensitivity is enhanced, to improve the reaction time in this critical flight segment. That means, the A/THR reacts faster to changing approach speeds caused by wind or glideslope alterations.

The sequence for Aircraft configuration and speed reduction to V_{APP} is as follows:

O Speed +10 — Select F1.

S Speed +10 — Select F2. When the flaps are extended (see ECAM), select Gear Down.

F Speed +10 — Select F3 when the gear is extended (gear indications are **green)**.

F Speed — Select F Full and reduce to V_{APP}.

Speed reduction	Time	Distance
for every 10 knots	25 seconds	1NM

Flight Phase	Configuration	Speed	Pitch	Power N1
Approach	F-3	F	4°	GW – 15%
Landing	F-Full	V_{APP}	2,5°	GW – 10%

During the final approach the spoiler should not be used as they are less effective below 200 knots. If the pilot realizes that the approach or the speed is too high, then the gear should be extended below 220 knots in order to reduce the speed or improve the sink rate further.

Under certain conditions (e. g. thrust levers above the MCT detent) the spoilers will be retracted automatically, to prevent the Airbus from entering a critical flight condition. Nevertheless, it is recommended that the pilot flying keeps his hand on the spoiler lever whenever the spoilers are extended. This is to avoid forgetting to retract the spoilers on time.

SPEED BRAKE Auto Retract	Flap Configuration
A319 und A320	Full
A321	3 and Full

The same procedure shall be applied for the thrust levers. Even though the A/THR may be active, the pilot flying shall place his hand on the thrust levers to be able to react without delay if required.

When flying with manual thrust and the APPR speed drops, the pilot flying shall immediately set the thrust levers into the CL detent. Applying TOGA thrust is only recommended in critical situation, as the thrust increase may result in a rapid altitude gain. Moreover, depending on the flight phase setting TOGA thrust will result in the activation of the Go-Around mode.

How to calculate V_{APP} manually?

Starting point is the following table with the basic reference speeds:

Landing Weight	Reference Speeds in Knots (Knots)				
Tons	**O Dot**	**S**	**F**	**VLS 3**	**VLS Full**
60	205	185	145	135	130
50	185	168	130	124	121

Example calculation:

VSL Conf. Full 121 knots (lading weight, LAW 50 tonnes)

Additions + 2 knots for a CG value under 25% (these values can be read at the FLT CTR page in the lower ECAM display).

+ 5 knots for the expected crosswind of 15 knots (equal to 1/3)

V_{APP} **= 128 knots.**

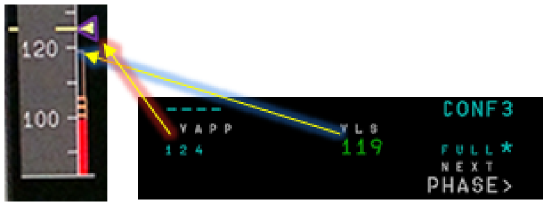
In case the A/THR is in use, 5 knots need to be added.

V_{APP} with A/THR **= 135 knots**

2.5.2 The V_{LS} Check

Before reaching the final approach speed V_{APP}, the pilot must cross-check the speed indications on the APPR-PERF-page with the PFD speed tape.

However, the pilot does not cross-check the V_{APP} but V_{LS} instead. The reason is, that the V_{APP} may show different values caused by wind influence, while the V_{LS} is purely a mathematic equation.



The speed indication on the PDF and in the APPR-PERF-Page are calculated as follows:

- V_{APP} in the APPR-PERF-Page is calculated by the FMGS based on pilot inputs before take-off (ZFW, CG).
- V_{APP} on the PFD is calculated by the FAC based on actual Performance Data (Pitch, AoA, actual GW, actual CG). The actual GW is the difference between the GW entered before the take-off minus the consumed fuel (in tons).

In the event, that the FAC-calculated V_{LS} on the PFD is higher than the FMGS-calculated V_{LS}, indicated in the PERF-Page, then the V_{APP} on the APPR-page must be altered by the same value. If the PFD V_{LS} is equal or lower, no action is required.

In the example it is assumed, that the V_{LS} differs between PFD and MCDU by 3 knots.

Therefore, the pilot writes the actual V_{APP} + 2 knots into the Scratchpad and modifies the V_{APP} with LSK5L.

The V_{LS} cannot be modified and remains as it is.

2.5.3 The GS-Mini Function

In non-Airbus aircrafts, the approach speed is calculated based on the reference speed V_{REF}. The approach speed = V_{REV} + ½ wind + gust factor. This calculation method does not take into consideration that the wind drops at ground level.

The GS-Mini (Minimum Ground- Speed) is an Airbus specific function, which ensures that the Aircraft energy is maintained even under a dynamic wind situation.

It is calculated as follows:

- In order to calculate the V_{APP}, 1/3 of the ATC headwind (see APPR PERF page input) is added to the V_{LS} (min. 5 to max. 15 knots). The GS-Mini is used by the FMGS but not shown to the pilot.

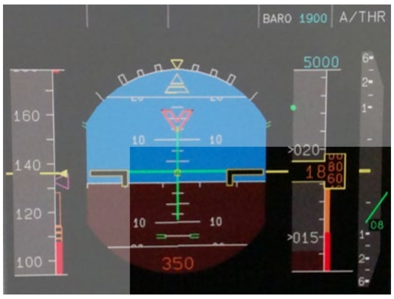
- The V_{APP} is modified by subtracting the complete wind with a minimum value of 10 knots up to a maximum of 15 knots. The wind value has been entered in the APPR PERF page by the pilot.
- The final V_{APP} is determined by adding the actual headwind to the GS-Mini speed.
- This value is called $V_{APP\ TGT}$ (target) and shown on the PFD speed scale.

2.6 The Approach Procedures

2.6.1 General Indications and Procedures

Even so, the ILS approach is standard today, landing at the destination airport remains a challenging part of any flight. This is particularly the case, when the pilot has to execute a non-precision approach, known as NPA. The Airbus assists the pilot in the complex landing phase with specific information.

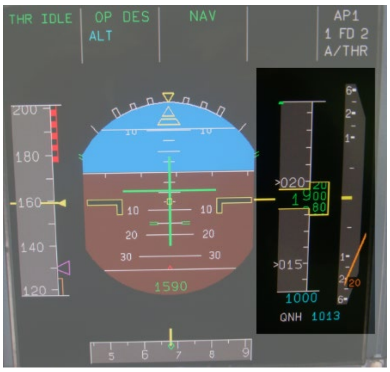
PFD Indications



When passing the MDA, the altitude indication changes to **Orange**, as an alert that the MDA has been overflown. The MDA is displayed on the FMA as BARO**1900**.

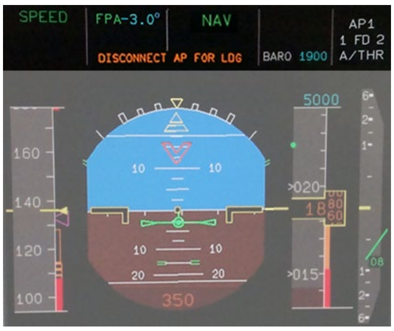
At 400 feet, the RA (Radio Altitude) changes from **Green** to **Orange**. This colour change is independent from the approach type and always pops up, even for a visual landing.

If a DH (decision height) has been entered in the APPR-PERF-page instead of the MDA (minimum descent altitude), e. g. for an ILS-CAT I-approach, then RADIO**200** is shown in on the PFD.



Whenever a high sink rate occurs during the approach, the V/S indicator may change from **Green** to **Orange** to draw the pilot's attention to a potential risk.

For any NPA approach, the message "**DISCONNECT AP FOR LDG**" will appear on the PFD, when passing the MDA.



If a MDA has been inserted in the APPR PERF page, the message appears at the MDA. For manual flight training, the MDA may have been omitted and the message pops-up when passing 350 feet (400-50 feet) AGL, as seen in the picture on the left.

Remark: *In the real A320 world, several standards/versions exist for the FMGS as well as the Flight Instrument presentation. Therefore, the Aerosoft or any FSX Add-on can perform differently as explained in this chapter.*
There are also two types of PER-APPR-page input formats according to the aircraft type variant: DH/RADIO and MDA/BARO.

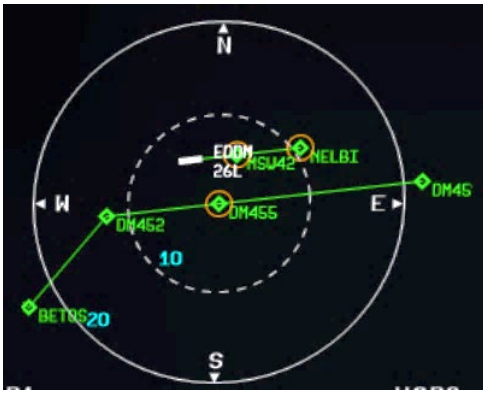
2.6.2 The Manual Approach

In Germany, e.g. EDDM, a special procedure is applied for approaches. The approach track runs parallel to the Runway and the final approach course includes a DISCONTINUITY between the Intermediate and final Approach.

Example- EDDM ILS26L approach: after WPT-**DM459** the approach course is a straight line without an end. Until **DM459** the pilot must have received a heading/vector to intercept the ILS by ATC. In the F-PLN-Page **MANUAL** is displayed in line 3 and line 4 includes a DISCONTINUITY. In this case, Manual does not mean that the pilot must fly manually, but that a manual action by the pilot is required.

As for any DISCONTINUITY the AFS-mode changes from **NAV**- to **HDG**-Mode automatically and the Airbus continues on the actual heading.

Under normal traffic circumstances, ATC provides a vector or a DIR TO towards WPT-**NELBI** well before **DM459**. This approach procedure allows the ATC to better coordinate the approaching traffic and avoid holding patterns.



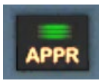
2.6.3 The ILS Approach

Today the ILS Approach (Instrument Landing System) is the standard approach procedure. All international Airports are equipped with the required technical equipment. In most cases the ILS installations allow fully automated landings, provided the Aircraft itself is properly equipped.

The ILS segment starts with the IAF (initial approach fix) and continues via the deceleration point (D) to the FAF (final approach fix), where the final ILS approach begins. The approach segment is either flown in the managed modes **DES** und **NAV** or selected modes **OP-DES** und **HDG** (depending on the ÁTC instructions). During the IAF segment, the approach speed will be reduced to **S** Speed and the flaps set into position F1.

At the latest, when overflying the IAF the ILS approach must be armed by pressing the APPR button. The FMA will display the available landing category. CAT I will be displayed above 2.500 feet and CATII or III below 2.500 feet when the radio altimeter is available. The pilot must also insert the DH into the MCDU APPR page.

As the next step the pilot checks if the LS button is illuminated and the ILS approach armed. The ILS ID is shown on the PFD (left low corner). Also, the FD button must be pressed if the FD is not already active.



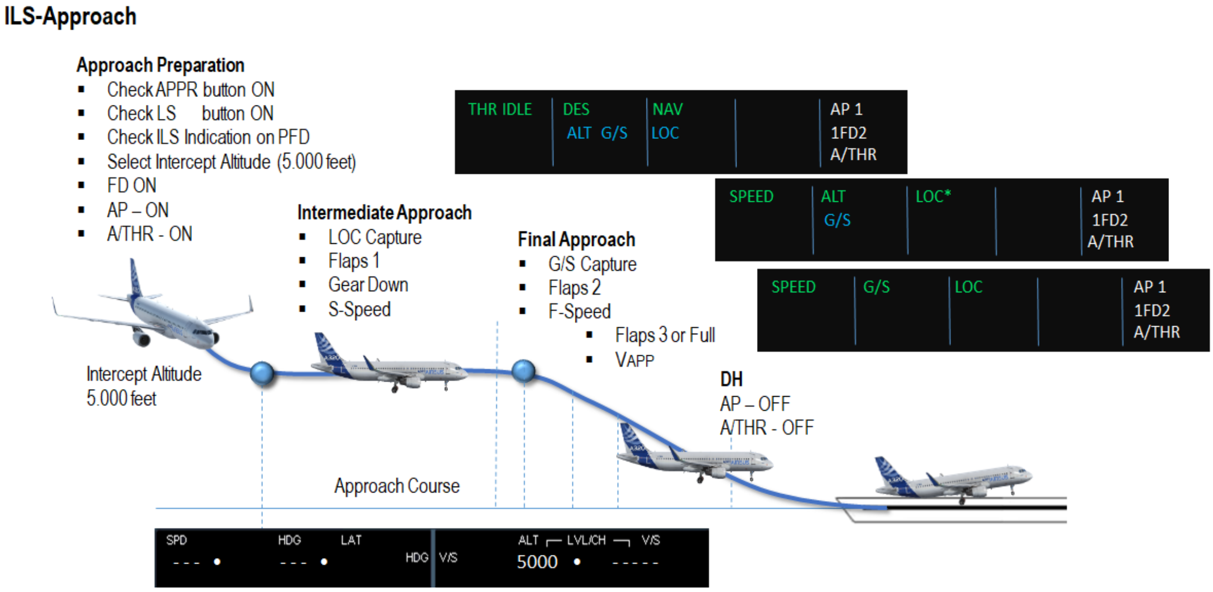
The activation of the ILS approach starts by pressing the APPR button. Prerequisite is that either an active F-PLN is available or the ILS ID (or frequency and course) has been entered into in the RAD-NAV page.

For training purposes, the FD can be switched off and the ILS approach is then flown using Raw Data only (**Magenta Rhombus** for glideslope and localizer) without AFS modes. The thrust control is set to A/THR or the pilot controls the thrust manually.

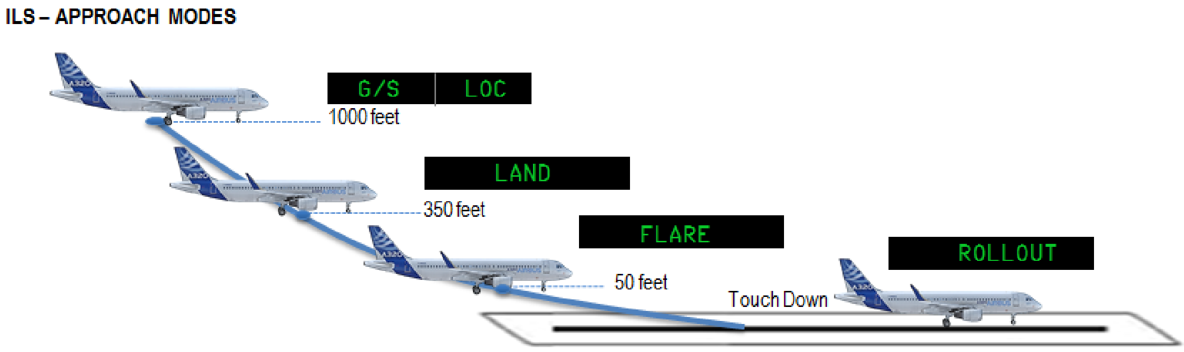
Before reaching the FAF the Airbus will be slowed down to **S** speed and the flaps extended to F1, followed by the arming of the spoilers. The localiser (LOC) shall be captured before the FAF that means before the final descent.

The ILS Approach Profile

When overflying the FAF the Airbus captures the G/S. After the glideslope has been captured, the Airbus is fully established on the ILS. Now, the speed will be reduced to **F** speed and following to **VAPP**. The Landing is carried out either with F3 or Full.



The FMA indication change according to the following sequence:

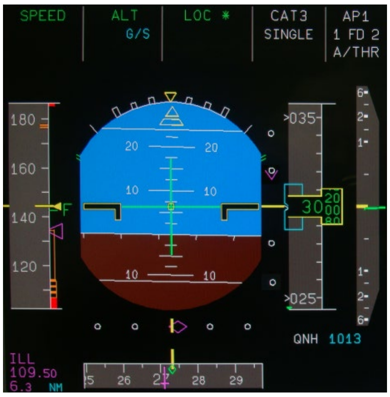


The ILS Approach Categories

Altitude	CAT III		CAT II
DH	15ft	50ft	100ft
Minimum RVR	102m	139m	254m
CAT I	For a CAT I approach the DH is 200 feet.		

The following pictures shows the ILS approach to RWY27L (ILL) at EGLL (London Heathrow) with the FAF at WPT-**ILL75** at 3000 feet and a RWY elevation of 83 feet.

In the example, manual Aircraft control with the A/THR OFF is performed after the FAF. The ND display mode is ARC with a range of 10 NM.

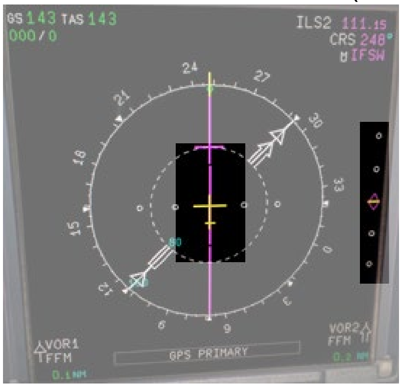


The Airbus is intercepting the localizer – **LOC*** mode. Vertically the **ALT** mode is active with the **G/S** mode armed. The Aircraft is intercepting the glideslope from below.

The A320 is slightly left of the localizer. The blue line is the MA with a seldom procedure, requiring a left turn at 1.100 feet before overflying the RWY threshold.

The PFD shows the final approach. The altitude has been set to the MA-ALT of 3.000 feet. The PLI (pitch limit indicator) is displayed. AP and A/THR are OFF.

Alternatively, the ND can be set to NAV-ILS to provide a representation similar to a HSI (Horizontal Situation Indicator).



This representation is very useful for manually flying an ILS approach, in particular with Raw-Data.

The **Magenta Rhombus** for the vertical deviation is seen on the right similar to the PFD. The lateral rhombus is substituted by the **Magenta Deviation Bar**.

2.6.4 The Non-Precision Approach (NPA)

Any non-precision approach (NPA) is always more challenging than an ILS approach. The ILS approach has a defined vertical and lateral guidance provided by a calibrated and precise ground equipment. Contrary the NPA approach is based on traditional navigation aids with limited precision, therefore called Non-Precision Approach.

However, with today's technology, the Airbus FMGS is able to fly precision-like NPAs, if the approach is appropriately coded and stored in the FSM data base. The pilot needs to select the approach on the F-PLN page and fly the approach as described in this chapter.

The NPA can be classified into three categories:

1. Conventional non-precision approaches, selected/selected **FPA** / **TRK**
2. Precision-like non-precision approaches, selected/managed **FPA** / **NAV**
3. RNAV approaches, managed/managed (fully managed) **FINAL** / **APP**

The following general procedures are to be considered:

- NPAs may be flown with AP und A/THR on, down to the MDA (**M**inimum **D**escent **A**ltitude or Baro-Reference respectively). If no Barometric information is available, 400 feet would be a good substitute value.
- In order to reduce the pilot's workload, it is recommended to de-activate the A/THR when passing 1.000 feet and control the thrust manually.
- At the final approach fix (FAF) or final approach waypoint (FAWP), or Descent Point (D) respectively, the Airbus should be configured with gear down and flaps 3 or Full. Which of the fix designation is used, depends on the approach chart layout.
- NPAs can also be flown managed like ILS approaches in **FINAL/APP** modes, if appropriately stored in the FMS data base. Laterally, Navigation aids such as NDB, VOR or LOC (localizer), or WPTs are used. The vertical profile is kind of a CDO (Continuous Descent Operation) procedure.

The lateral guidance after the FAF can be either:

- a Localizer (e. g. Innsbruck LOWI-RWY26), **LOC** mode
- a VOR radial (e. g. Zürich LSZH-VOR28), **TRK** or **NAV** mode
- a NDB QDM (e. g. EDDM-NDB08R), **TRK** or **NAV** mode

- a WPT course (e.g. EDDM-RNAV08R), **NAV** mode

The vertical guidance after the FAF can be provided by either:

- The selected modes **FPA** (Flight Path Angle), or **V/S** (Vertical Speed)
- The managed mode **FINAL** (descent profile), if the vertical approach is stored in the FMS data base

The NPA approach is normally flown with AP (ON) down to the MDA, regardless of selected or managed modes. As already mentioned, the A/THR may be switched off at 1.000 feet AGL to reduced workload at the MDA. Nevertheless, AP and A/THR can simultaneously be switched off at the MDA.

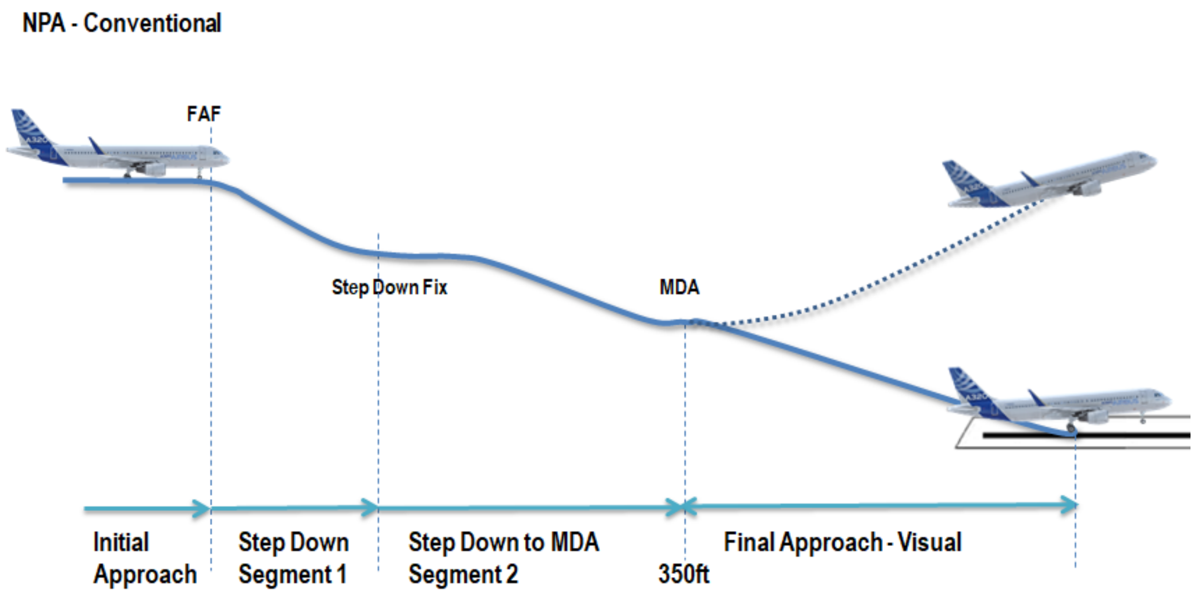
If the NPA approach is flow with AP ON, the AP will not automatically disconnect at the MDA and remain ON until touch down. The Message - Disconnect AP for LDG – appears on the PFD. However, older FMGS versions provide an automatic AP switch-off at MDA -50 feet.

The Conventional NPAs

Today, conventional approaches also known as step approach, are less common. Step approach means, the descent profile consists of several altitude steps with a short level segment at each intermediate altitude.

Generally, the A320 can perform conventional approaches like any other IFR equipped Aircraft. This book concentrates on the advanced NAV capabilities of the A320, therefore, the basic techniques of flying conventional NPAs are not discussed.

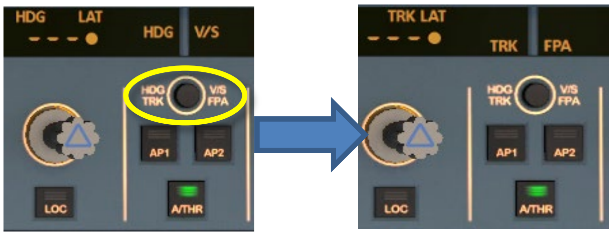
The A320 is not well suited for conventional NPAs and only able to intercept a VOR radial or a NDB QDM when the data is part of an active F-PLN. With the AP engaged, the course must constantly be adjusted by the pilot using the HDG knob on the FCU. Or the pilot flies the approach with manual Aircraft control.



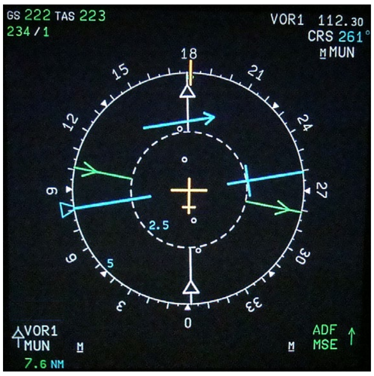
Conventional NPAs are flown with **TRK**/**FPA or HDG/V/S** modes. The track mode (**TRK**) corrects any lateral course deviation caused by wind. Vertically, the **FPA** (Flight Path Angle) or **V/S** (Vertical Speed) is used to command the sink rate independent from ground equipment.

The FCU representation is changed from HDG-V/S to TRK-FPA via the push-button of the glare shield panel.

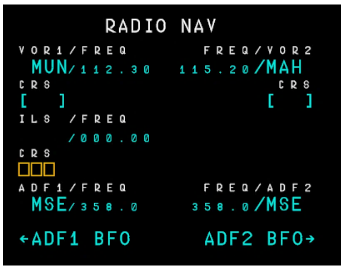
Remark: *On the FCU the track indication is TRK, while on the FMA it is **TRACK**.*



Following are two examples of possible ND indications related to a conventional NPA. The Navigation facilities (NAV Aids) are tuned via the Radio Navigation page (RAD NAV) on the MCDU.



VOR radial indication on ND. The **Green Arrow** is the QDM to the approach beacon MSE (ADF).

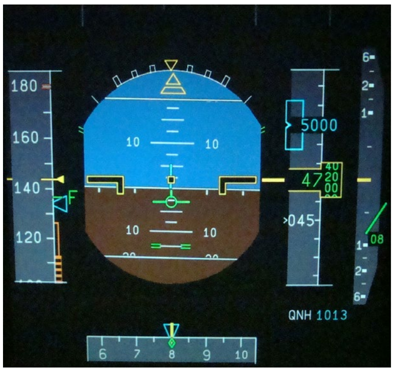


RAD NAV page set-up for a conventional NDB approach to RWY 08R at EDDM.

ND in ARC mode. The Aircraft is on intercept to final approach course.

Remark: *The latest MCDU version only provides one ADF prompt, but it can be selected as ADF 1 or 2 on the EFIS panel (see chapter 6).*

Both PFD indications show the final approach shortly after starting the descent, leaving the initial altitude of 5.000 feet.



The left picture shows the PFD for a manually flown approach without modes. The Bird (FPV-Flight Path Vector) provides basic descent information.

The right picture indicates the AFS modes for a selected/selected approach.

The approach is still manually flown but with FD ON, guidance through the FPD (Flight Path Director) is provided.

In chapter 10, the function of the bird (FPV) and the FPD (similar to the FD indication) are explained in detail.

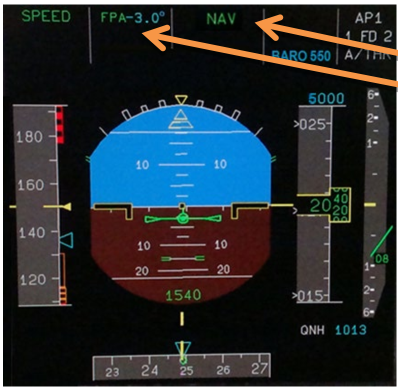
The Precision-like NPAs (RNAV Overlay)

Precision-like NPAs are similar to RNAV overlay approaches can be flown by FMS and non-FMS aircraft (see also under RNAV approaches in this chapter) usually with AP and A/THR engaged.

For NPA overlay approaches, the data (waypoints) are stored in the FMS data base allowing to fly the approach laterally with the managed **NAV** mode. Vertically the approach is flown with selected modes, which are either **FPA** or **V/S**.

In principle, it is important that the Airbus reaches the Final Approach Fix (FAF or F) at a defined altitude. From this point the pilot must start the descent conforming to the published descent profile and course.

The following pictures shows the setup of a selected/ managed NPA with **FPA/NAV** modes.



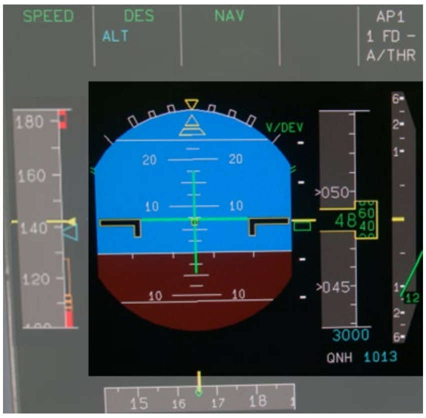
In the example, the Airbus flies the final approach with a **FPA -3.0°** and an approach course of 248° (EDDF RWY 25C) in **NAV** mode. Initial APPR and MA altitude is 5.000 feet.

The **Green** FPD symbol (Flight Path Director), commands the lateral and vertical flight path, requiring **TRK-FPA** selection on the FCU.

The Vertical Control

For an overlay NPA approach, the selected **FPA** mode guides the Aircraft vertically. The Lateral mode can either be selected (**NDB** -QDM, **VOR** -Radial, **LOC**-localizer) using ground-based NavAids, or managed (stored in the FMS data base) as part of the F-PLN.

The pilot is supported by a **V/DEV** indication (**V**ertical **DEV**iation), similar to the ILS-Rhombus. The FMGS calculates the actual deviation from a theoretical vertical profile based on the following conditions:



- **NAV** mode is active, or HDG/TRK mode with a cross track (XTK) less or equal 4 NM.
- A stored NPA (**VOR**, **LOC**, **NDB**) is the active F-PLN.
- The Airbus is in the APPR or GA phase.

The **V/DEV** symbol is displayed as follows:

- At the PROG APPR page as a +/- value.
- At the PFD as a **Green Rectangular Symbol**. Depending on the aircraft variant the indication may be in **Magenta**.

The exact value is displayed at the PROG APPR page. The V/DEV window stays **black** without value if the conditions are not fulfilled.

The range is +/- 200 feet, with two sub areas with 100 feet each, see picture to the right. If the **V/DEV** is not within the +/- 200 feet area, then the symbol is kept at the upper/lower edge until the **V/DEV** is within 200 feet.

The LS button remains OFF for an NPA approach. In case the pilot inadvertently presses the LS button, the display mode will change from sink profile (FPA) to glideslope (ILS). The **V/DEV** indication is displayed in **Amber** and the V/DEV symbol is not shown. As an additional attention getter, the V/DEV indication will blink.

The pilot starts the final descent approximately **0.3 NM before the FAF** by pulling the V/S knob thus activating the FPA sink profile. The following data is used to calculate the sink profile:

- A FPA of -3° is equal to a descent rate of 300 feet per 1 NM.
- An increase to -3.1°, changes the descent rate to 310 ft/NM that means plus 10 feet.
- A FPA of -4° results in 400 ft/NM.

Example: The approach is 50 feet too high meaning100 feet above the runway threshold instead of 50 feet (see landing distance calculation). In order to return to the proper flight path, the FPA needs to be increased to -3.5°. The descent rate is now 350 ft/NM and the Airbus will be back on the correct profile after 1 NM.

The Altitude (ALT*) Trap*

The pilot must give particular attention if the Aircraft reaches the initial altitude close to the FAF with a low descent rate. In this case, the Airbus may still be in the **ALT*** mode. During the time when the **ALT*** mode is active, no other vertical mode can be selected. As the result, the FAF may be overflown when the **ALT** mode engages, before allowing the pilot to select the **FPA** mode for the descent.

A possible solution is changing to a higher altitude by more than 250 feet. This will automatically activate to the **FPA** mode and **ALT*** will not engage, but the pilot shall have already switched to **TRK/FPA** mode in anticipation of the FAF.

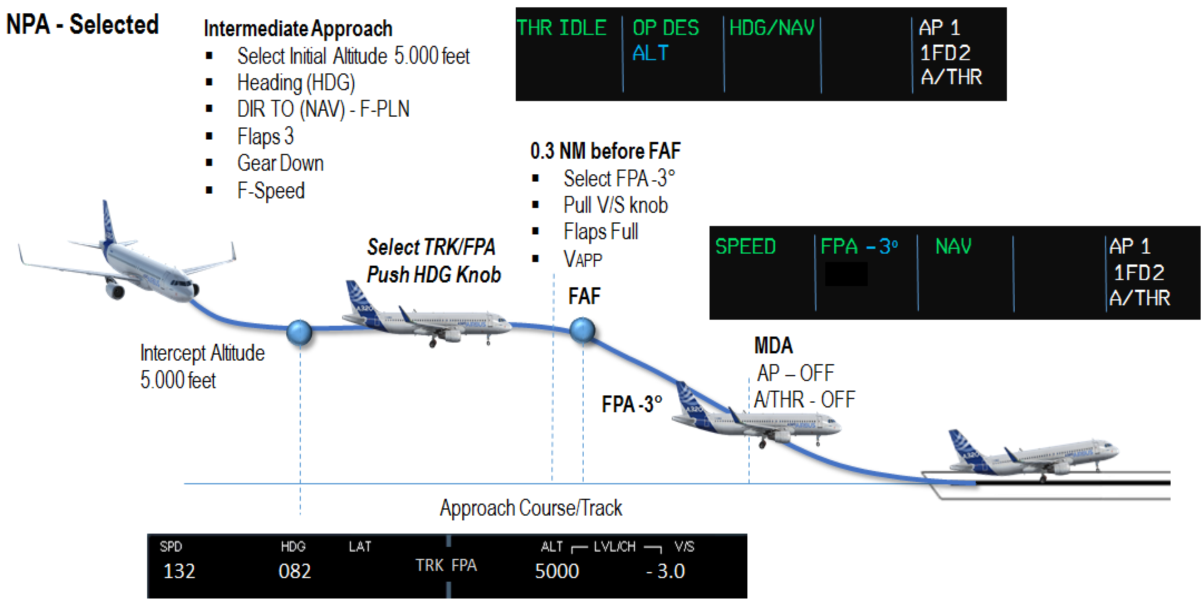
Or, when reaching the initial altitude, the pilot pushes the V/S knob to level off. The FMA indicate **FPA +0.0°.** At 0.3 NM before the FAF, the pilot dials the FPA value, e. g. **FPA -3.0°** and activates the mode by pulling the V/S knob. Once the Aircraft has started the final descent, the pilot can select the MA altitude at the FCU.

The Lateral Control

For the lateral control the following procedures are possible:

- If the DIR TO function is used to fly towards the FAF, the F-PLN sequencing is automatically done when pressing the „**INSERT**" key. The FAF is then the TO-WPT. In case the ATC requires a certain Intercept-Heading (vectoring), the Pilot must observe the conditions for the **HDG** / **NAV** mode change, see chapter 8.
- For a **LOC** approach, at about 25 NM (Cross Track / XTK), the pilot presses the LOC button to arm the **LOC** mode. The ATC may provide vectors for a 30° intercept angle.
- Instead of the **LOC**, a **VOR** radial may be the lateral guidance reference. Chapter 8 explains, how a **VOR** radial can be flown using the DIR TO function. Setting the ND to **VOR** (Rose mode), enables the pilot to visually track the intercept and fly the approach manually.

The following picture shows the general characteristics of a selected/managed NPA approach.

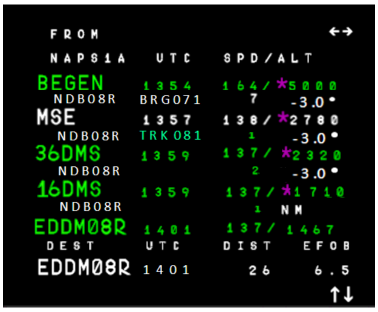


Example of a NPA-NDB-Approach (NDB08R-EDDM):

The NPA EDDM-NDB08R approach is part of the active F-PLN and is flown vertically with the selected mode **FPA** and laterally with the managed **NAV** mode.

BEGEN is the FAF, where the Airbus must be at 5.000 feet and start the final descent. The descent profile can be checked at the waypoints **MNE** and **36DMS** and **16DMS**. However, in the real world, the profile is checked at each NM against the approach chart.

The following F-PLN page specifies the EDDM08R NPA approach.



During the flight towards BEGEN a change from HDG-V/S to TRK-FPA function (FCU) is initiated and the speed is reduced to F-speed with flap configuration 3 or Full.

The distance to the FAF BEGEN can be seen on the right top of the ND (3.2NM). Moreover, BEGEN can be inserted into the PROG page, enabling the pilot to permanently read the distance, (see in chapter 6). For a VOR or LOC approach the 0.3 NM distance point can also be taken from the DME value.

When the Airbus is less than 2NM X-TRK to the approach course, the pilot pushes the HDG knob to activate the **NAV** mode. The Airbus will immediately intercept the final approach course.

When on approach course and reaching 0.3 NM BEGEN the sink rate of **FPA -3.0°** will be selected and activated. Thereupon, the final descent starts. Laterally, the managed **NAV** mode is active and the FMGS steers the Airbus according to the F-PLN data.

After passing WPT BEGEN the FMA shows the **FPA** of **-3.0º**, as selected by the pilot. In the example, the pilot is just leaving the initial altitude of 5.000 feet, which is also the MA (Missed Approach) altitude.

Latest by 350 feet, the pilot must have the Runway in sight, or execute a Go-around. Typically for an NPA, and as the pictures vividly show, the Airbus may not exactly be lined up with the Runway.

The Managed NPA-Approach

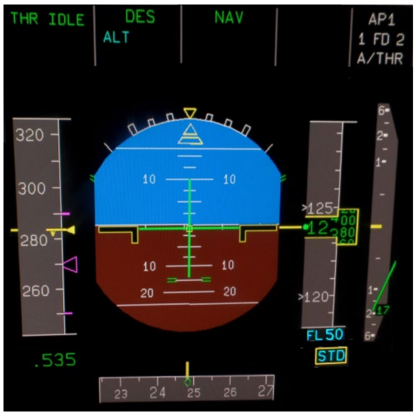
The NPA training to Runway 28 at Zurich can be nicely combined with a short flight from Munich (EDDM) to Zurich (LSZH).

In the first part, the Airbus is descending and flies towards the WPT- KL011 with the active AFS modes **DES-NAV**. If not already done, the pilot presses the APPR button to arm the managed NPA Approach before reaching the deceleration point **(D)**. The LS-button is not *selected* for a managed NPA approach.

The picture on the left shows the FCU and the EFIS controller of the PF. FD, AP, A/THR and APPR are ON, the LS button is OFF.

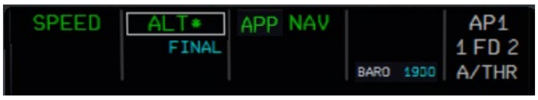
The Airbus has been cleared directly to WPT-KL011 by ATC, which is the FAF for the NPA. The pilot has used the DIR TO function, which is apparent by the **T/P** (turning point), as the FROM WPT, in the F-PLN page. KL011 is the TO WPT. The ND representation is set to ARC modus and a range of 40 NM.

Shortly before KL011 the Airbus reaches the deceleration point **(D)**, where the speed will be reduced in steps to reach VAPP just before KL011. The APPR-PERF-page is automatically activated as the Airbus passes the **(D)** point and the FMGS commands **GD** Speed. In case the A/THR has been used in selected mode, the pilot may change to managed A/THR mode by pressing the SPD knob.



The second part starts shortly before the FAF-KL011, where the Airbus must have levelled off at 5.000 feet. If the FAF is missed by more than +/- 200 feet, the APPR modes will not be activated.

In the FMA **ALT*** and the vertical NPA mode **FINAL** are displayed. The vertical mode is armed and therefore shown in **Blue**. The lateral mode **APP NAV** is already active. The MDA (Baro) is **1900** feet MSL.



Both, the vertical profile and lateral path of the managed NPA approach are flown with FD, AP and A/THR ON much like a normal ILS approach. The WPTs after the FAF are defining the lateral path and the vertical profile. In principle, these WPTs are kind of constraints with barometric altitude values calculated to form a 3^0 descent profile.

The third part is the final NPA approach starting at the FAF **KL011**, now the FROM-WPT, with the intercept of the final approach course and the initiation of the final descent. First WPT after **FINAL APP** activation is **KL088** with an ALT of 3500 feet followed by **KL006** and so on.

With the start of the final approach, the AFS-Modes change to the **FINAL APP** modes (**FINAL** for vertical and **APP** for lateral). On the F-PLN page and the ND, the missed approach is displayed in **Blue**.

Before intercepting the final approach course, the pilot can check the course on the F-PLN page.

In the 1st info line (line 2 of the F-PLN page) the F-PLN page shows the actual bearing (BRG) of the Aircraft towards the TO WPT. In the example the BRG is 278º compared to the approach course of 275º, therefore the Airbus is either slightly off course or correcting the wind influence.

Info line 2 (Line 4 on the F-PLN-page) shows the approach TRK of 275^0 and VOR28 as the approach. The approach course (TRK) is only shown for the TO WPT, being the reason that the F-PLN must be sequenced in the way that the FAF is the TO WPT with the DIR-TO Radial-In function.

Again, the pilot can check, if the approach course (TRK information) corresponds with the runway course, or if there is a XTR deviation. On the right side of the Info line in column 4, the sink profile of -3.3°.is shown. The figure left to the sink profile is the distance between the WPTs in this example 3 NM from **KL006** to KL032△. WPT-KL032 is the last WPT before the RWY und must be compulsory overflown, to be seen on the OVFL-△ symbol.

The MDA (minimum descent altitude) of **1900** feet (barometric value) has been entered into the APPR-PERF-page and is shown on the PFD. The runway altitude in ZRH is 1.420 feet, hence the runway must be in sight at 480 feet, otherwise a Go-Around must be carried-out.

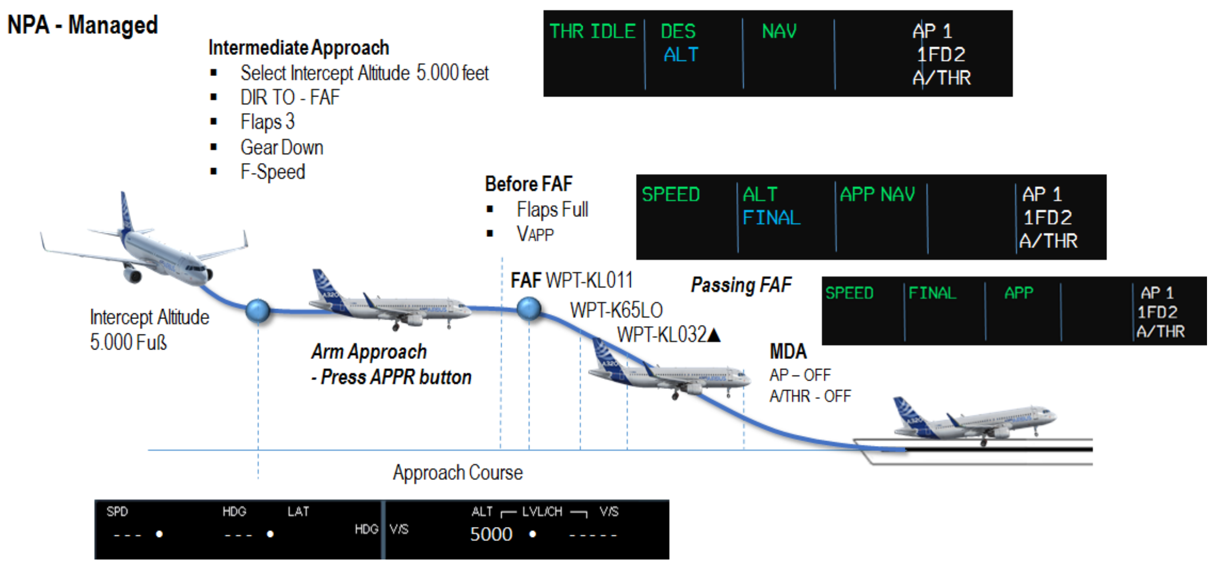
The WPTs in **Blue** after KL032 are the WPTs of the **Missed Approach** (MA) F-PLN. Once a GA has been executed, these WPTs will be shown in **Green** as the new active F-PLN.

Generally, Managed NPAs (sometimes the term fully manged is used) are flown with the AFS modes **FINAL** for the vertical and **APP** for the lateral path and must be coded and stored in the FMS data base.

Depending on the Airline SOP, NDB-VOR-RNAV and RNAV-Overlay approaches can also be flown in fully managed modes, however, it is not possible for LOC approaches.

In order to fly managed NPAs, the APPR button must be selected (but not the LS button), which would automatically select the localizer and glideslope (G/S) functions. By pressing the **LOC** button on the FCU, only the localizer will be selected and the **FPA** remains the only choice for the vertical path.

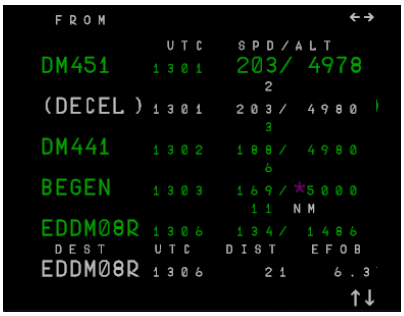
The following picture shows the characteristics of a manage NPA approach.



2.6.5 The RNAV Approach

The RNAV is a GPS based approach but still a non-Precision approach (NPA). All before mentioned procedures (selected/managed) apply for the RNAV approach as well. RNAV approached are designed on GPS positions and therefore more accurate than NPAs with NDB or VOR guidance.

The RNAV08R at EDDM approach looks very similar to the NDB08R approach as discussed before. The WPTs starting with the prefix DM… are indicating, that it is a GPS-based approach. Another distinct difference is, that only two WPTs are forming the final approach, WPT-**BEGEN** as the FAF and RWY WPT-**EDDM08R**.



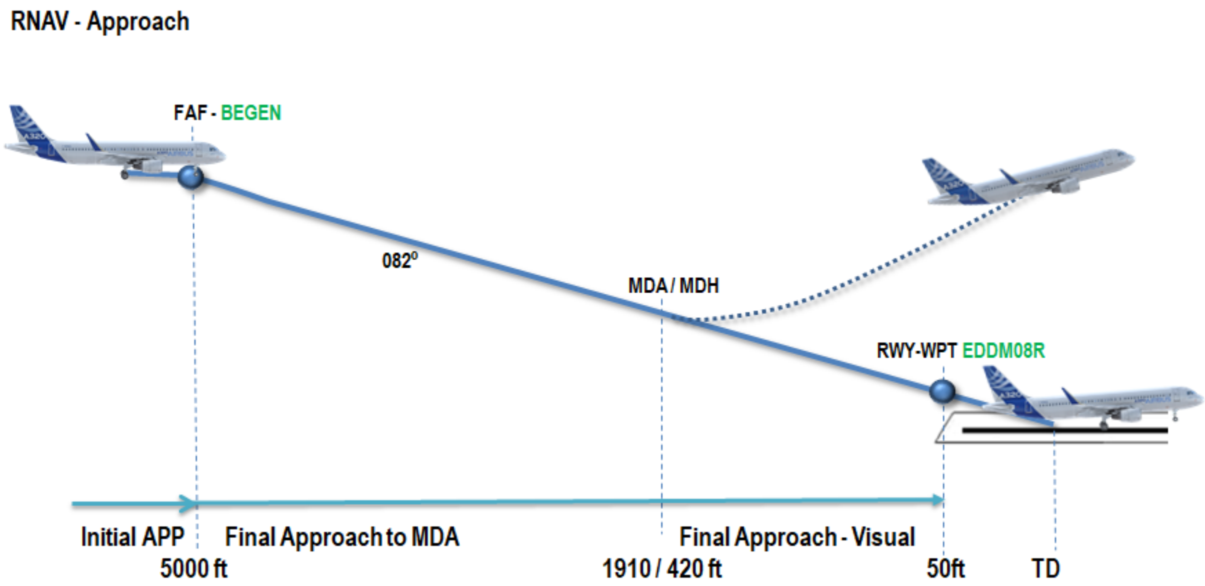
F-PLN page of the final segment from FAF **BEGEN** to **RWY08R**. WPTs **DM451** and **DM441** are part of the initial approach segment.

The RNAV approach after selection. ND is set to PLAN modus.

Rounded course line, displayed by the ND when in flight.

GPS position provide a maximum lateral deviation of 0.3 NM and require the correct functioning of the on-board GPS equipment. The ND and respective MCDU pages must display GPS PRIMARY, otherwise a RNAV approach is not permitted.

The following picture shows the Final Approach to **EDDM08R** with only two WPTs defining the Final Approach segment. Vertically the approach is a straight CDO-like path from the FAF-**BEGEN** down to the RWY-WPT-**EDDM08R** located 50ft above the RWY threshold.

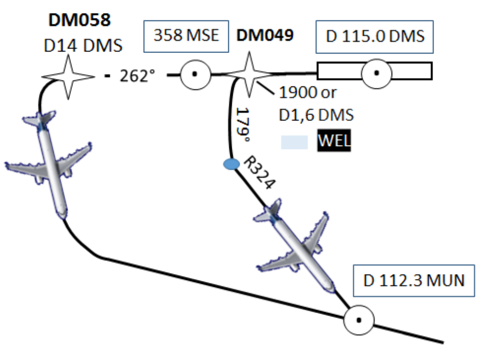


What is RNAV Overlay?

As the title suggests, a RNAV overlay is a standard departure or arrival route laid over a conventional route. That means for any waypoint or fix there are two parameters published, a GPS/IRS position for the RNAV and a DME value for the conventional route. In the absence of a DME value, the waypoint can also be determined by the intercept point of a **HDG** value and a **VOR** radial, or two **VOR** radials.

The example illustrates a typical RNAV overlay design for the SID-RWY26L (Standard Instrument Departure) at EDDM.

WPT **DM058** is defined by a GPS position as stored in the FMS data base but also by a **DME** value of 14NM from the **VOR DMS**. The Aircraft flies towards the waypoint on a course of 262°.



Conventional WPTs may also be defined by means of intersection points. In this example, the intersection point (**Blue** point) is determined by a **HDG** of **179º** from WPT-**DM049/1.6DMS** and the Radial **R324** from **VOR MUN**.

RNAV and RNAV-Overlay approaches provide a maximum lateral deviation of 0.3 NM and are flown just as the other NPA approach types. However, RNAV-Overlay approaches can also be used by non-GPS equipped Aircrafts.

There are two versions of RNAV approaches:

1. LNAV/VNAV - **L**ateral **NAV**igation **/ V**ertical **NAV**igation: When flown fully managed the FMGS guides the Aircraft laterally and vertically according to the FMS data base. This approach type may also be indicated as LNAV+V.
2. LNAV – **L**ateral **NAV**igation: In this case, only the lateral path is stored in the FMS data base and can be flown managed. The vertical part must be conducted in selected mode using **FPA**.

Minimum Decision Height - MDH

RNP/RNAV	LOC	VOR-DME	VOR	NDB
250 feet	250 feet	250 feet	300 feet	300-400 feet

Conventional NavAid Accuracy

NDB	VOR	LOC	DME
+/- 5º	+/- 3º	+/- 0,2º	0.2 NM or 2.5% of distance

What is RNP?

The term RNP stands for **R**equired **N**avigation **P**erformance. The difference to RNAV is, that RNP procedures require on-board performance monitoring and alerting capability of the GPS function. The lateral deviation is usually less than 0.3 NM, improving the accuracy of the approach further.

Recently, the RNAV approaches at EDDM have been changed to RNP procedures. The layout of the approaches has not changed but the requirements for the Aircraft equipment to qualify for the operation. With RNP a highly-optimized use of the airspace can be achieved.

2.6.6 Cold Temperature Correction

Another important item to be considered for any NPA is a possible cold temperature correction, whenever the Airport OAT (Outside Air Temperature) is 0° or below.

RNAV approaches may be conducted without correction, if the threshold temperature is indicated on the approach chart, e. g. VNAV -15° for the RNAV08R NPA approach at EDDM.

That means: up to an OAT of -15° the NPA can be flown without corrections, with managed modes **FINAL APP** and the AP ON down to the MDA.

If the approach chart does not contain temperature information, such as for the NDB08R at EDDM, the altitude must be corrected for cold temperatures and the approach conducted with the selected vertical mode **FPA**.

In Airline operations, cold temperature corrections are calculated by means of a specific program which is not available to the FSX-flight simulator pilot. The following is a basic example that can be used by the FSX-flight simulator pilot (*it is not to be used for real flying*).

Calculating the correction –approaches at EDDM

EDDM ISA +12° 450 meters (1.470 feet), according to the ISA standard atmosphere
EDDM actual <u>- 20°</u>
∆ 32° 4% correction per 10° = 13%

RNAV08R no correction till -15° (**BARO** VNAV -15° - according to approach chart)

Actual -20° correction required for Approach correction at **BEGEN**

FAF 10.9 NM from 08R corrected +13% = 9.5 NM or 5000 +13% = 5600ft

FPA -3° corrected +13% = -3.4°

NDB08R no temperature threshold – correction always required when ≥ 0°.

EDDM MSA 4.000 feet (for NDB08R 3.700 feet)

4.500 feet corrected

Intermediate ALT 5.000 feet Intermediate ALT > MSA corrected

5.600 feet corrected

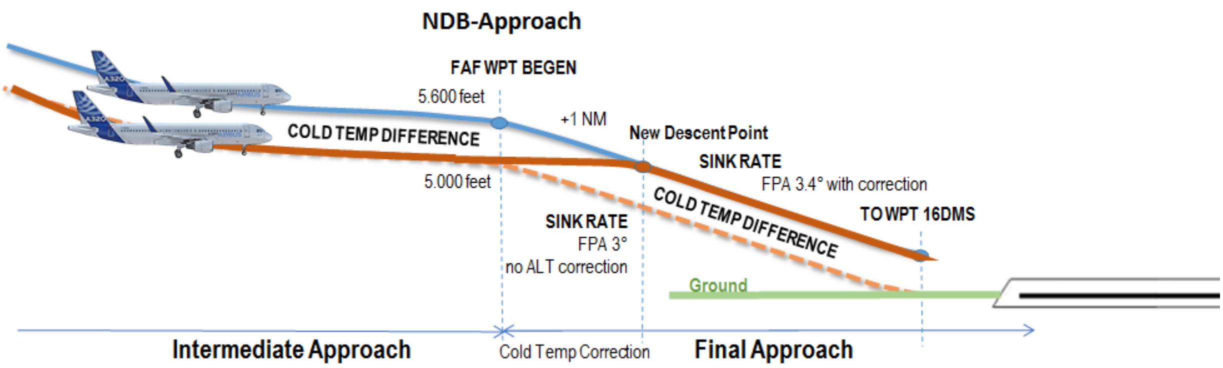
Rule: Whenever the heights without correction are higher than the corrected MSA, than a cold temperature correction is not necessary.

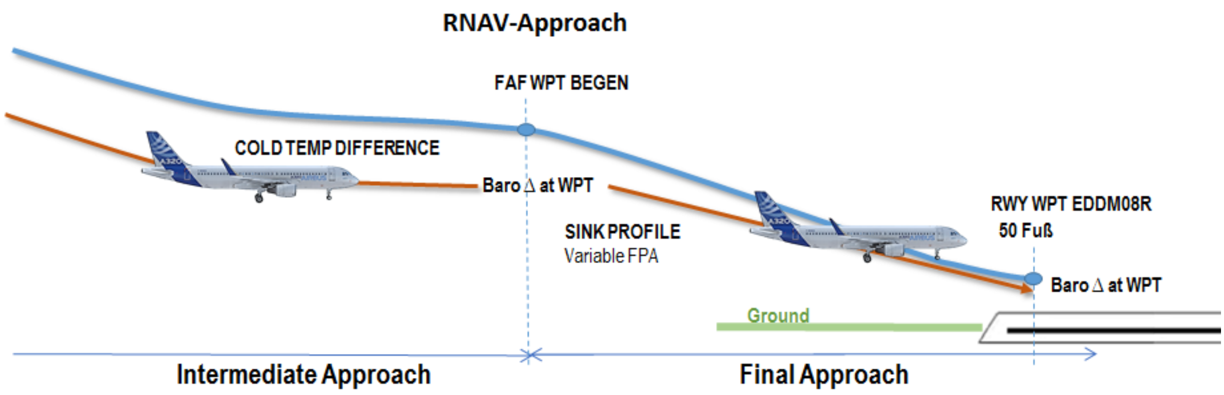
In the example, the Intermediate ALT (5.000) is higher than the corrected MSA (4.500). Therefore, the approach can be conducted without cold temperature correction at the Intermediate ALT of 5.000 feet at FAF-**BEGEN**. This is applicable for both, the RNAV and the NDB approach.

What is the reason for the different cold temperature procedures between the RNAV and NDB approach?

The NDB NPA is a steady 3º descent. Under cold temperature conditions, altitude and FPA need to be corrected manually by the pilot, otherwise the Aircraft flies parallel to the published flight path. The pilot has two choices for correction:

- Extend the descent point (later descent) and rate (steeper descent) as per the cold temperature calculation.
- Adjust the altitude and fly the published descent rate, usually 3°. In this case a clearance by ATC would be required.





RNAV approaches are vertically still based on barometric reference, but laterally on GPS-WPTs instead of conventional navigation aids. That means, the cold temperature corrections become less, as more the Aircraft get closer to the RWY WPT. It is not a steady 3° FPA, but kind of a sink profile.

The following table provides the FS-pilot with approximate figures for selected heights above field, that are good enough for his/her purpose.

Correction to be added in feet			
Height	ISA -10º	ISA - 20º	ISA - 30º
1000	40	80	120
3000	140	260	380
5000	220	420	620

Correction values for other heights may be calculated by interpolating the above figures.

2.6.7 The Visual Approach

Nowadays, visual patterns are still common at regional Airports alike. The procedure is quite similar to the traffic pattern, which is covered in this chapter.

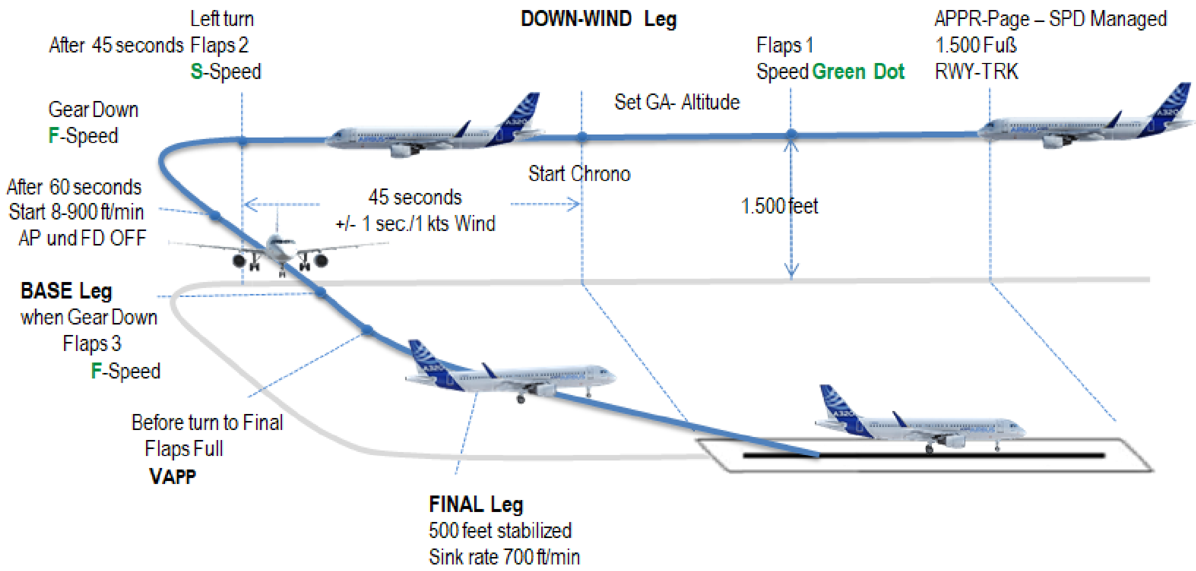
Visual approaches are either completely flown manually with/without A/THR or with AP support until the descent is started at the base leg. It has already been discussed that some Airlines do not allow mixed control procedure (manual Sidestick control and A/THR),

The visual approach is likewise flown in 1500 feet AGL (Above Ground Level). Instead of AGL other designations may be used such as AAL (Above Airport Level) or AFE (Above Field Elevation).

The approach procedure is a repetition of the main steps of the traffic pattern:

(1) Flaps 1 and **S** speed are set when abeam the Runway threshold
(2) Flaps 2 and **F** speed are set before turning to the base leg
(3) When the flaps are in position 2, the gear is lowered (Gear Down)
(4) When the gear is down and locked, the flaps are set to configuration 3

(5) Before turning the Final, the flaps are extended to configuration Full and **VAPP** is now the target speed



For the visual approach procedures, the A/THR can be used in Selected or Managed Mode. In order to use the Managed Mode, the APPR-PERF-Page must be activated during the downwind leg. A detailed description on how to use the A/THR in Managed Mode is included in chapter 6.

2.6.8 The Circling-Approach

The circling approach is a special variation of the visual approach. It may be used when only one Runway direction offers ILS capability for LVO approaches (Low Visibility Operation). Another reason is the landscape surrounding the Airport, which does not allow a straight in approach or weather conditions, e.g. a tail wind exceeding the Aircraft's performance limits.

One perfect example is Salzburg (LOWS) that is also primarily used to describe the various approach techniques in this book. The circling approach to LOWS RWY33 follows a special tear-drop procedure but this section only concerns the standard circling approach.

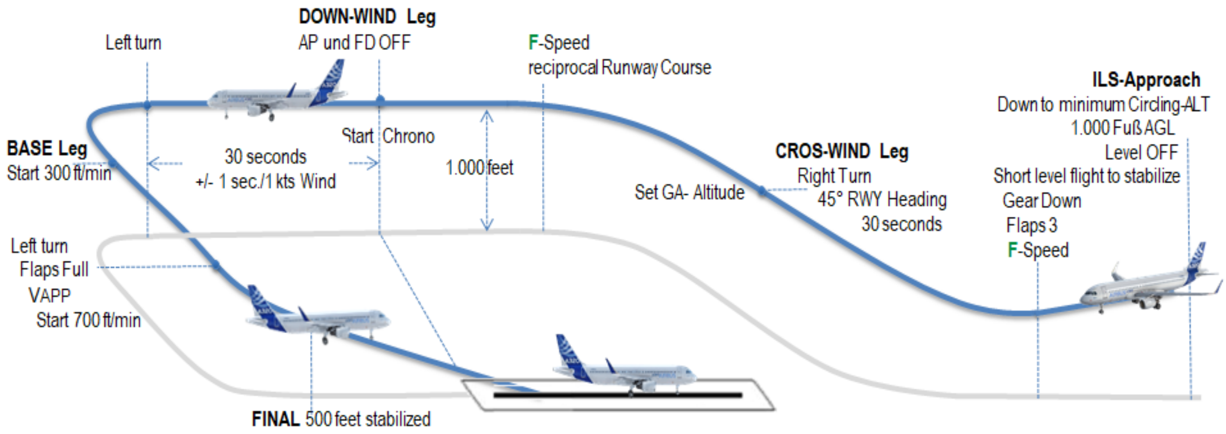
Any circling approach starts with a standard ILS approach from the opposite direction down to the minimum circling altitude. The circling altitude can be taken from the corresponding approach chart and is usually lower than the visual pattern altitude. Once the Runway is in sight, the pilot must maintain visual contact to the Runway at all times. If the visual contact is lost a GA must immediately be initiated.

The circling approach can also be flown by preparing a simple F-PLN, or a specific SEC-F-PLN, as described in chapters 7, 8 and 9.

In this example the Airbus flies down the ILS to a circling altitude of 1000 feet (AGL) using only ILS raw data. Using the 1:3 rule, 1000 feet (AGL) the Fix where the circling approach starts is about 3 NM before the Runway edge. The Airbus reaches the Fix with the gear down, the flaps in configuration 3 and **F**-speed. It would not be economical to fly the circuit with the high-power setting required for a level flight in configuration Full. Moreover, a GA under LVO circling conditions would be a difficult manoeuvre and is easier to perform with flap configuration F 3.

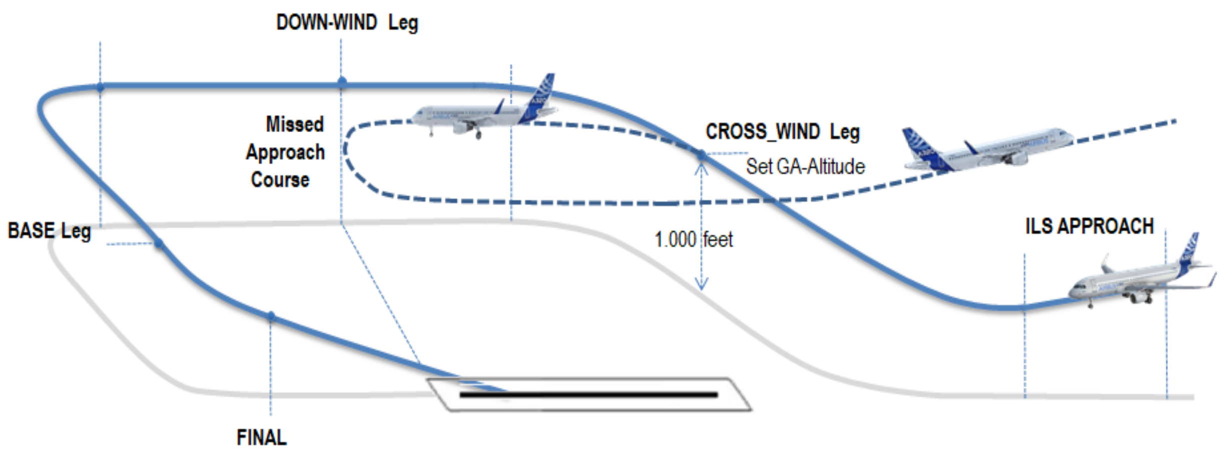
The flaps are extended to Full shortly before the turn to the Final approach and the speed is reduced to **VAPP**. Due to a lower circling altitude, the Airbus will only be about 400-500 feet high when turning to Final.

Even though LOWS is the preferred Training Airport in this book, it is not an optimal place for a circling approach training, due to the very special tear-drop procedure. Frankfurt (EDDF) may be used instead like for the traffic pattern training. In real life, it would be challenging (if impossible) to get approval for pattern or circling training at EDDF. But that's the good thing of a flight simulator, all is possible at the user's discretion.



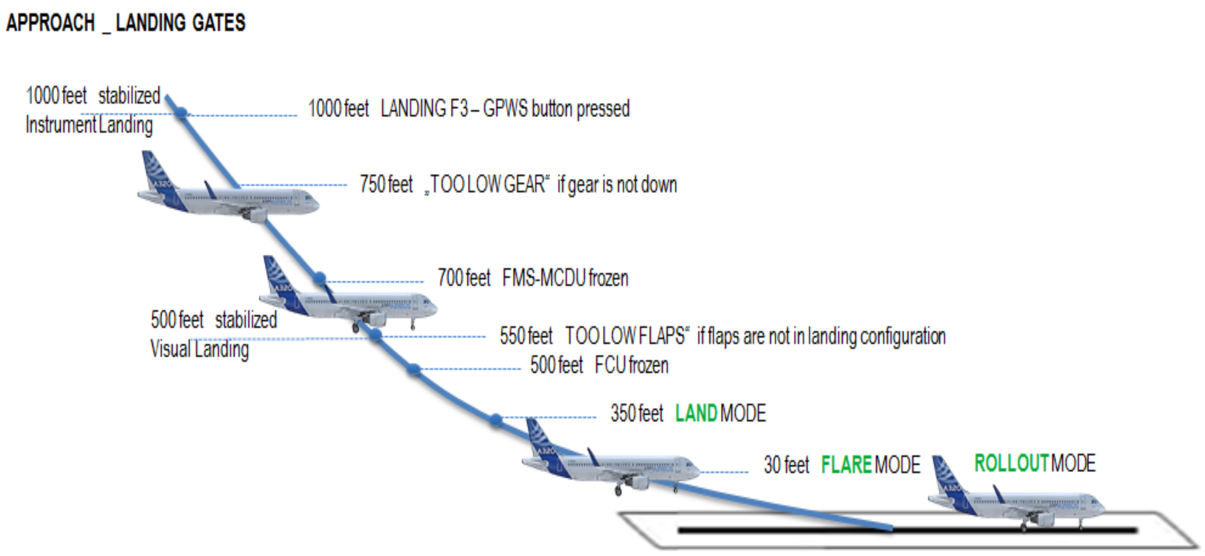
GA after Circling Approach

The actual landing Runway is always the reference for the Missed-Approach (MA) procedure. When flying a missed Approach or Go-Around, the first step is a 180º turn towards the course of the landing Runway, followed by the published MA procedure. The following picture illustrates such a MA procedure.



2.6.9 The Approach Gates

During the approach, the pilot must meet defined criteria at certain points within the approach segment. Such approach points are also called gates (like passing through a door) and are summarized on the following picture. Moreover, the EGWPS (Enhanced ground Proximity Warning System) alerts the pilot, if he/she fails to meet these criteria, e.g. “TOO LOW GEAR”.



2.7 The Go-Around

2.7.1 The Standard GA

In most cases the reason for a Go-Around (GA) is an unstable approach, meaning the conditions at 1000 feet (IMC) or 500 feet (VFR) are not met. However, it is also quite normal, that ATC request a GA, e. g. the runway has not been vacated in time.

During a normal approach the GA must be initiated at the latest at the DH-MDA. To do this, the pilot pushes the thrust lever full forward into the TOGA detent, the FMGS activates the GA modes.

MAN TOGA	SRS CLB	GA TRK		1FD2 A/THR

In case the pilot moves the thrust levers inadvertently into the FLX-MCT detent, then the GA modes will not be activated. The automatic call-out „Retard“ will be triggered and the FMGS will not command GA.

With the GA initiation, the pilot must command a pitch of 15° (A320) or 10° with one engine out (EO). Only then, a proper transition from the descent to a climb takes place and an accelerated descent will be avoided. In such a case, there is risk of flap overspeed and/or terrain approximation with GWPS warning.

The flaps are moved 1 step up (Full to F3, F3 to F2), followed by Gear-Up and subsequently to flap configuration F1, regardless if the actual configuration is F3 or F2.

A320 variants of the 3rd generation feature an advanced GA procedure. After GA initiation, the lateral **NAV** mode is activated instead of the **GA TRK** (go-around track). Pre-requisite is that the F-PLN includes the missed approach. The vertical mode is always **SRS**.

The FD will automatically be activated regardless if the approach was flow with the bird indication on the PFD or without the FD engaged. The GA-ALT is selected in the FCU window either when **G/S** and **LOC** modes are active (ILS) or after GA initiation (NPA).

After passing the ACC-ALT (or GA-ACC-ALT), the vertical mode changes from **SRS** to **OP-CLB** and the **GD** speed becomes the target speed, rather than the SPD-LIM 250knots/FL100. If no ACC-ALT data are available, the **SRS** mode remains active until the pilot chooses another vertical mode (**OP-CLB** or **V/S**). The GA does not offer the managed vertical mode **CLB**. Therefore, no constraints are considered and the pilot must select the constraints altitude in the FCU ALT window, if required.

The GA Profile

As mentioned before two lateral modes are available:

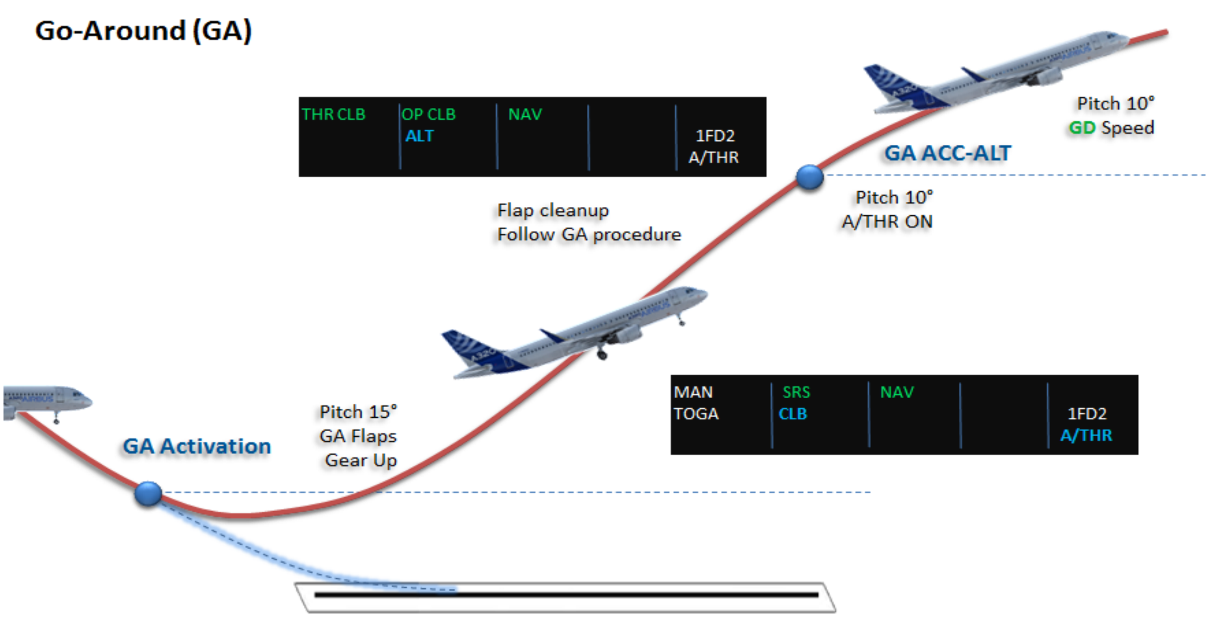
1. The **NAV** mode whenever the missed approach is part of the active F-PLN.
2. The **GA-TRK** mode when the approach is carried out in the **NAV** mode but no missed approach is included in the F-PLN.

The corresponding modes are: MAN TOGA, **SRS**, **NAV or GA TRK**.

In case of a visual approach flown with Raw-Data **V/S**-**HDG**, the **HDG** remains as the lateral mode after GA initiation.

The corresponding modes are: MAN TOGA, **SRS**, **HDG**.

The following picture shows the characteristics of a standard GA procedure.



The GA procedure is a very dynamic event and it may be necessary to select climb thrust quite early after initiation by moving the thrust levers into the CL detent. The LVR CLB indication flashes on the FMA, to alert the pilot of the impending action.

The Missed-Approach is displayed on the ND and the FPLAN page in **Blue** and changes to **Green** (active F-PLN) with GA initiation.

The PERF page changes from the APPR to the GA with the GA initiation, for both the PERF as well as the PROG pages. From the GA-PERF page, the pilot can directly activate the APPR page for a second approach, which is considered the normal procedure by the FMGS.

The target speed after a GA is the **GD**-speed instead of 250 knots. The **GD**-speed is also the target to start the aircraft configuration for a second approach.

If no second approach is flown, a pilot action is required to change from the GA to the CLB page. Three variations are available to the pilot, which are:

- Alternate or New Destination
- New FL in PROG page (NEW CRZ FL message in MCDU)
- Change of **GD** speed to **CLB** speed of 250 knots

Chapter 3

Content

3 The A320 Systems

Any modern Aircraft such as the Airbus A320 has a very complex systems architecture. Within this book it was not possible to explain all the A320 systems in detail. Therefore, only relevant aircraft systems are explained as far as necessary.

Like any other technical equipment, the A320 consist of a hardware (aircraft control surfaces) and a software part (fly-by-wire control). The hardware is part of this chapter while the fly-by-wire control is explained in chapter 1.

3.1 The Airbus Cockpit

When the first A320 was delivered in 1988, especially the new cockpit design caught the interest of the aviation industry. Six displays, at that time considered to be big, replaced the many single flight instruments. However, some of the analogue flight instruments had already been replaced some time before by instruments incorporating a small CRT display (Cathode Ray Tube). Airbus with the A310 was also the frontrunner of this development.

For the A320, Airbus further replaced the control yoke with a sidestick controller giving an unobstructed free view of the flight instruments. Before the A320, sidestick controller had only been used in military aircraft.

The Airbus cockpit philosophy was further enhanced with the introduction of the A330/340 family. All Airbus aircraft share a high degree of communality and it is indeed difficult to distinguish between the various aircrafts.

The following pictures show the nearly identical cockpit design of the A320 and the A330. Only a very experienced flight simulator pilot can see the small differences.

A320 Cockpit

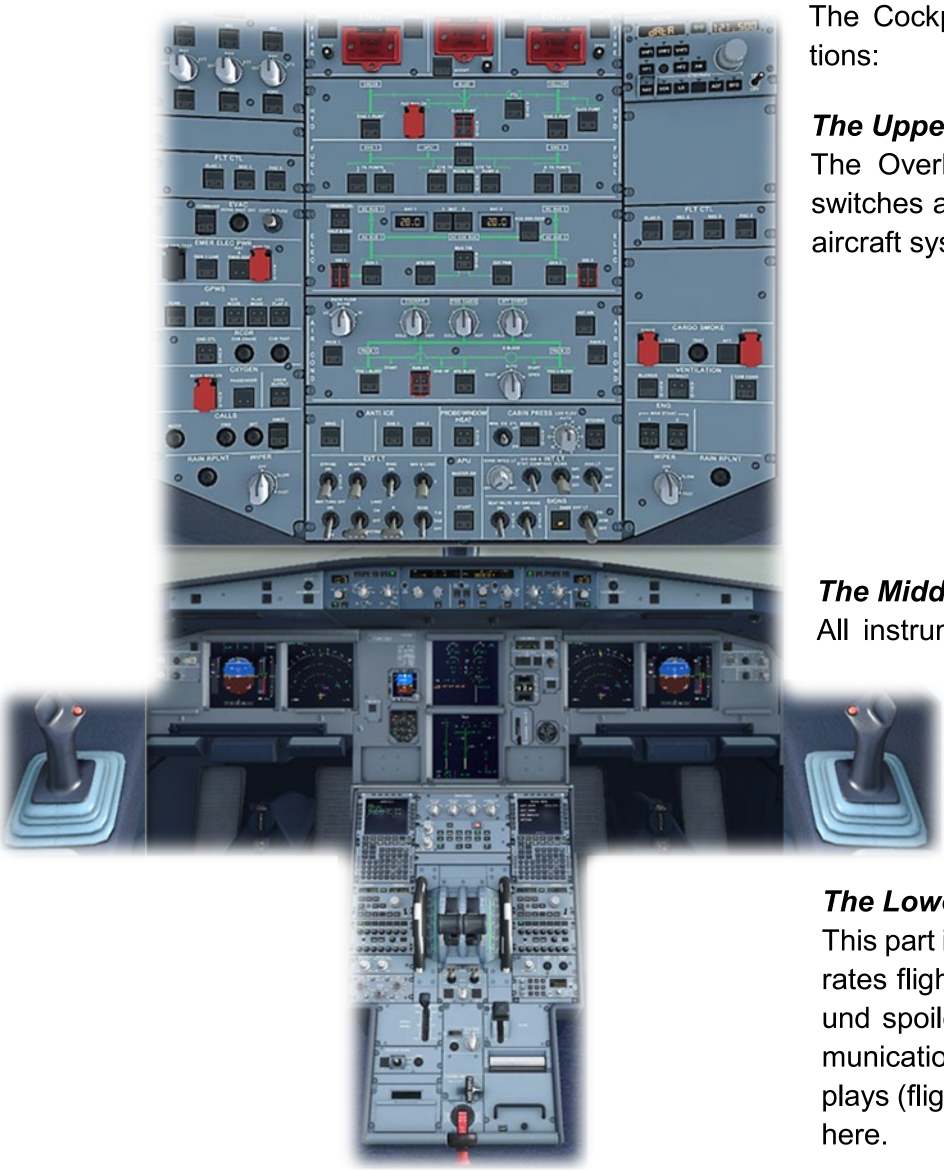
A330 Cockpit

There are actually only two distinct differences:

1. In the A320 cockpit, the control knobs for the brightness control of the flight instruments are placed next to the Primary Flight Display. While in the A330 cockpit they are at the far right/left of the cockpit frame.

2. The A330 has a 3rd MCDU-Display-Unit located on the pedestal between the spoiler and the flap levers.

3.1.1 The Airbus Cockpit Overview



The Cockpit can be divided into three sections:

The Upper Section
The Overhead Panel houses all important switches and displays required to control the aircraft systems.

The Middle Section
All instruments of the EIS and some flight controls are located in this part of the cockpit. This includes: the Sidesticks, the gear lever and the push-buttons for the automatic braking system.

The Lower Section
This part is also called pedestal and incorporates flight controls such as the thrust- flap- und spoiler-levers. All devices for the communication with ATC and the MCDU-displays (flight management) can also be found here.

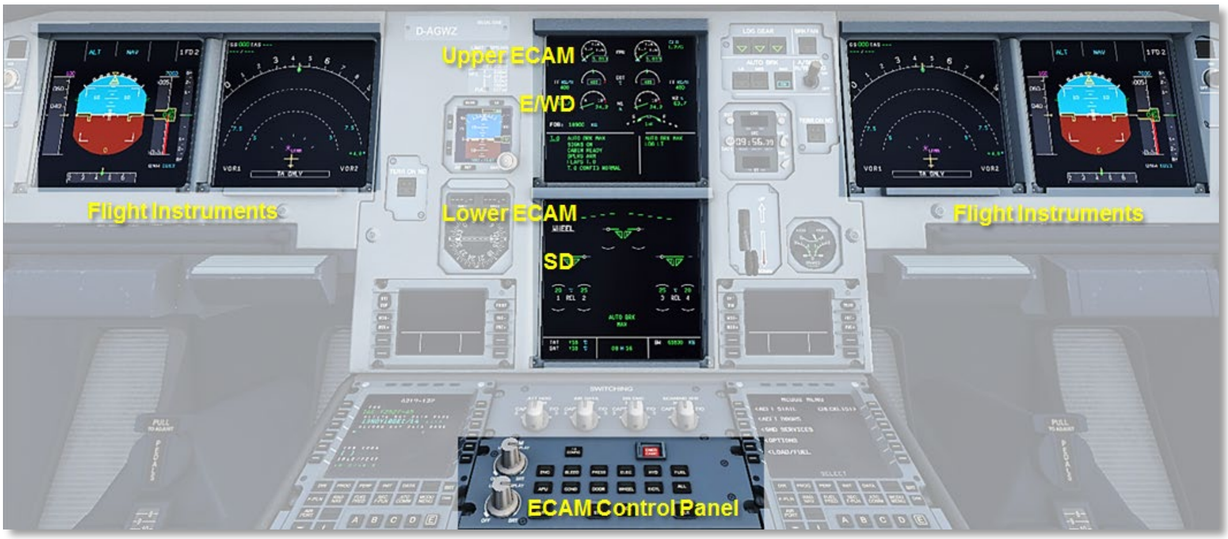
3.1.2 What is the EIS System

The EIS (Electronic Instrument System) provides the pilot with all information required to safely operate the aircraft and consists of the following instruments:

- The PFD (Primary Flight Display)
- The ND (Navigation Display).
- The ECAM System separated into the E/WD (Engine and Warning Display) in the upper and the SD (System Display) in the lower display.

The EIS combines six LCD (Liquid Cristal Display) displays, replacing the former analogue flight instruments. The large number of the analogue instruments was known under the nick-name watch shop.

The following picture shows the placement of the six LCD displays (or screens) as well as the Control Panel for the ECAM System.



The upper ECAM display includes important information such as the different engine parameters, fuel on board und flap positions. Everything is constantly updated throughout the flight.

The lower ECAM display shows aircraft systems information, e. g. fuel, electric, hydraulic and pressurization in a graphical representation.

During the flight, system information related to the actual flight phase are automatically shown on the display. That means, the ECAM system automatically displays system pages according to the actual flight phase, e. g. engine display for the take-off. However, the pilot can select specific pages and verify the system at his/her discretion at any time.

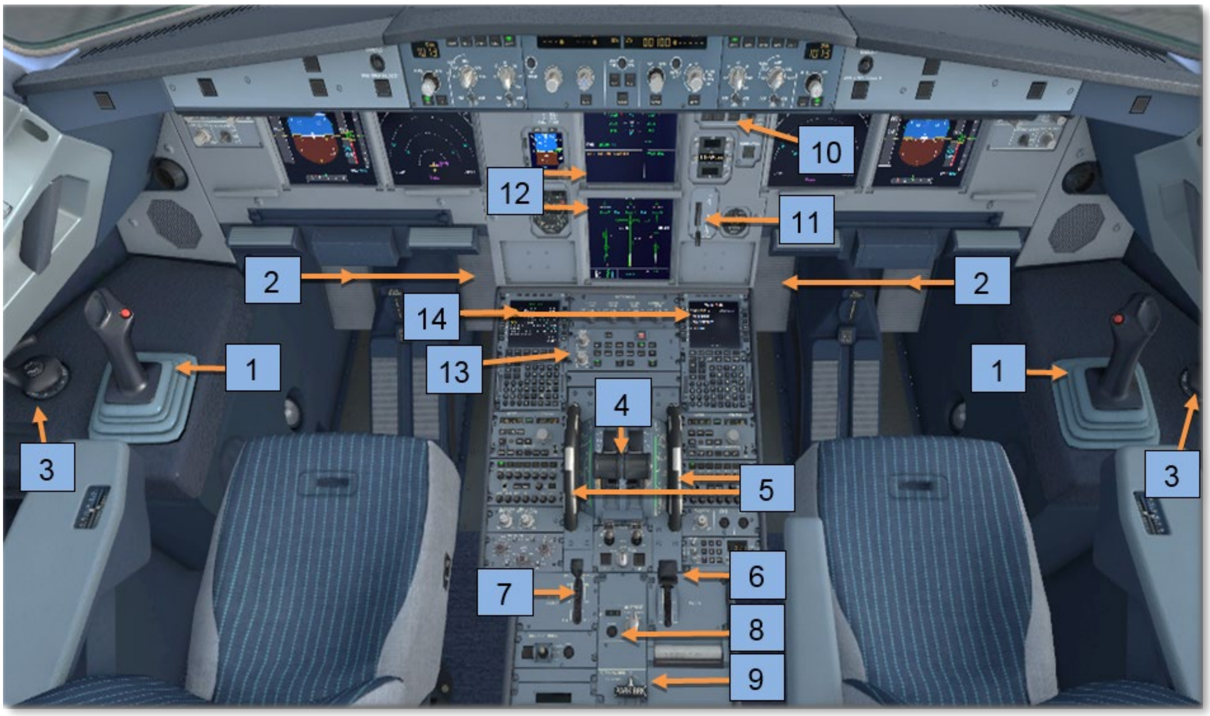
In order to select a specific system page, dedicated push-buttons can be found at the ECAM control panel, which is located between the MCDU-Displays.

In this chapter the A320 aircraft systems are divided into two sections:

1. Control devices for the fly-by-wire (FBW) flight control system.
2. Individual aircraft systems which are controlled via the overhead panel.

3.2 The FBW Flight Control System

The picture shows the locations of the individual FBW-controls within the A320 Cockpits. These controls will be explained separately and in detail within this chapter.



1. Sidestick used to control the elevator and aileron devices and indirectly the rudder though the automatic roll coordination
2. Pedals for the rudder control and the brakes
3. Handrail for the nose wheel steering control (NWS-Tiller)
4. Thrust-levers for the engine control
5. Trim-wheels for the mechanical control of the horizontal stabilizer (THS)
6. Flap-lever for the slats- and flaps control
7. Spoiler-lever for the control of the spoilers (air- speed-brakes)
8. Rudder-trim-console for the rudder-trim-setting
9. Parking brake
10. Console for the selection of the automatic braking system
11. Gear-lever
12. ECAM Displays
13. ECAM control-panel
14. MCDU (multi-functional control and display unit)

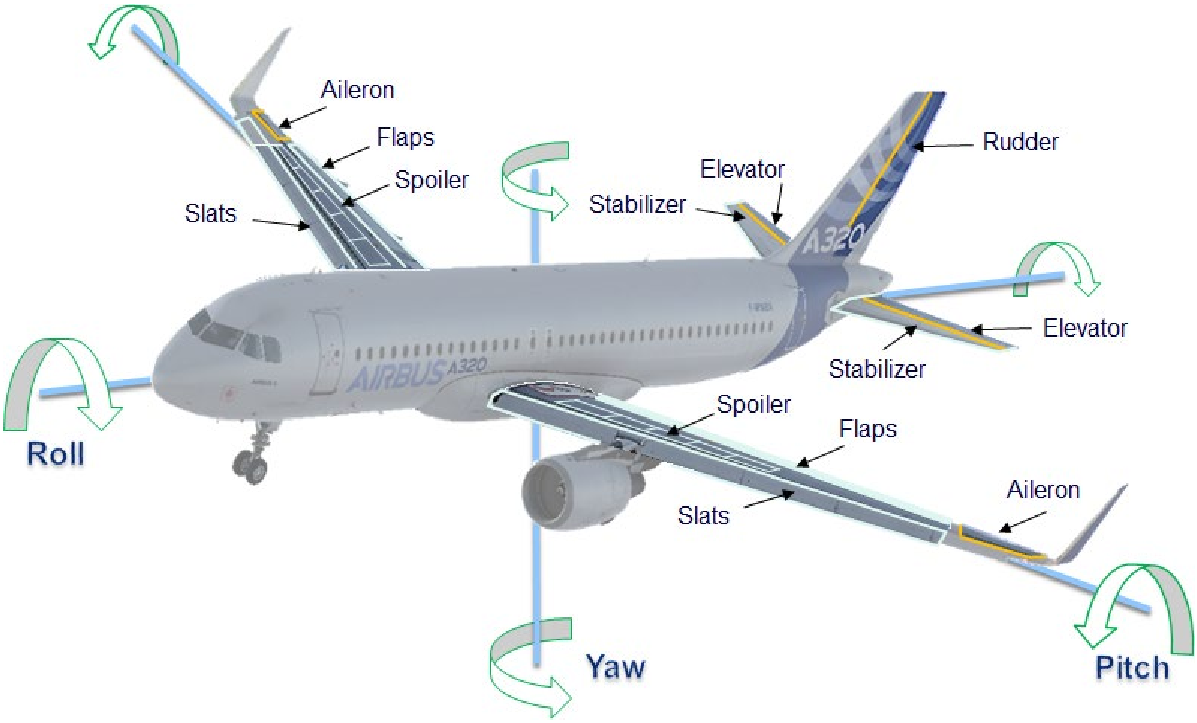
The Airbus uses, like a conventional aircraft, aerodynamic devices(control surfaces), to transform Pilot inputs into the required aircraft movement. These aerodynamic devices are classified into primary and secondary Flight-Controls.

3.2.1 The Primary Flight Controls

An aircraft can be controlled in space three-dimensional, meaning over three axes, which are:

• The Longitudinal Axis	=	Roll/Bank	Ailerons	Sidestick
• The Lateral Axis	=	Pitch	Elevators	Sidestick
• The Vertical Axis	=	Yaw	Rudder	Rudder-Pedals

The intersection of the three axis is the center of gravity (CG).



3.2.2 The Secondary Flight Controls

The secondary flight controls are supporting the primary devices to perform a flight maneuver, consisting of:

- The Slats
- The Flaps
- The Spoilers
- The trimmable Horizontal Stabilizer (THS)

What are the differences between the FBW- and the conventional flight-controls?

Conventional flight control	Fly-by-Wire control
▶ Mechanical link between pilot's input- device and the flight-control- surfaces, heavy weight penalty.	▶ No mechanical link between input and output device, substantial weight savings.
▶ The aircraft reacts to the pilot input in accordance with the aircraft dynamics, stick to rudder.	▶ Flight Control Computer provides modulated flight control commands to the control surfaces.
▶ No stall protection available, only stall warning by means of Stick-Shaker or Stick-Pusher respectively.	▶ Flight Control Computer improve aircraft stability and provide protection against stall, overspeed and unsafe attitudes.
▶ Mechanical Stabilizer-Trim only.	▶ Flight Control Computer incorporate automatic elevator trim.

3.2.3 The Principle of the FBW System

The Airbus Fly-by-Wire System (FBW) uses Sidestick controllers for pilot control inputs instead of the usual flight control wheel/yoke.

The pilot uses the Sidestick to give a control input and returns the stick back into the neutral position, once the requested aircraft attitude is achieved.

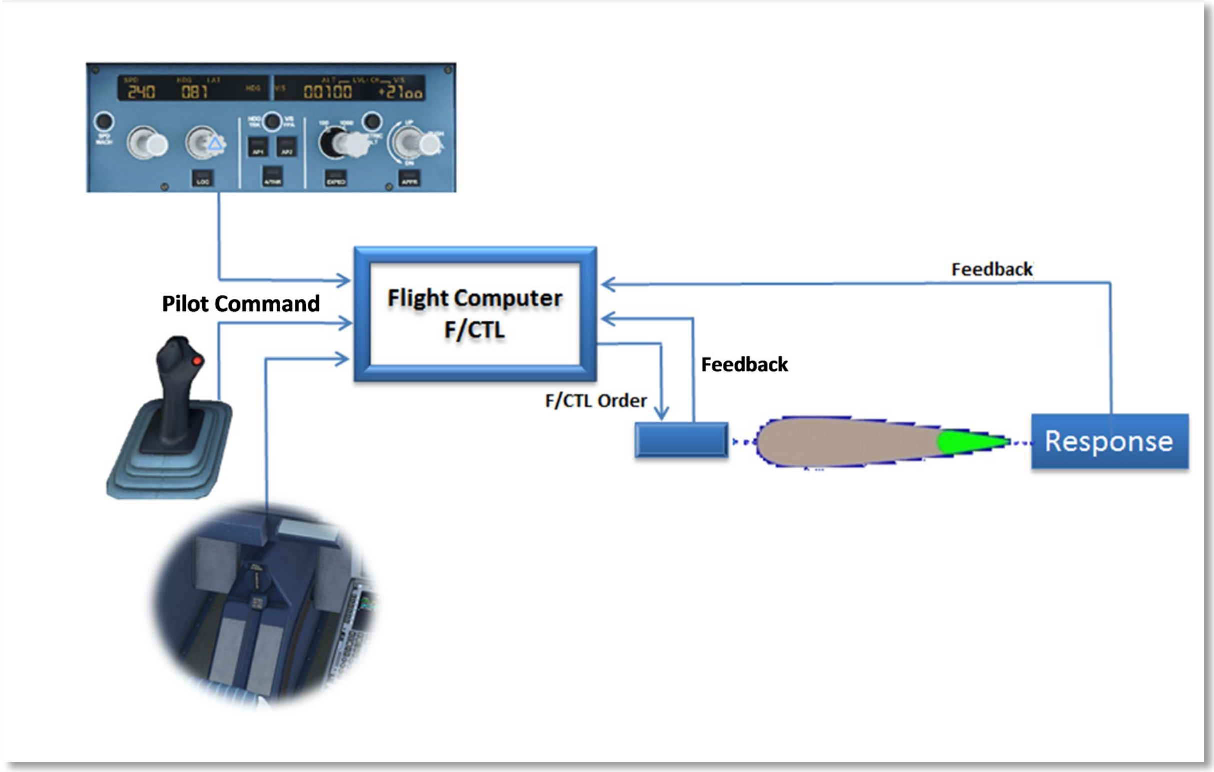
The Sidestick can be moved in four directions, with free movement. There is no cascade like for the gear-box in a car.

- Forward-push– Nose Down
- Backwards-pull – Nose Up
- Right– Bank (Roll) to the Right
- Left– Bank (Roll) to the Left

The Sidestick inputs (demands) are electrically transmitted to and processed by the Flight Control Computer (FCC). Afterwards the FCC sends the commands electrically to the actuators which are controlling the control surfaces. The aircraft than holds the demanded attitude, e. g. pitch/bank, until a new input is given by the pilot.

The actuators are hydraulically driven devices which transform the electrical signal into hydraulic pressure, which steer the surface. There is no mechanical link between the Sidestick and the actuators.

Contrary to conventional flight control systems, the FBW systems gives a feed-back to the FCC, which is processed further. The result is a stable and optimized aircraft path (attitude) throughout the entire flight maneuver.



It is important to understand that the pilot does not command a specific pitch or bank. He demands a specific flight path (climb-descend-horizontal-turn, or a combination of it).

The Airbus holds a load factor of 1g, that is the equivalent of the acceleration of a standing person through the earth rotation. In order to climb a higher load of >1g is demanded by pulling the stick. By pushing the stick to descent, a lower load of <1g is demanded. Once the new attitude has been established the load-factor returns to 1g, for a stable flight path. There is no need for trim by the pilot as it is done by the automatic elevator trim function.

To perform a turn a specific roll-rate is demanded, for example 5° per second. Depending on the actual speed, the bank-angle is different for the same turn-radius. At a higher speed, more bank will be needed compared to a low-speed maneuver. Roll coordination (coordination of aileron and rudder) and yaw-damping is automatic. In a manually flown turn, no rudder input is required like in a general aviation aircraft. As for the climb/descend the new attitude (roll-rate) is hold stable by the FCC until the pilot gives a new stick input (demand).

Under normal flight conditions the A320 will hold a stable attitude even under windy conditions.

Overview of the FBW-System

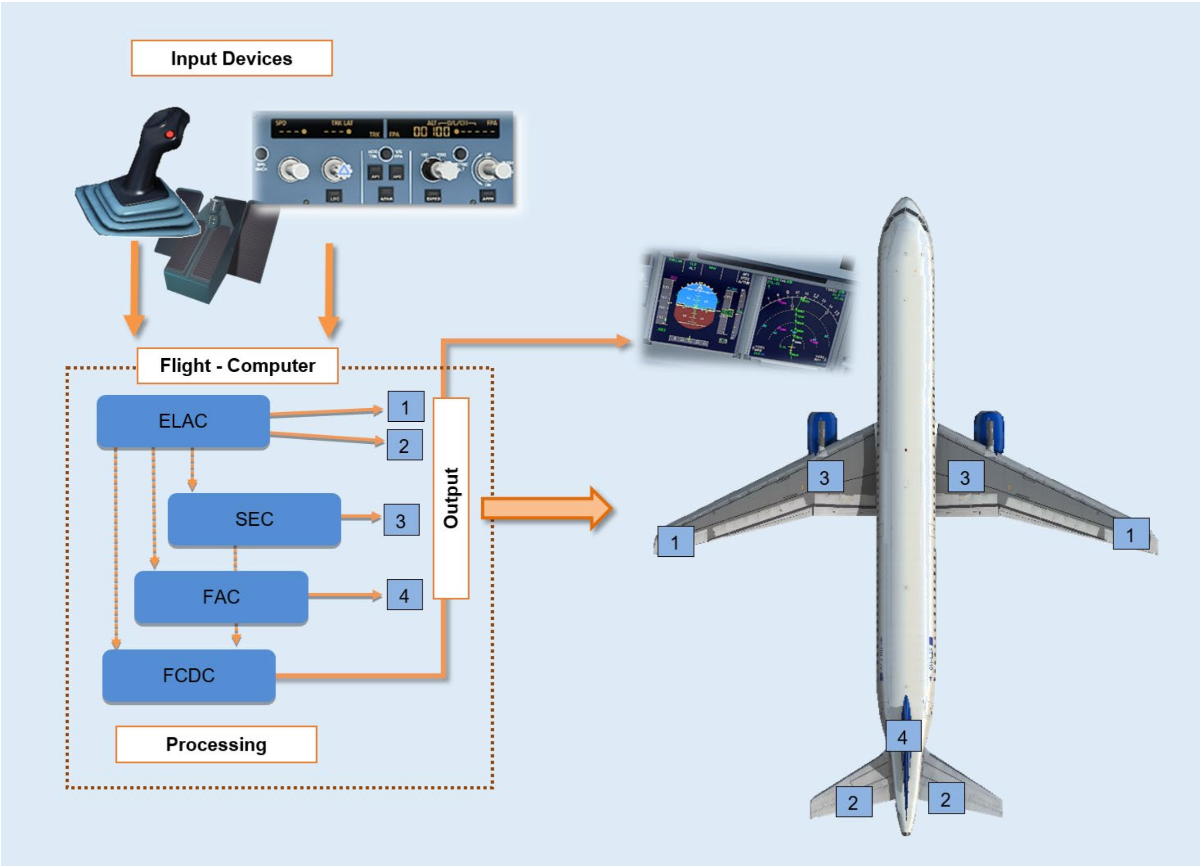
The FBW-system consists of the following computer equipment:

- 2 ELAC — Elevator und Aileron Computer
- 3 SEC — Spoiler und Elevator Computer

- 2 FAC Flight Augmentation Computer
- 2 FCDC Flight Control Data Concentrator

The computers of the FBW-system all have different hard- and software. This design ensures, that any problem resulting e. g. from software upgrade or hardware change can never affect the entire system.

The Flight Control Computer



As mentioned above, the A320 Flight Control Computer is made of several computer devices which are:

ELAC: The Elevator und Aileron Computer controls the elevators and ailerons (Pitch und Roll Control) and gives coordinating information to the FAC (Flight Augmentation Computer).

SEC: The Spoiler und Elevator Computer controls the Spoiler (Airbrakes) and acts as the back-up for the elevator control as well as the trimmable horizontal stabilizer.

FAC: The Flight Augmentation Computer is foremost responsible for the rudder control including the roll-coordination (Aileron/Rudder) and yaw damping. Additionally, the FAC is involved in the flight data acquisition and speed calculation.

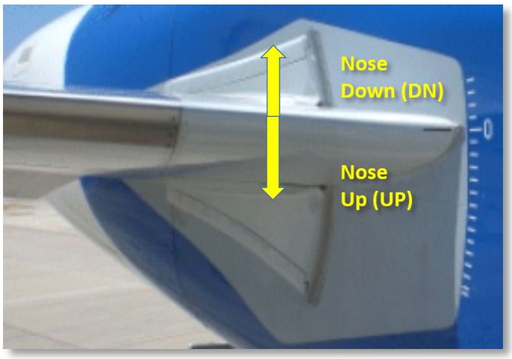
FCDC: The Flight Control Data Concentrators are required to transfer data to the flight instruments.

3.2.4 The Pitch Control

The Pitch Control (Nose Up/Down) is done via the ELAC Flight Computer. The ELAC calculates the rudder movement of the elevators and the THS (Trimmable Horizontal Stabilizer).

Two elevators and two horizontal stabilizers are forming the pitch control unit located at the far end of the Airbus as part of the aircraft's tail fin.

The elevator-trim is automatic and assists the pilot by reducing the workload. The elevator-trim is provided by moving the entire THS up or down according to the trim-commands by the ELAC Computers.



The maximum elevator deflection is limited to 30º nose-up and 17º nose-down. The maximum stabilizer deflection is 13.5º nose-up and 4º nose-down.

The THS moves up to generate a pitch-down (nose-down) and down for a pitch-up (nose-up) trim.

In the event of a double ELAC failure, elevator and stabilizer functions are provided by the SEC computer. At any time is the pilot able use the mechanical trim-wheels to operate the THS.

The mechanical trim has priority over the automatic trim function of the FBW system.

3.2.5 The Roll Control

The roll control is done by means of conventional ailerons. If a high roll-rate is required the ailerons are supported by spoiler deflection. In normal operations the ELAC controls the ailerons and the SEC the spoilers.

There is no back-up for the aileron control if all ELAC computers fail. In this case, roll control is provided by the spoilers in coordination with the rudder.

The maximum deflection of the ailerons is 25º. The maximum deflection of the spoilers is limited to 35º. When the flaps are extended, the ailerons are moved 5º down to improve the lift. This function is known as Aileron Drop.

The bank is limited as follows:

- Maximum bank right/left 67°
- Normal operations right/left 33º
  AP (Autopilot) normal operations 25º
  AP maximum bank if required, e. g. localizer capture 33º

The stabilizing function is available up to 33º (automatic trim and roll control) and will temporarily be switched-off, if the pilot commands a bank exceeding 33º. The Airbus is than controlled like a conventional aircraft requiring manual pitch and bank inputs to fly the maneuver.

Setting the Sidestick into the neutral position will bring the Airbus automatically back to 33º. Automatic trim and roll control will then be available again.

3.2.6 The Yaw Control

The rudder is controlled by means of the rudder pedals like in a conventional aircraft. Besides the FBW control a mechanical link is provided as a back-up function.

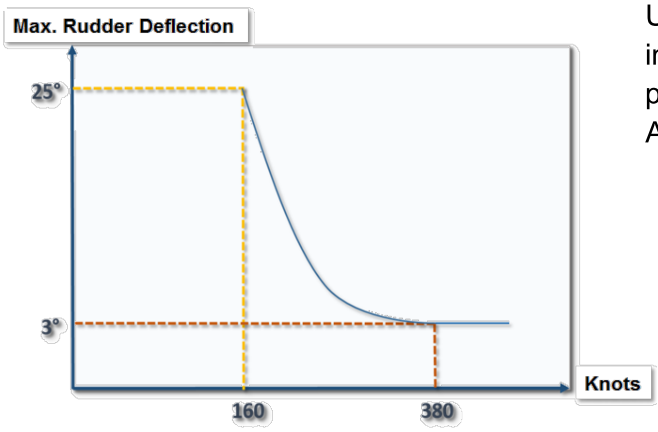
The roll coordination, also known as auto-coordination, is provided by the FAC with information given by the ELAC. At any time can the pilot overrule the FBW control by using the rudder pedals which have priority.

In normal operations roll-coordination and yaw-damping is done automatically.

The deflection of the rudder is limited in accordance with the actual speed. The reason for the limitation is to avoid large rudder deflections which can result in an instable flight situation. Large rudder deflection can further damage the rudder and aircraft's tail fin respectively.

The left picture shows the rudder deflection on ground and during the take-off run. The rudder is fully deflected. In the right picture the FBW limits the rudder deflection in flight according to the actual speed. In normal operation the rudder is not used to control the aircraft, due to the roll-coordination of aileron und rudder. However, for cross-wind (X-wind) landing and in case of an engine failure rudder control is required, to compensate for the wind drift or the yaw effect by the live engine.

If no rudder action is taken by the pilot, the Airbus will roll towards the dead engine. The FBW control will then stop the roll by applying aileron and spoiler. The roll will stabilize before reaching 10º bank, equal to a heading drift of approximately 0,5º/second.



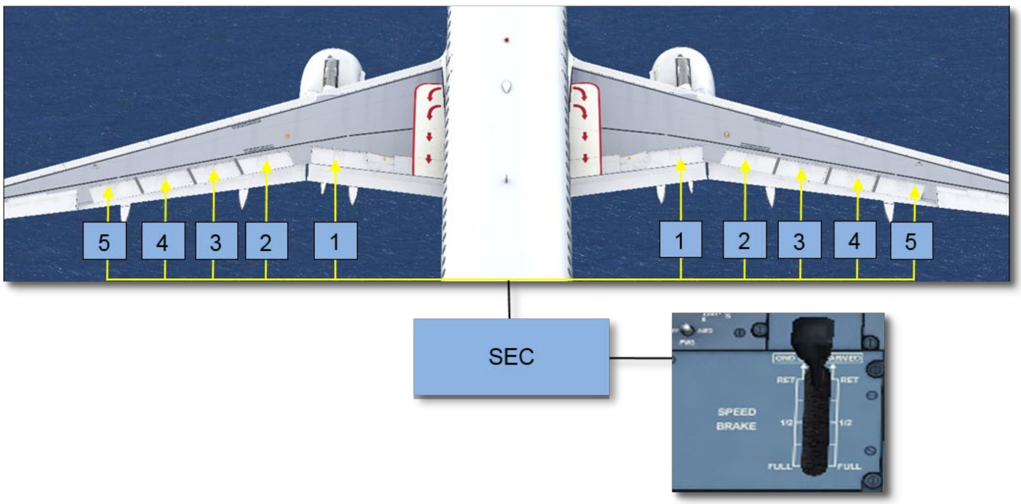
Until 160 knots the rudder deflection is maximum 25º. Until 380 knots, the deflection is progressively reduced to 1.4º for the A318/A319/A320 and 2.9º for the A321.

The rudder trim function is normally not used for the wind drift due to the roll stabilization of the Airbus. In case of an engine failure however, the trim function is required to stabilize the aircraft. Otherwise, the pilot would be required to permanently make rudder inputs to keep the aircraft on track.

The rudder trim console is located between the spoiler and flap lever. Under normal conditions the trim display shows 0.00. In an engine out event, the setting can go up to 13L/R (left or right). Once stabilized and with cruise power the trim setting is approximately 5L/R.

3.2.7 The Spoiler Control

The spoilers are located on top of each wing, they are also called airbrakes or speed brakes. The A320 arrangement consists of five spoilers on each wing.



The Airbus spoiler control is very complex covering the following functions:

- Roll control in coordination with the ailerons (spoiler 2 – 5).
- Airbrake (speed brake) function for speed reduction in flight (spoiler 2 – 4).
- Ground spoiler function for reducing the lift and increasing the aircraft's brake efficiency(spoiler 1 – 5).

- Sink-rate and speed control for steep approaches (spoiler 3 and 4), A318 only.

The Roll-Spoiler Function

During the flight the spoilers are used to reduce the aircraft's speed as well as to support the roll capabilities. Spoiler support for the ailerons is necessary when a certain roll rate is demanded.

The picture shows the setting for a left turn with a high roll-rate demand.

Left wing: the left aileron is deflected upwards with the left roll-spoilers up.

Right wing: the right aileron is deflected downwards. The roll-spoilers are not up.

The Speed Brake Function

By using the spoiler lever, the pilot controls the deflection of the spoilers. Thus, increasing the aircraft's resistance and reducing the actual speed in flight. Deflecting the spoilers will further increase the aircraft's sink rate. The speed brake function is effective until 200 knots with a decreasing effectiveness afterwards.

The spoilers are generally limited in its range in flight even though the lever is set to full, to avoid stalling the wing. The speed bakes are always deflected simultaneously. In case spoilers fail on one wing, then the spoilers on the other wing are limited accordingly to avoid asymmetrical operation.

For example: If spoiler number 2 on the left wing fails, then spoiler number 2 on the right wing will not be deployed to avoid asymmetry..

The following picture shows the extended spoilers as speed brakes in flight.

With the AP ON, the spoilers of the A320 only extend up to 50%, even though the lever is set to full. The trainee pilot can show his/her proficiency to the instructor, by setting the lever into the half position.

Whenever the pilot needs the full spoiler deflection e. g. to increase the decent rate, the AP must be disconnected and the aircraft hand flown. Only then will the spoilers deflect to the maximum position. This procedure is for the A320 only.

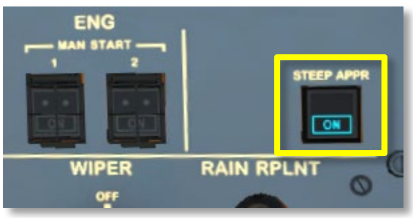
The range and conditions of the spoiler deflection differ within the aircraft types of the A320 family, as detailed in the following table:

Spoiler	A318 - A319	A320	A321
2	12,5° - Flaps 3 17,5° -Flaps Full	20° - manual flight 12,5° - with Autopilot	
3 und 4	25°	40° - manual flight 25° - with Autopilot	
2, 3 und 4			25°

Steep Approach Function

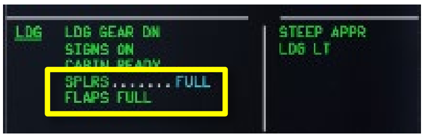
Because the A318 is certified for steep approaches a specific Steep-Approach function is available to the pilot and allows Flight Path Angles (FPA) of 4.5º to 5.5º. The function is not fitted on A319, A320 and A321.

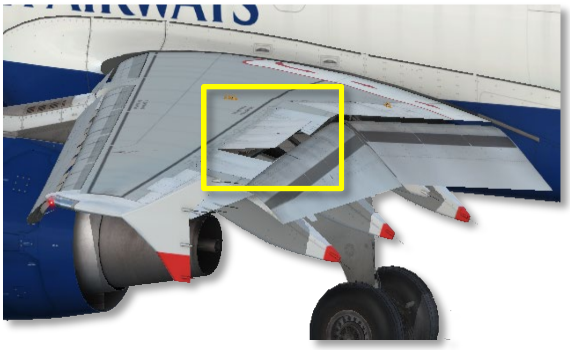
The function is activated by a specific push-button on the lower overhead panel just above the F/O wiper panel with the rain repellent push-button.



Once the pilot has activated the function, spoiler 3 and 4 are extended to 30º. Pre-requisite is that the gear is down and the flaps are set into configuration Full.

The Function is available down to 80 feet, when the spoilers will automatically retract to 8°. On the ECAM, the active function is confirmed when passing 800 feet **Green** (Active), **Orange** (Caution) or **Red** (Warning) not available. In the latter cases the ECAM indicates INOP (inoperative).

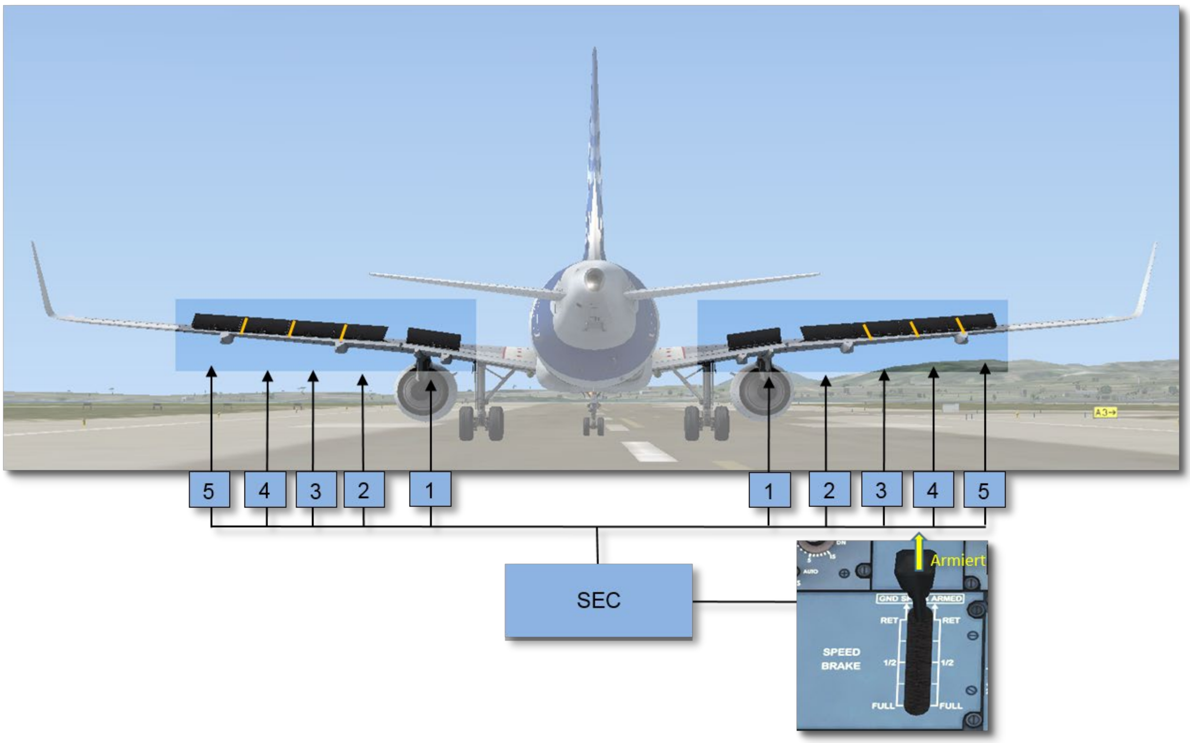




Setting the SPL-lever to Full, arms the GRD-SPL and they deploy normally after touch-down.

The Ground-Spoiler Function

After touch-down the spoilers are extending till 60° to cut the lift of the wings. Besides braking support, the spoiler deflection assists the pilot to avoid a bouncing of the aircraft after touch down. Especially a touch down with a pitch greater than 8° may lead to a bounce.



The spoiler activation after landing happens in different ways.

1. Pulling the spoiler lever during approach will arm the spoilers. After touching down, the spoiler will automatically and immediately deploy to the maximum ground position. In order to trigger the spoiler deflection both bogeys of the main gear must be compressed or the tire speed is above 72 knots or the radio altitude is < 6 feet. In case of a bounced landing, the spoiler will be kept in the extended position as long as the thrust levers remain at idle (< 4° or < 15°) and the aircraft below 10 feet.

2. During an AutoLand, the spoilers extend at half-speed about 1 second after touch down of both main gear bogies (A320 only, not A318-319-321).
3. If the spoilers are not armed for landing, they will deploy with the selection of the reverse thrust. They will retract when the thrust levers are set back to idle. It is sufficient when one thrust lever is in the reverse position, e. g. in case of one engine out (EO). However, it is good practice to also reverse both thrust levers in an EO landing to make sure that the live engine is set into reverse.
4. If the spoilers are not armed and the thrust levers remain in idle after touch down, the spoilers will not deploy. This procedure is applied for touch and go procedure training.
5. In case of a rejected landing the spoilers will be retracted when the thrust levers are set above 20º.
6. The spoiler roll function is inhibited when the spoilers are extended in ground mode.

Requirements for spoiler deployment after landing:

- Tire speed is > 72 knots or
- Both main bogies are compressed or
- Radio altitude is less than 6 feet and
- Spoilers are armed with both thrust levers in the idle position or
- Reverse thrust is set at least on one engine.

The spoilers will partially be extended to 10º when:

- Only one main gear bogie is compressed and
- Reverse thrust is set at least on one engine.

This procedure will limit the lift of the wings and help the other main gear to smoothly touch down. When both main gears are firm on the runway (compressed), the spoilers will fully extend..

The spoilers retract under the following conditions:

- After landing, when the pilot disarms the spoilers.
- The retract automatically when at least one thrust lever is set above 20º (e. g. rejected landing, bounced landing),
- With A318, A319 und A320, when the flaps are set to the full position,
- With A321 when the flaps are set to the configuration 3.

For a RTO – Rejected Take-off the following applies:

- Spoiler 1-5 deploy immediately if they are armed, the air speed is > 72 knots and both thrust levers are set to ide, or
- Spoilers are not armed but deploy when the air speed is > 72 knots and reverse thrust has been set at least one engine. This may be the case in an RTO-EO.

Normally the SEC computer commands the deployment and retraction of the spoilers. In case of an SEC failure, the spoiler function is not available. That means the roll function is limited but the aircraft's control is not compromised.

However, in case of a rejected take-off (RTO), the limited ground spoiler function results in an extended stopping distance.

ECAM - Messages

The pilot receives an attention getter through the ECAM systems display (SD), when the spoilers are extended and at least one thrust lever is not in the idle position. The Message – **SPEED BRAKE** – flashes in **Yellow**.

The ECAM further informs the pilot when the spoilers are automatically retracted by the flight control system, e. g. during approach with the spoiler lever still in the out position. The message – **Spoiler still out** – also flashes in **Yellow**.

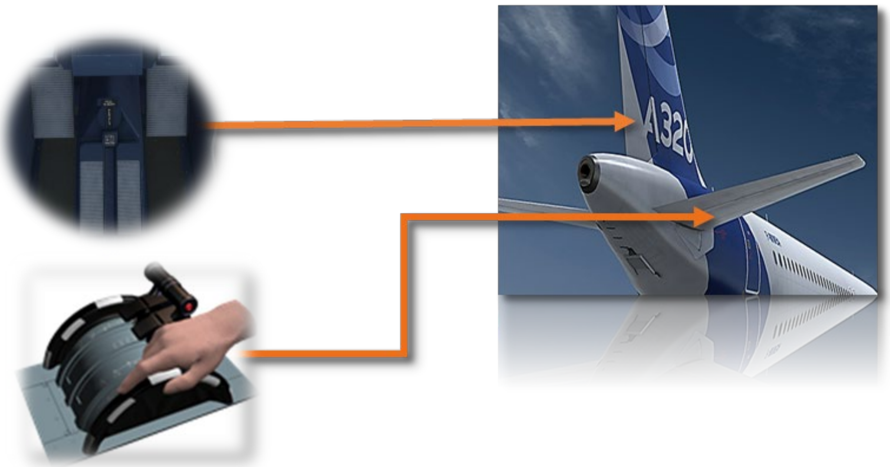
The spoiler symbols are shown in **Green** on the ECAM Flight Control Page when the spoilers are extended, either in flight or after landing. After touch-down, the PNF/PM calls out - **Spoilers Green** - to confirm the extension of the ground spoilers.

3.2.8 The Backup System

So far, there is no confirmed case of complete loss of the A320 FBW-control system. However, as a precautionary measure, the A320 comes with a mechanical back-up system. The system consists of the following components:

- A mechanical link between the rudder pedals and the rudder actuators.
- A mechanical link between the trim wheels (next to the thrust levers) and the actuators of the horizontal stabilizer (THS).

At least one hydraulic system (**Green**, **Blue** or **Yellow**) is required for the back-up to operate.



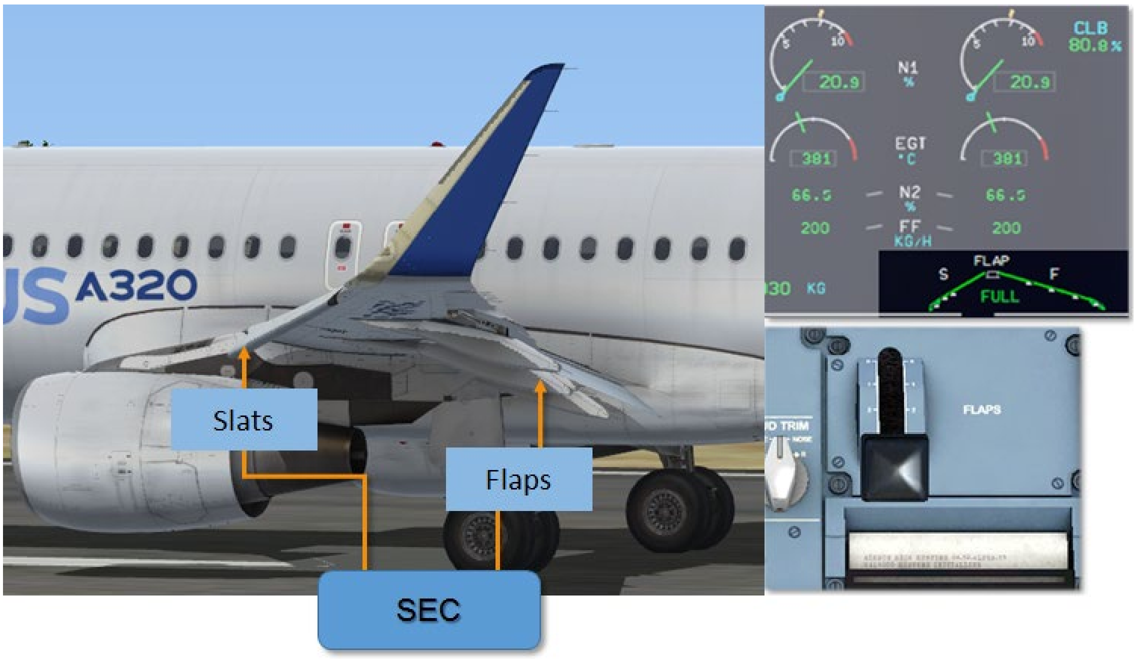
The back-up system is designed to bridge the gap before the RAT (Ram Air Turbine) is deployed providing electrical and hydraulic basic functions. The FBW system is then switched to Direct Law.

3.2.9 The Slat/Flap-System

The A320 flap system actually consist of the slats or leading edges (in front of the wing) and the flaps or trailing edges (in the rear of the wings). Generally, the term flap system or flaps means both slats and flaps together in order to simplify the definition. If only the slats are concerned, then off-course the term Slats is used.

The slats/flaps are operated with one common lever, the flap lever. It is positioned behind the thrust levers opposite the spoiler lever, with the rudder trim-panel between them.

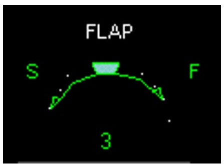
The monitoring of the flap extension/retraction is provided by the EW/D (Engine Warning Display) display, the upper display of the ECAM system. The EW/D display also contains the important engine gauges for thrust setting and control.



During the flap extension/retraction the flap indication in the ECAM E/WD changes colours to inform the pilot about the status of the slats/flaps.

Slats/flaps are moving.

Selected position is shown by **Blue markers** and the **Blue number 3**. The FLAP header is **Blue**.



Slats/flaps are in the selected position.

All indications are in **Green**. FLAP header is White.

The A320 Flap system does include two Airbus specialities:

Due to aerodynamic reasons, the flaps are deployed differently for take-off and approach with the flap lever in position 1. The A320 knows exactly if it is on ground or in the air (</> 100 knots) and commands the flap deployment accordingly. For the take-off, more lift is required and the slats and flaps are both moved into position 1. In the first stage of the approach less additional lift is required. The Airbus flies at about 200-220 knots and only the slats are deployed.

The other Airbus speciality concerns only the take-off phase: In case of a heavy weight take-off (around 70 tonnes and more), the max. flap 1 speed is 215 knots which, for this case, is above the $V_{FE\ NEXT}$ for the next flap position. If the pilot moves the flap lever to 0, both slats and flaps would retract and the aircraft could enter a critical speed range.

The A320 solves the problem by means of a simple solution. When the Airbus reaches 210 knots the flaps are automatically retracted. The slats remain extended and the flap lever in position 1 (Automatic-Flap-Retraction). After reaching the speed for slat retraction, the pilot moves the flap lever to 0 and the slats will be retracted (see also under chapter 1).

The Flap/Slat-Speeds

The table shows the flap lever position and the associated maximum flap speeds:

Flap-Lever Position	**A318 - A319 Max-Speed**	**A320 Max-Speed**	**A321 Max-Speed**	**ECAM Display**
1 *(TO)*	230/215	230/215	230/215	1+F
1 *(APP)*	230	230	230	1
2	200	200	200	2
3	185	185	195	3
Full	177	177	190	Full

The Flap/Slat-Configurations

The flap lever has 5 positions which command both the slat and flap deployment and retraction respectively. Each slat/position implies a defined extension (º) of the slat and flap surfaces.

Flap-Lever Position	**A318 - A319**		**A320**		**A321**		**ECAM Display**
	Slats	**Flaps**	**Slats**	**Flaps**	**Slats**	**Flaps**	
0	0º	0°	0°	0°	0°	0°	0
1 *(TO)*	18º	10°	18°	10°	18°	10°	1+F
1 *(APP)*	18º	0°	18°	0°	18°	0°	1
2	22°	15°	22°	15°	22°	14°	2
3	22°	20°	22°	20°	22°	21°	3
Full	27°	40°	27°	35°	27°	25°	Full

The slats/flaps are deployed according to the various flight phases as shown in the next table.

Flap-Lever Position	Flight Phase
0	CRUISE / HOLD
1	APPROACH
1+F	TAKEOFF
2	TAKEOFF / APPROACH
3	TAKEOFF / APPROACH / LANDING
Full	LANDING

3.2.10 The Gear and Brake System

The Gear-System

The Airbus contains a traditional main gear arrangement with two wheels on each of the main gear strut and another two wheels on the nose gear. The nose gear retracts forward and the main gears sideward to the centre of the fuselage.

Like for the flap system, specific operation speeds need to be observed for the gear extension and the retraction:

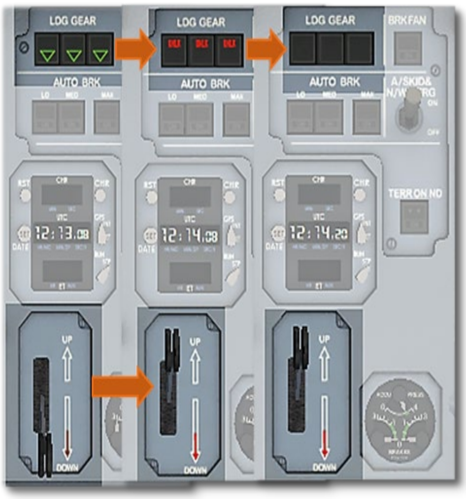
- The maximum speed for the gear extended is 280 knots. A master warning will warn the pilot in case of overspeed.
- The maximum speed to extend the gear is 250 knots. For speeds >250 knots, a master warning will warn the pilot and the gear will not extend.
- The maximum speed for gear retraction after take-off is 220 knots. If the pilot pulls the gear lever up after passing 220 knots, the master warning will warn the pilot and the gear will not retract. The pilot than has to reduce the speed below 220 knots to retract the gear.
- The maximum altitude for a flight with the gear extended is 25.000 feet.

The picture on the left shows the nose and main gear during the re-traction phase.

The gear bay doors are still in the open position.

After the gear is retracted, the bay doors are fully closed limiting the aerodynamic resistance.

The gear is operated by means of a gear lever which is located in the centre of the cockpit panel, together with the associated gear indication lights.



The gear lever has two positions:

- Gear Up (UP) and
- Gear Down (DN).

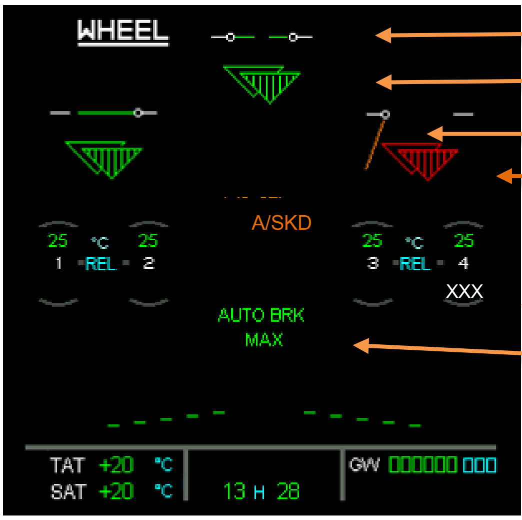
The A320 has no middle position for hydraulic relief like the Boeing B737 series.

Three gear indication lights represent the two main gears (left and right indication) and the nose wheel (indication light in the centre).

The **green** triangle is shown, when the gear is down and locked. After gear extension a **Red UNLK** indicates that the associated gear is not properly locked.

The **UNLK** indications are further used to inform the pilot that the gear is in transit, as it is shown in the picture above. The indication lights are off, when the gear is retracted and properly stowed.

The retraction and extension of the gear is further shown on the ECAM wheels page.



Gear doors closed

Gear extended

Gear doors open

Gear in transit

Brake temperature

Tire pressure (PSI) – option

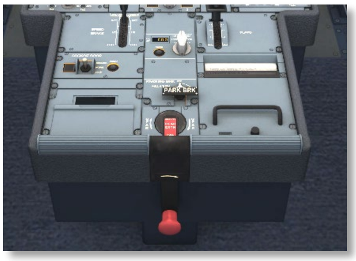
Message area:

- *Autobrake ON – confirmation*
- *A/SD not available – failure message*

When the gear is properly retracted and stored, no gear symbols (triangles) are shown benaeth the gear door indications. Two gear symbols (triangles) for each gear represent two gear sensors and computers (LGCIU 1 and 2) providing a graphical status information for each gear.

To confirm that the gear is down and locked, one green symbol is enough. If the second symbol is red, it is considered a sensor failure and not a gear malfunction.

For take-off, the wheel page is displayed until take-off power is set. During the approach phase, the wheel page will come up automatically on the ECAM with the gear extension.



The lever for the emergency gear extension is located at the end of the pedestal (centre console). To extend the gear, the lever must be lifted and rotated 1 ½ cycles to the right.

The Brake-System

The A320 brake systems consist of state-of-the-art carbon brakes with an anti-skid and automatic braking (AutoBrake) systems. The anti-skid system (A/SKID) is similar to the known ABS system in cars. The A/SKID system is deactivated below 20 knots.

In order to limit the engines wear and tear and to reduce the noise level, the maximum available reverse thrust is usually only used for short runways or critical low visibility approaches. In normal operations only the wheel brakes, supported by the ground spoilers, are used to decelerate the aircraft. The wheel brakes are controlled via conventional rudder pedals.

The carbon brakes are very robust with a life span averaging 1.200 Cycles (landings). Nevertheless, like for the tires the life span of the brakes very much depends on the landing condition and the pilot handling.

With 1.200 Cycles and 4-5 landings per day, the brakes must be replaced every 8-10 months.

The Auto-Brake Function

Like any other modern airliner, the A320 features an automatic braking system, called AutoBrake. The pilot can choose between three stages of braking intensity, which are selected via three pushbuttons mounted in the centre console above the gear lever.

LO – The low brake intensity is used for long and dry runways. The brake activation occurs 2 seconds after ground spoiler deployment with a deceleration rate of 1.7 meter/second.

MED – The medium intensity is mostly used including wet runways. The deceleration starts when spoiler deployment conditions are met. The deceleration rate is 3 meter/second.

MAX – The maximum intensity is only used for rejected take-offs. The deceleration starts with maximum braking power immediately when the thrust levers are set to idle.

The **Blue ON** light in the respective pushbutton indicates that the Auto-Brake is armed with the selected intensity.

The **Green DECEL** light replaces the **ON** light, when 80% of the deceleration rate is reached.

The maximum intensity (MAX) cannot be selected in flight. However, MAX can be selected after touch-down to apply maximum braking power. But this is not an approved procedure.

There are two ways to de-select the AutoBrake. Normally, the pilot pushes the brake pedals and continue with manual braking. The other way is to press the illuminated pushbutton and switch-off the Autobrake. The AutoBrake should be disconnected prior to 20 knots to avoid brake jerking.

Landing on wet runways can cause the Anti-Skid function to keep the deceleration rate below the selected intensity. In this case the **DECEL** light will not come on which can be misleading. Even so the light is not ON, the Autobrake is functioning but with a reduced deceleration rate. Under certain conditions (wet runway, landing weight), the **DECEL** light may flicker.

The design of the A320 baking system is redundant:

- The normal braking function is provided by the **Green** hydraulic system.
- The alternative braking function uses the same carbon brakes of the main gear. It will be activated in case of a **Green** hydraulic system failure and is powered by the **Yellow** hydraulic system. Apart from the AutoBrake, the functionality of the alternate braking system is the same as the normal system. In case the A/SKID System is not available, the alternative system uses a limited braking intensity to avoid damaging the tires.

The brake accumulator (ACCU) provides brake pressure in case the engines are not running or neither the **Green** nor the **Yellow** hydraulic pressure is available. The ACCU serves the alternate braking system as well as the parking brake. The ACCU load is good for 5-7 attempts, depending on the braking intensity.

The Brake Temperature

The optimum temperature range of modern carbon brakes is between 150° and 250°. However, carbon brakes are very resistant against high temperatures, up to 500° and more.

Special attention should be given for the taxi operations. Riding the brakes during taxi will operate the brakes exactly at the critical temperature.

For the take-off, the brake temperature should be around 150° up to maximum of 300°. After taking-off with a brake temperature just lower than 300° but higher than 240°, the ECAM will advise the pilot to delay retraction of the gear for further cooling by the airstream. The ECAM message, **LG…DN FOR COOL** (Landing Gear Down for Cooling) disappears when the brake temperatures are lower than 300°.

Above 300° a take-off is not permitted, as full braking force in case of a RTO (rejected take-off) may not be available. The brakes can either be cooled by means of the brake fan if installed (option). Otherwise, without the brake fan, the take-off must be delayed until the brake temperature is below 300°, which can take a while.

A take-off with hot brakes holds another pitfall often not considered: In the event of an engine out after take-off the gear must be retracted to increase the climb performance. It is not a good idea to retract hot brakes, because the A320 has no fire warning for the gear bay.

The Parking Brake

The parking brake is operated by a rotary switch located at the end of the pedestal (centre console). The pilot has to lift and turn the handle to set or release the parking brake.

The indication instrument for brake pressure and the parking brake can be found on the centre panel next to the gear lever

Before the engine can be started, the pilot must check that the ACCU PRESS arrow points towards the **green** point on the instrument. Then, there will be enough brake pressure available, even without running engines.

If the parking brake is released (OFF), both brake arrows point to 0 (no pressure), see left picture above.

If the parking brake is set (ON), both brake arrows point to 3, meaning 3.000 psi, see picture below.

In case the alternate braking system is active, both arrows also point to 3 when the pilot performs braking actions. This confirms, that the parking brake is part of the alternate braking system.

3.2.11 The A320 Tires

The tires of the A320 are tubeless with only a little tread pattern, very different from car tires. For the tires it is only important to avoid aquaplaning. Directional control of the aircraft is done aerodynamically by the rudder.

The tires are filled with nitrogen instead of oxygen because it is less flammable. Remember, the carbon brakes can reach more than 300°C in normal operation.

Aircraft tires are remoulded and used several times before new tires are mounted to the aircraft. The check of the tire conditions is part of the exterior inspection by the pilot.

The maximum allowed tire speed for the A320 is 200 knots.

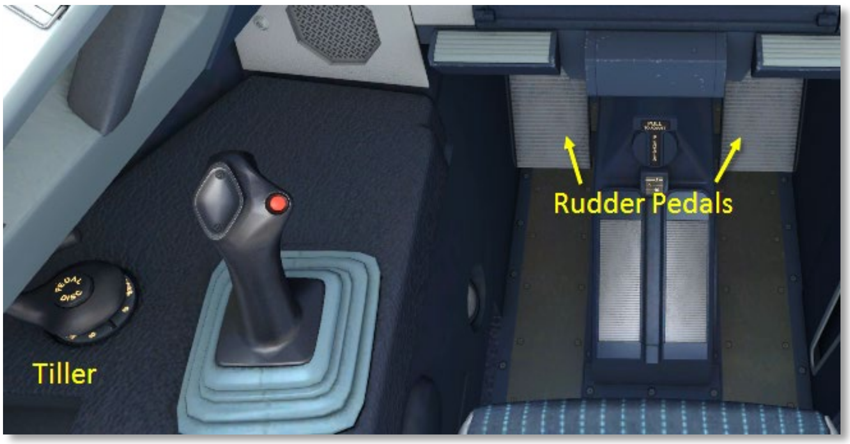
Like for the brakes, the tires do have a defined lifespan, which depends on the landing performance (runway conditions, aircraft weight, soft vs. hard landings and tire pressure). In average, the lifespan of a tire is 150 landings.

That means, with 4-5 landings per day, the tires must be replaced approximately every 6-8 weeks.

3.2.12 The Nose Wheel Steering (NWS)

Tin tight turns, the nose wheel movement of the A320 is controlled by a hand wheel called tiller, as in a conventional aircraft. However, the tiller of the A320 is part of the Fly-by-Wire flight control system and there is no mechanical connection. The connection is pure electrical and reacts sensitively to large inputs by the pilot.

Therefore, the pilot needs to exercise care when steering the aircraft by means of the tiller. The tiller can move the nose wheel up to 75º in both directions, compared to 7º of the rudder pedals.



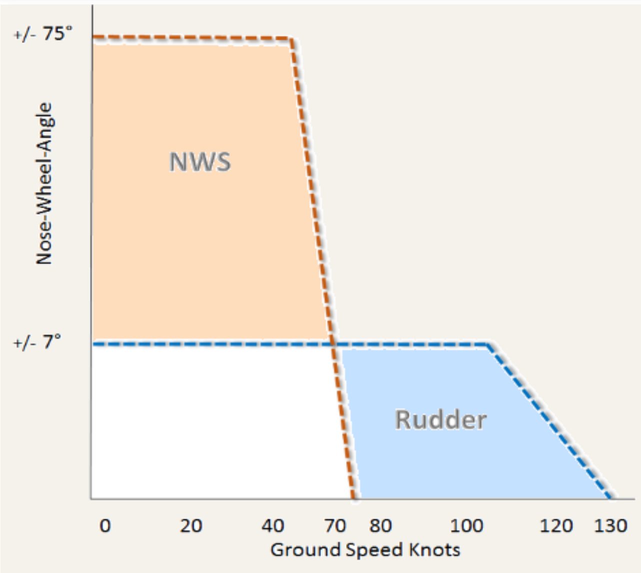
When exceeding a taxi speed of 20 knots, the nose wheel control range decreases linearly until 70 knots.

Simultaneously, the effect of the rudder increases and takes over the directional control.

Therefore, it is an accepted procedure using the rudder pedals when taxiing above 20 knots instead of the tiller. Notwithstanding, only the rudder should be used for directional control on the runway. The tiller remains the means to align the aircraft with the runway centre line.

The nose wheel control via the rudder pedals is designed similarly. From 40 until 130 knots ground speed, the control range decreases from 7º to 0º.

In the left picture, the A320 is entering runway 28 at Zurich, with a fully deflected nose wheel and rudder respectively.



The picture on the left shows the deflection range of the tiller and the rudder pedals respectively.

Reaching 70 knots the rudder is fully effective. The transition from nose wheel steering (NWS) to the rudder takes place between 40 and 70 knots.

The rudder deflection can be monitored on the F/CTR page of the ECAM system display (SD-lower ECAM display).

The NWS is powered the BSCU (Brake and Steering Control Unit). In older A320 aircrafts, the green hydraulic controls the NWS. Newer versions of the A320 use the yellow hydraulic circuit.

The push-back requires the nose wheel to be deflected more than 75º in order to make a sharp turn in the terminal area. Hence, the ground crew deactivates the NWS for towing, allowing the nose-wheel to be turned up to 95º in either direction.

The nose-wheel doors must be closed and one engine running as pre-conditions for the hydraulic system to provide pressure to the steering actuator. After take-off the nose-wheel is automatically centred before the gear is retracted.

A push button has been integrated in the middle of the tiller handle, named Pedal Disc.

If the pilot presses the button, the nose wheel will be isolated from the rudder to allow the rudder check as part of the pre-take-off flight controls check.

3.2.13 The Engine Control

The Airbus engines are controlled by means of thrust levers, which are placed in the centre of the pedestal. It contains of the following devises:

- Thrust levers.
- Engine master and ignition switches for the engine start.

The thrust levers do not have a direct connection with the engines. A thrust command is electrically transferred from the levers to the FADEC computer (Full-Authority-Digital-Engine-Control). Today, thrust control via the FADEC computer is standard in commercial aviation.

Nevertheless, Airbus introduced a new method of thrust lever operation.

The manual thrust control functions is like in any other aircraft by moving the levers in the correct position commanding the engines to deliver the desired amount of thrust. The way of operating in automatic thrust mode (AutoThrust - A/THR) completely differs from the method used in other commercial aircrafts.

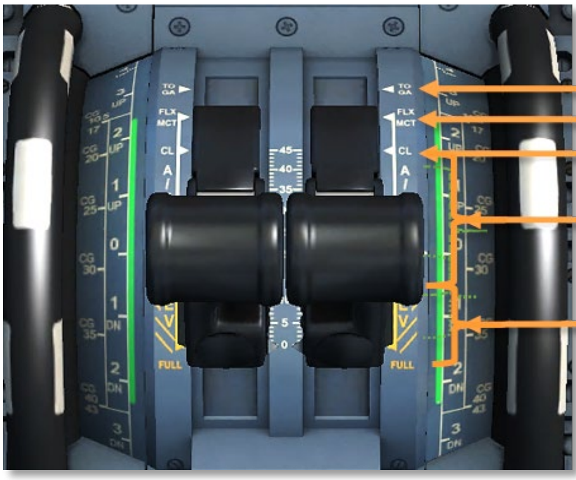
In order to activate the A/THR system, the pilot places the thrust levers into a defined detent, where they remain as long as A/THR is active. The levers do not move according to thrust changes as it the case in Boeing aircrafts. Airbus consequently named the mode automatic thrust system compared to auto throttle by Boeing.

The following detents are available for thrust control:

- **TOGA** = Maximum Thrust for Take-off and Go-Around.
- **FLX-MCT** = Flexible Thrust for Take-off (FLX) or maximum continuous thrust for engine-out operations (MCT).
- **CL** = Climb Thrust. This is also the detent for the AutoThrust (A/THR) operation.

Additionally, two ranges of thrust operations are available to the pilot:

- Range for manual thrust setting.
- Range for reverse thrust setting.



TOGA detent
FLX-MCT detent
CL-detent

Manual thrust range

Reverse thrust range

The engine start is fully automatic via the FADEC computer. The engine master and ignition switches for the engine start are placed under the thrust lever quadrant.

Engine master switches.

Rotary ignition switch.

3.2.14 The Engines of the A320-Family

The A320 family of aircrafts can be fitted with the choice of two engines:

- The CFM-56 engine, manufactured by the CFM International consortium consisting of General Electric (GE) und Snecma, a French engine manufacturer.
- The V2500, manufactured by International Aero Engines (IAE).
  IAE is likewise a consortium including the firms: Pratt & Whitney (P&W), Rolls-Royce (RR) and MTU (Motoren und Turbinen Germany).

The CFM-Engine

The IAE-Engine

The V2500 engine features cascade (clam-shell) reversers, while the CFM-56 uses bucket type reverse thrust doors.

	CFM-56	IAE V2500
Thrust	12.000 kg 27.000 lbs	12.000 kg 27.000 lbs
Fan diameter	1,74 m	1,61 m
Weight	2.400 kg	2.360 kg
Length	2,4 m	3,2 m

The A318 Engines

The A318 can also be ordered with the CFM-56 engine. Due to the lower gross weight of the A318, the offered engine is a thrust reduced version. The IAE consortium does not offer an engine for the A318.

The alternative engine choice for the A318 is the Pratt & Whitney PW 6000 with 22-24.000 lbs or 10 to 10.8 tons of thrust.

The PW 6000 has been developed for commercial aircraft in the 100-seat category and is therefore much lighter than the CFM-engine.

Thrust	Fan diameter	Weight	Length
22.000 lbs / 10.000 kg 24.000 lbs / 11.000 kg	1,4 m	2,2 kg	2,7 m

What is the Power Output of modern Jet Engines?

Jet-engine like the CFM-56 produce thrust of 27000 lbs/12.300 kg equal to 5000 PS.

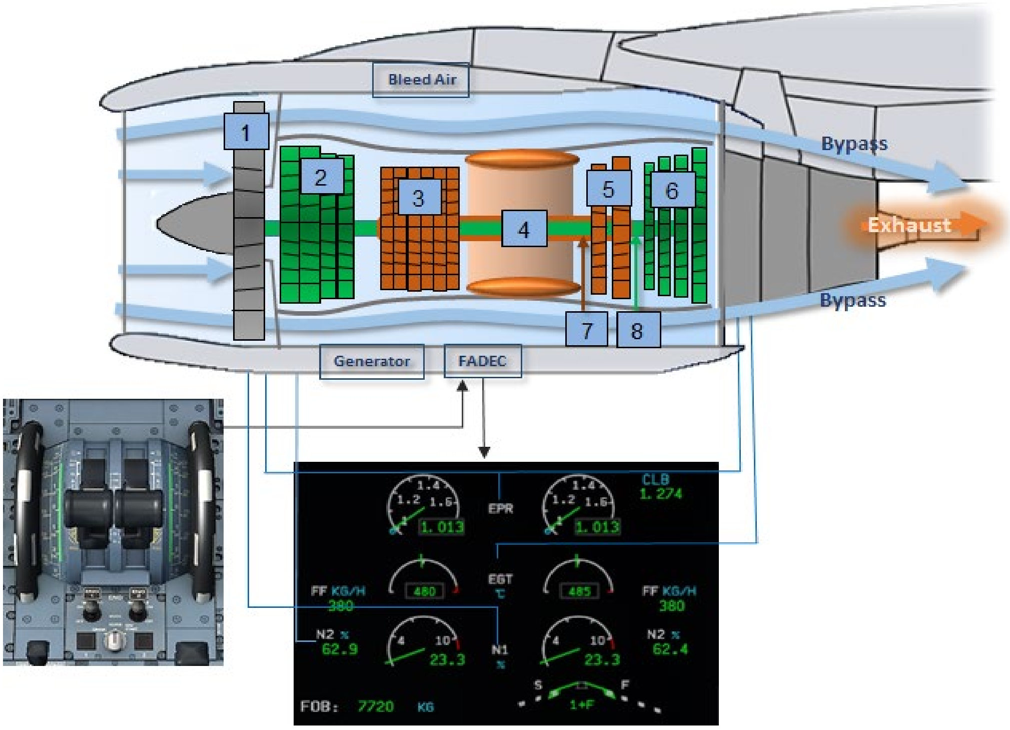
Only a small portion of the air intake is used for the turbine. The larger portion of the air by-passes the turbine core in a duct, where it is accelerated. The amount of air which passes through within one second at full power can fill two hot-air balloons.

Modern jet Engines, like for the A320 NEO (New Engine Option) and the A350, produce about 90% of thrust through the bypassing air. The bypass-ratio is rising with these new engine developments, from 5:1 (CFM-56) to about 11:1 (LEAP-1A). A positive side-effect of the bypassing air is, that the air flow provides a kind of sound isolation layer making the engine quieter.

How does a Jet-Engine work?

A jet engine produces thrust predominantly by passing and accelerating an extensive amount of air through the engine.

The fan in front of the engine intakes air which is compressed and accelerated in the low-pressure compressor stages. The compressed air flows on to the combustion chamber where it is mixed with fuel and ignited. The resulting very hot air drives the high-pressure compressor before it leaves the engine through the exhaust. The high-pressor compressor drives the low-pressure compressor and the fan by two different shafts. The reason is that the fan is rotating at much lower RPM than the compressor.



The main engine components are:

1) Fan for air intake
2) Low Pressure Compressor
3) High Pressure Compressor
4) Combustion Chamber
7) High Pressure Shaft
8) Low Pressure Shaft

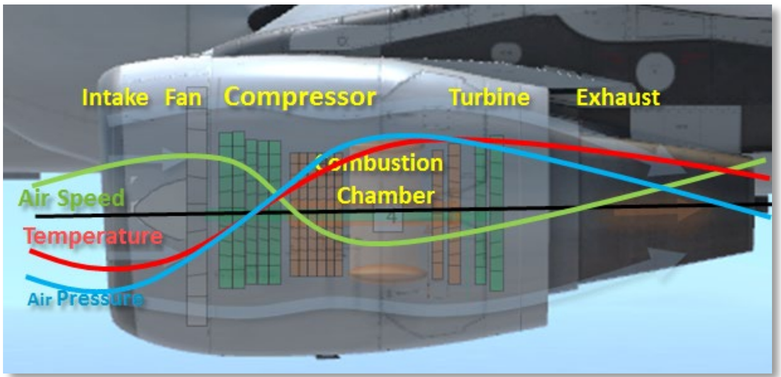
5) High Pressure Turbine
6) Low Pressure Turbine

The following indications are available to the pilot for engine monitoring and thrust setting:

- **N1 –** is the rotation speed per minute of the fan (RPM). The fan is driven by the low-pressure turbine and the low-pressure shaft. The RPM of the fan is converted in % and indicated as thrust, for example 98% N1 as TOGA thrust. The N1 indication is used with GE-engines.
- **EPR (Engine Pressure Ratio) –** is the ratio of the pressure at the inlet (fan) and the turbine exit, e. g. 1.02 EPR. As mentioned before EPR is the main thrust indication with P&W and RR engines.
- **N2 –** is the rotation speed per minute of the high-pressure shaft, which is driven by the high-pressure turbine.
- **EGT (Exhaust Gas Temperature) –** is the temperature at the turbine exit, the exhaust. The EGT of a CFM-56 engine operating at 88% N1 (climb power) is slightly above 700°C.

The N2 and EGT indications are mostly used for the engine start-up phase.

Picture below: Progressive diagram of the most important indications within a CFM engine:



- Air speed
- Temperature
- Air pressure

The Engine Indications

The ECAM system (Electronic Centralized Aircraft Monitoring) provides all necessary indications to monitor the engines on both the ECAM displays. The ECAM displays are located at the centre panel and are good visible for the Captain and the First Officer (F/O) alike.

The upper display called engine and warning display (E/WD) contains the most important engine indications such as N1, EPR (if applicable), EGT, and FF (Fuel Flow – actual fuel consumption).

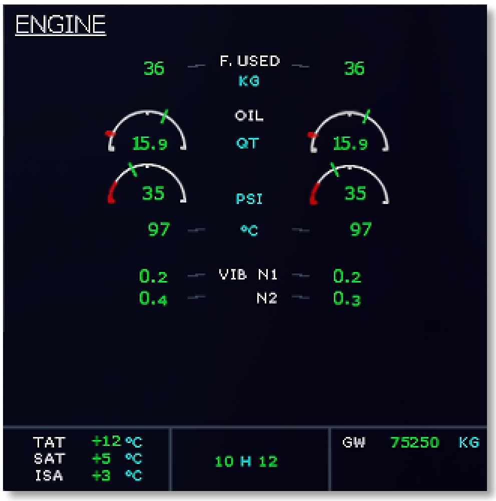
The fan (N1) of the CFM engine rotates with 5.300 rpm while the turbine (N2) runs with approximately 15.000 rpm.

The temperature of the high-pressure turbine (HP) goes up to 1.200 °C.

On the left side at the end of the engine parameters, the actual Fuel on Board (FOB) is displayed. It is constantly calculated and updated. At the right from the FOB-indication, the flap position gauge is shown.

The lower part of the E/WD is divided by a white separation line providing two message areas for system related information. On the left area a kind of take-off and Landing check-list is displayed, while on the right side the system status is shown, e. g. TCAS STBY (stand-by).

The left area is further used for ECAM check-lists and procedural information for immediate attention by the pilot.



The lower ECAM Display named SD (Systems Display) shows additional engine parameters such as F. USED (Fuel used) and N1 (fan) and N2 (turbine) vibrations. The N1 vibration is used as an indicator for engine icing conditions.

While the upper display is fixed, various system pages can be selected and shown on the lower display.

More information about the system pages can be found at in this chapter.

3.2.15 The Engine Control System (FADEC)

FADEC means, Full-Authority-Digital-Engine-Control. As already mentioned, there is no mechanical link between the thrust levers and the engines. Similar to the FBW control, the pilot uses the thrust levers to give a command to the FADEC for a certain engine power or thrust. The FADEC translates the pilot command into engine specific information.

The FADEC takes the thrust lever position as one important input but also takes outside air temperature, and air density (barometric information) into consideration in order to calculate the required fuel flow and other engine parameters.

The FADEC is always installed directly on the engine. In case of a FADEC failure, the engine will also fail to operate, even though the engine is mechanically fully intact.

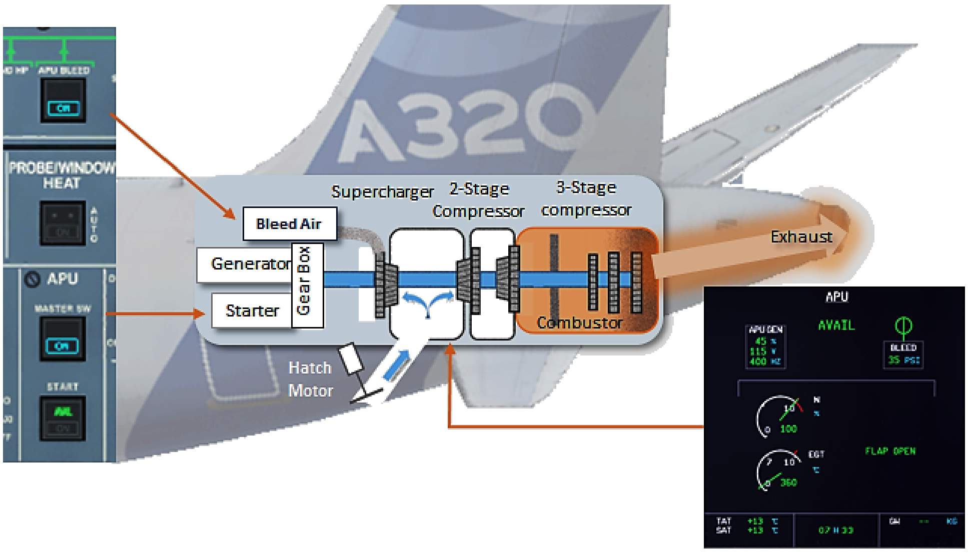
3.2.16 The Auxiliary Power Unit (APU)

The APU serves as an additional energy supply unit and is located at the rear of the aircraft. It can be operated in flight as well as on ground to provide energy in form of electricity and air bleed, but not hydraulic pressure.

The APU is generally a small jet engine and functions in the same way as explained before. The air intake flows to the compressor and combustor where it is mixed with fuel and ignited. The hot exhaust air drives the shaft for the gear box of the electric generator and the air compressor.

Electric power and bleed air are required for engine start and aircraft supply on ground. This is especially required on small Airports. where ground equipment is not always available.

However, even on international Airports the APU is necessary to supply the Bleed Air needed to spool-up the engines during the start procedure. The electric-power is usually supplied by an external electric power equipment provided by the airport.



In flight, the APU can take over the air energy provision in case of an engine failure, e.g. for air condition and pressurisation. In normal operation, one generator (IDG) is able to provide sufficient power to serve all electrical systems and users.

As mentioned before, the APU does not provide hydraulic backup pressure. However, hydraulic pressure can be made available by means of electric pumps, served by the APU.

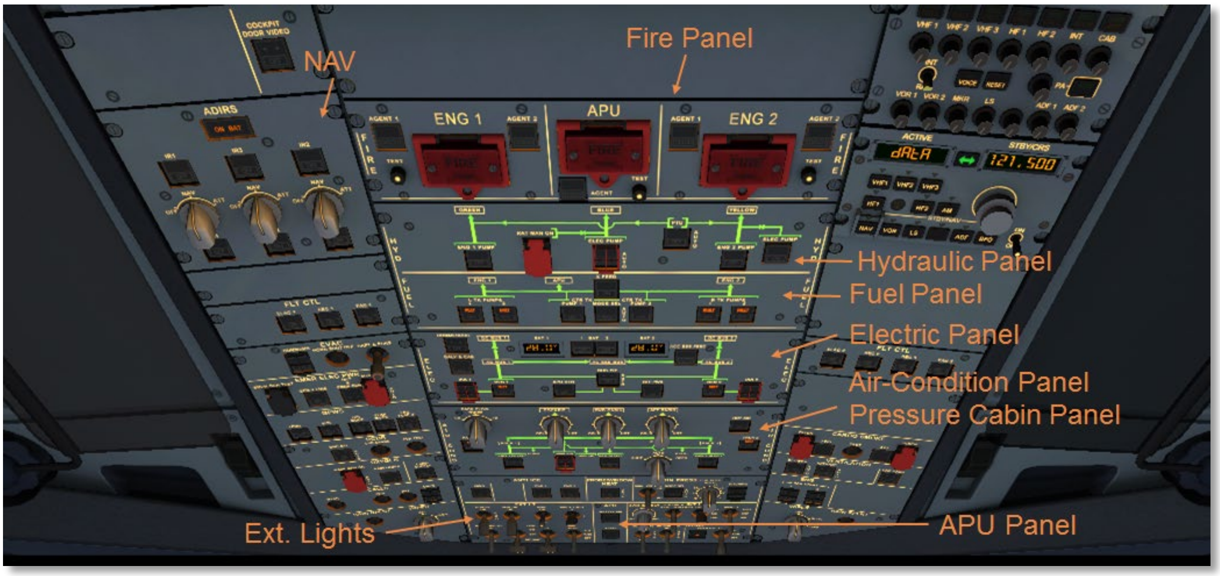
The APU is started and operated via buttons at the centre of the lower overhead panel, next to the external light switches. The pilot can monitor the APU operation via the ECAM APU page.

3.3 The Cockpit Overview

1. Overhead Panel
2. EFIS Control-Panel - Captain / First-Officer
3. FCU (Flight Control Unit)
4. Flight Instruments (EIS) - Captain / First-Officer
5. ECAM (Electronic Centralized Aircraft Monitoring)
6. Gear and Brake System
7. MCDU (Multifunctional Control and Display Unit) - Captain / First Officer
8. Engine Thrust Levers.
9. Trim Wheels
10. Spoiler Lever
11. Flap Lever
12. Parking Brake
13. Manual Gear Extension
14. Sidestick Controllers
15. Rudder and Brake Pedals

3.4 The A320 Aircraft Systems

The picture below gives an overview of the Overhead Panel and the Aircraft systems which are covered in the following section.



The sequence of the systems description corresponds with the location, from top downwards.

3.4.1 The Fire Panel

The fire-panel is located on top of the overhead panel and houses all necessary switches and indication devices (e.g. lights) to manage an engine or APU fire.

The **Red** fire switches have special guards to avoid an inadvertently actuation by the pilot. Opening the guard and pulling-out the respective **Red Fire Switch** will cut-off the engine or the APU from fuel and electricity supply.

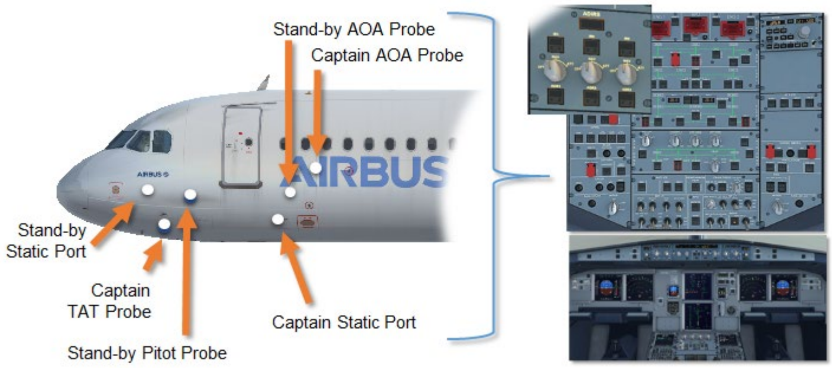
Left and right of the fire switch, two discharge buttons (agent 1, 2) are located. By pressing either button a special agent will be discharged to extinguish the engine/APU fire. Depending on the ECAM message one or both discharge button must be pressed. The APU has only one discharge button.

Each fire switch has a dedicated TEST button allowing the pilot to check the proper functioning of the fire-switching lights. It is not a function test of the fire switch components or the fire detection and extinguishing equipment.

3.4.2 The Air-Data Reference System (ADIRS)

The Air-Data-Reference-System (ADIRS) consists of 3 independent ADRUs (Air-Data-Reference-Unit), that are installed in the avionics bay beneath the cockpit and monitored via a control unit installed on top of the overhead panel, left of the fire switches.

The ADIRS receives data supplied by the various probes and ports, located outside on the Aircraft's fuselage.



In the left picture, the probes and ports of the Captain's side are shown.

Similar devices for the F/O are mounted at the opposite fuselage side.

The ADIRS provide the pilot with flight information, displayed either on the PFD (Primary Flight Display) and/or ND (Navigation Display). ADIRS failures have direct consequences for the Airbus flight control laws.

The ADIRS system consists of an ADR (Air-Data-Reference) and an IR (Inertial Reference) unit that are controlled via dedicated switches:

- IR 1-3 on the upper part of the control unit.
- ADR 1-3 on the lower part of the control unit.
- NAV 1-3 for mode selection. In normal operation, all 3 switches are in the NAV position.

The display on top provides specific information, e. g. ***ON BATT*** when the engines are not running and the ADIRS is set to NAV. On ground, at least one ADIRS is supplied by the batteries. There is no display with position data on the actual system version. GPS data are monitored/controlled via the MCDU (Multifunctional-Control and Display Unit) Data-Pages.

Which flight information is provided by the ADIRS?

IR – The Inertial Reference unit provides attitude (e. g. pitch), flight path vector, ground speed and position data. It uses a ring laser gyroscope together with an accelerometer, GPS and the various sensors to compile the raw data. They are further processed by the A320 flight information systems such as the FMGS (Flight Management and Guidance System) and the DMC (Display Management Computers).

ADR – The Air Data Reference supplies Mach number, angle of attack (AoA), temperature and barometric altitude. The information is also processed by the DMC computers and displayed on PFD and ND. There is no specific AoA gauge on the A320.

If the ADIRS is set to NAV after the first power-on of the aircraft, the position alignment may take up to 10 minutes. The remaining alignment time is shown on the ECAM-E/WD or on the Data Monitor Page, see under chapter 8.8. Like the professional Full-Flight-Simulator, the Aerosoft Airbus also provides a fast-alignment function.

Transmission within the A320 data network, e. g. between the pitot probes and the ADIRS is based on the so-called ARINC standard (in this case ARINC 429), comparable to the TCP-IP protocol of the Internet.

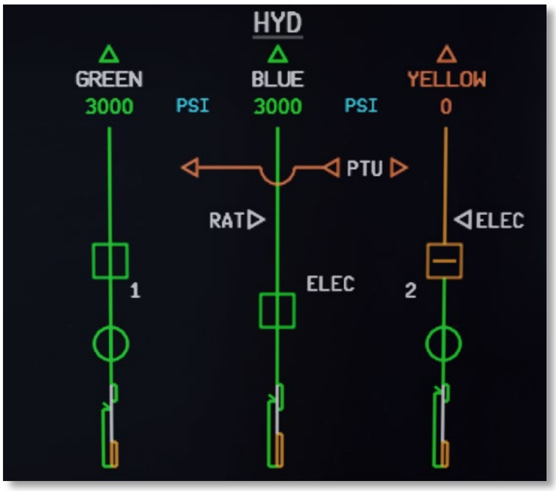
3.4.3 The Hydraulic System

Even though the FBW-flight control system uses no mechanical but electrical connections between the flight controls (computers) and the control devises, the A320 still needs hydraulic power. The hydraulic system is much smaller than on conventional aircrafts and necessary to operate the actuators for rudder/ slats/flaps/spoiler as well as the landing gear.

The hydraulic system is redundant and features three independent systems, which are defined by colours. The **Green** and the **Yellow** systems are driven by hydraulic pumps attached to the engines, while an electric pump drives the **Blue** system.

A graphic representation of the hydraulic systems in the lower ECAM SD-display (Systems Display) assists the pilot in monitoring the hydraulic system.

The hydraulic system is divided into three sub-systems (circuits):



1. The **Green** system, which is powered by engine number 1 (left engine) or via the PTU, if the engine is not running.
2. The **Blue** system, which is powered by an electric pump or the RAT (Ram Air Turbine). The RAT pressurizes the **Blue** system in case of a double system failure.
3. The **Yellow** system, which is powered by engine number 2 or via the PTU, if the engine is not running. If the engine pump fails and the PTU is not serviceable, then an electric pump is automatically switched on and powers the system.

In the picture above, engine number 2 and consequently hydraulic pump number 2 are not running. The **Yellow** system is not powered. The system name, PSI and the hydraulic circuit are all shown in **Amber**. If the PTU is not operational the link is also displayed in **Amber**.

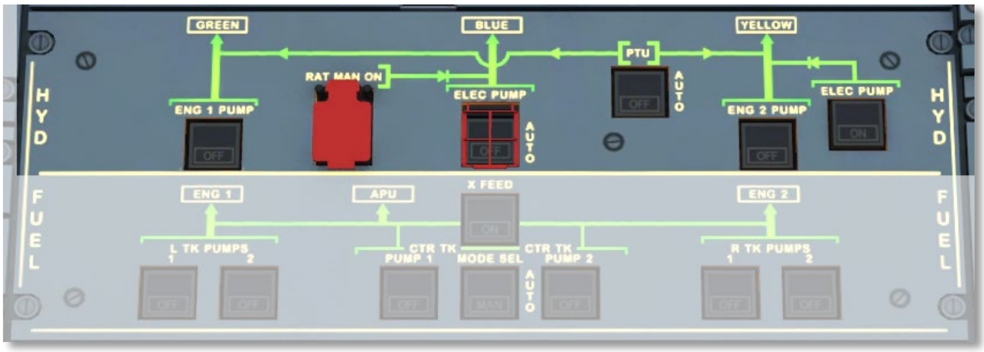
On ground, the **Blue** and the **Yellow** system can be pressurized by the electric pumps, or the **Green** and **Yellow** systems via the PTU.

For normal operation with a hydraulic pressure of 3.000 psi, the system indications are in White. They change to **Amber** when the pressure drops below the threshold of 1.500 psi.

A **Green** indication of the PSI means the pressure is in the normal range. If the value is shown in **Amber**, that indicates a low pressure. The same systematic applies to the hydraulic fluid quantity. *Note: The Aerosoft does not show a proper* ***Amber*** *colour, but rather uses* ***Orange****.*

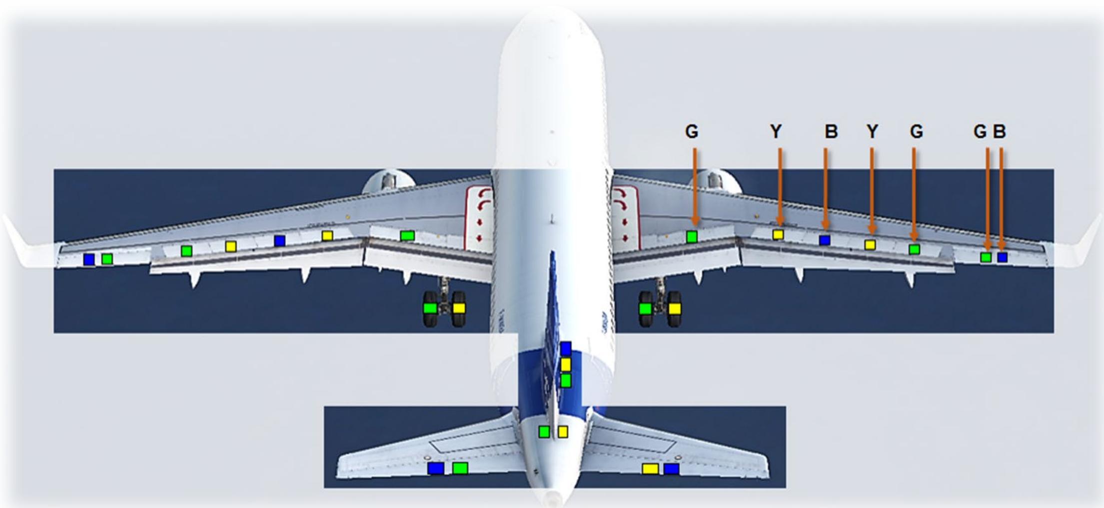
The PTU is automatically switched on in case of malfunction of the **Yellow** system. On ground, the **Yellow** system feeds important systems during the turn-around like parking brake and cargo doors. However, the cargo doors can also be opened manually.

Like the other aircraft systems, the hydraulic is operated and monitored via the overhead panel.



In case of malfunction and depending on its nature, the FBW controls Law may be degraded. The A320 remains fully controllable, only the roll-rate and the sensitivity are usually affected.

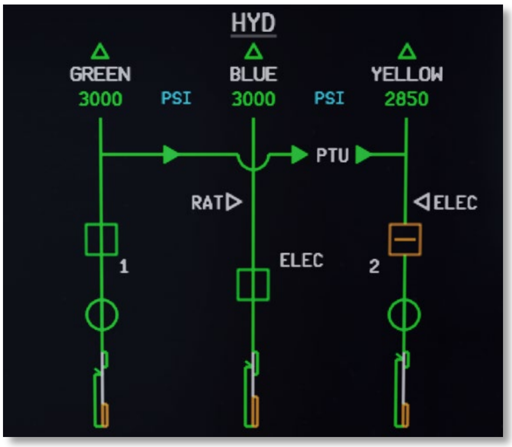
From the picture below, it is easy to distinguish which device or function is concerned by hydraulic malfunctions. With regards to the spoiler control, GYBYG is a known synonym for the hydraulic/spoiler operations.



With other words: the A320 becomes a bit sluggish, in particular when 2 circuits are not available. If two systems fail (double hydraulic failure), which is very seldom the case, the impact on the FBW control system is quite substantial and the A320 not easy to fly.

The Power-Transfer-Unit (PTU)

The PTU produces an unusual noise not known from any other commercial aircraft. During engine start-up or function test, a noise similar to the barking of a dog can be heard. Many of the readers of this book may have heard the sound and wondered what the sources might be.



The PTU levels the pressure difference between the **Green** and the **Yellow** hydraulic system in case one system is not powered by the main supply source, the engine pump.

No fluid is transported between the two systems, it's a sole pressure transfer.

The left picture shows the yellow hydraulic system served from the green system via the PTU.

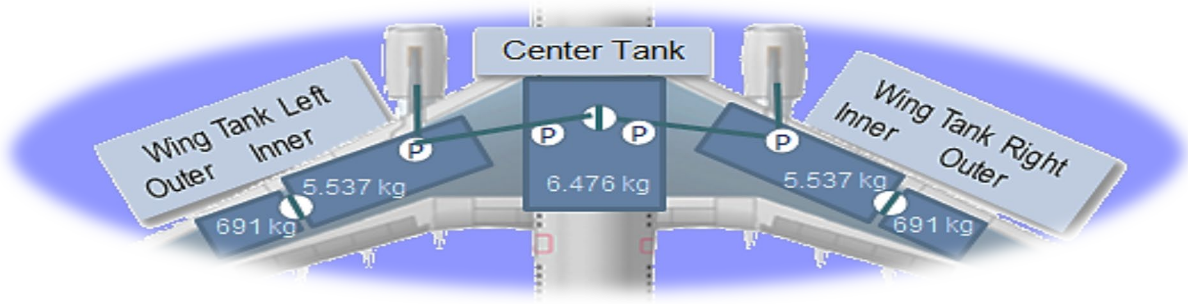
When the Airbus is taxiing on one engine (engine no. 1), a high pitch tone can be heard. This sound is not from the PTU but from the electric pump of the yellow hydraulic circuit.

3.4.4 The Fuel System

Within the A320 family, different fuel system layouts for A318 / A319 / A320 and the A321 are in place. Even though A319 and A318 have been developed after the A321, Airbus used the original A320 wing design.

The A318 / A319 / A320 Fuel System

As mentioned before, all version of the Airbus A320, A319 and the A318 feature the same tank architecture with 3 tank segments, left- and right-wing tank and one centre tank. The wing tanks are further divided into the inner and the outer tank segments.



The outer wing tanks are additionally utilized to support the aerodynamics by bending the wing. Bending the wing help to prevent wing flutter in turbulent air (flutter relief).

In normal operations, the left-wing tank feeds the left engine and the right-wing tank the right engine. A Cross-Feed-Valve allows the supply of both engines by either the left or the right-wing tank. Both engine fuel pumps, not the centre tank, are equipped with a suction valve.

The usage of the tanks follows the following sequence:

1. Centre tank: The fuel is pumped from the centre tank directly to both engines. Fuel which is not used will be transferred to the inner wing tank.
2. Inner wing tanks: Fuel is directly pumped to the associated engine.
3. Outer wing tank: The fuel (max. 690 kg) is transferred to the inner wing tanks via fuel valves, if the inner tank capacity is below 750 kg.

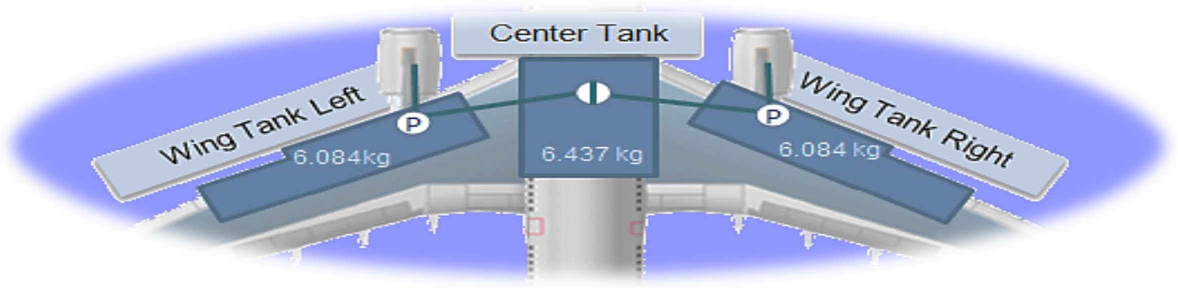
In case of pump malfunctions the fuel supply to the engines is done by means of gravity and the suction valves.

Overview of the tank capacities:

A318 / A319 / A320 Fuel Capacities					
		Outer Wing Tank	Inner Wing Tank	Centre Tank	Total
Volume	Litre	880 x 2	7.099 x 2	8.250	24.208
Weight	Kilogram	691 x 2	5.573 x 2	6.476	19.004

The A321 Fuel System

The layout of the A321 tank system is different than the A318, A319, and A320 aircrafts. In contrast to the other family members, the wing tanks of the A321 are not segregated, they are one unity.



Also, the fuel pump system has been changed. Fuel from the centre tank is transported to the wing tanks and from there to the engines by means of pressure feeding.

The A321 uses so-called Jet-pumps, which are driven by the fuel pressure in the wing tanks. Like the other A320 family aircrafts, the engines are supplied by their corresponding engine fuel pumps.

A321 Fuel Capacity				
		Wing Tanks	Centre Tank	Total
Volume	Litre	7.750 x 2	8.200	23.700
Weight	Kilogram	6.084 x 2	6.437	18.605

Auxiliary Centre Tank (ACT)

The tank capacity of the A319 and A321 can be extended by means of auxiliary centre tank units, which are installed in cargo holds. Each ACT increases the fuel capacity by 2.320 kg, but reduces at the same time the cargo capacity.

Up to six ACTs can be installed in the A319 providing an additional fuel capacity of up to 14.000 kg and a total of 33.000 kg. This gives the A319 a range of 11.100 km / 6.200 NM or 13.5 hrs flying time. This arrangement is mostly used for the A319 ACJ (Airbus Corporate Jetliner), where only a limited cargo capacity is required.

For the A319 LR (Long Range), range has to be traded against the need for cargo capacity (e.g. Pax baggage) and only four ACTs are installed. The additional fuel of 9.300 kg (4 x 2.320 kg) increases the fuel capacity to 28.000 kg, resulting in a maximum range of 11.5 hours or approximately 9.700 km/5.400 NM.

Depending on the aircraft variant, the A321 is fitted with up to 2 ACTs, increasing the tank capacity to 23.600 kg. The range extends up to 7.200 km/4.000 NM or 8 hours.

The fuel of the ACT is transported to the wing tanks/engines via the centre tank,

General Operation Procedures

1. The centre tank is emptied first. Take-off with fuel in the centre tank only, is prohibited. The reason is, that suction feeding may not be sufficient for the proper supply of the engines in case of an electric power failure.
2. In case of malfunction of both engine fuel pumps, only the wing tanks can be used by means of suction feeding. For this reason, the fuel in the centre tank is not useable.
3. The APU is supplied by the left tank. That means, a long operation of the APU can lead to a slight tank/fuel imbalance.
4. Some fuel is redirected and used for the cooling of the IDG (Integrated-Drive-Generators) and the engine oil on the V2500 engine. As a side effect the pre-heated fuel is helping to keep the fuel temperature within the necessary limit, thus avoiding low fuel temperature situations.

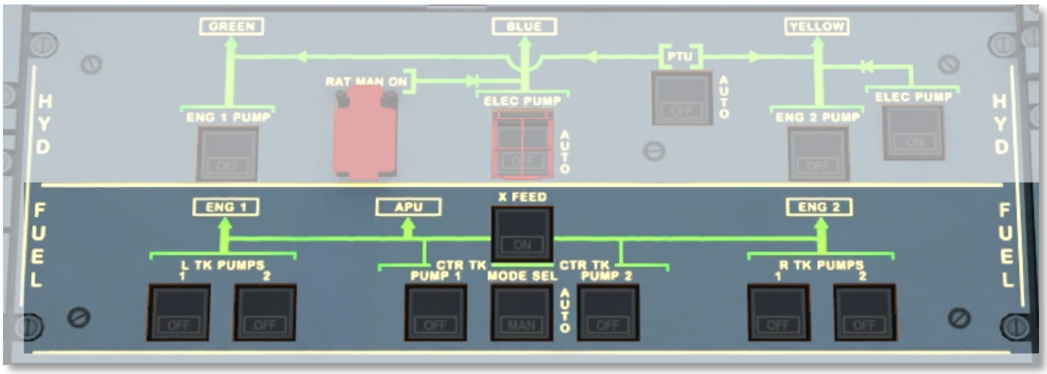
In normal operation Auto-Mode is the standard procedure. That means, the wing tank pumps are permanently on. The centre tank pumps are also set to on, if fuel is available in the tank and the slats are not deployed.

On ground, the centre tank pumps are running for 60 seconds when the slats are deployed to configuration 1+F. They are switched off for the take-off due of the reasons explained before.

The centre tank pumps are switched on again in flight, when at least 500 kg are used form the inner wing tanks and the slats are retracted. Usually, 500 kg is used up for taxi and take-off.

Average Fuel Consumption in tonnes/hour			
A318	A319	A320	A321
2,0 t	2,0 - 2,4 t	2,0 - 2,4 t	2,5 - 3,0 t

The Overhead-Panel Instruments



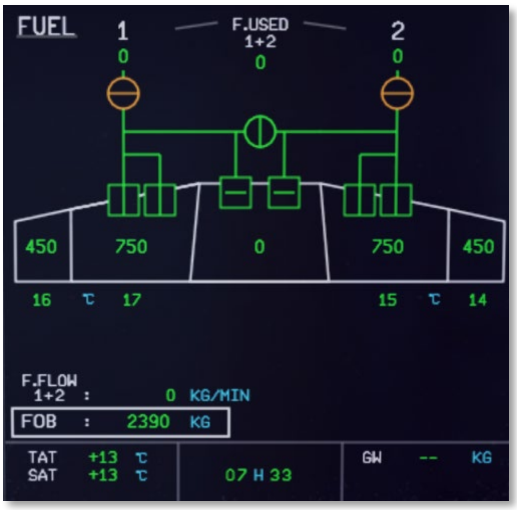
The Fuel Instruments

The fuel situation can be monitored by the pilot via the upper and the lower ECAM panel. All information shown on the displays are constantly updated during the flight.

The upper ECAM shows:

- The actual capacity (FOB - Fuel on Board)
- The fuel consumption by the engines (Fuel-Flow, FF).

The APU consumption is not displayed.



The lower ECAM displays detailed information about the actual situation of the various tanks.

The right picture presents the fuel page on the lower ECAM display.

3.4.5 The Electric System

Airbus calls the electrical power generators IDG (Integrated-Drive-Generators).

Both engine generators produce a power output of 90 kVA each with an alternate current of 115V/400-Hz. The APU generator also supplies 90 kVA (115V/400-Hz). Any of the three generators is able to supply the complete electrical power demand of the Aircraft.

The electrical network provides both AC (Alternate Current) and DC (Direct Current) Transformers-Rectifiers (TR) are converting AC into DC current.

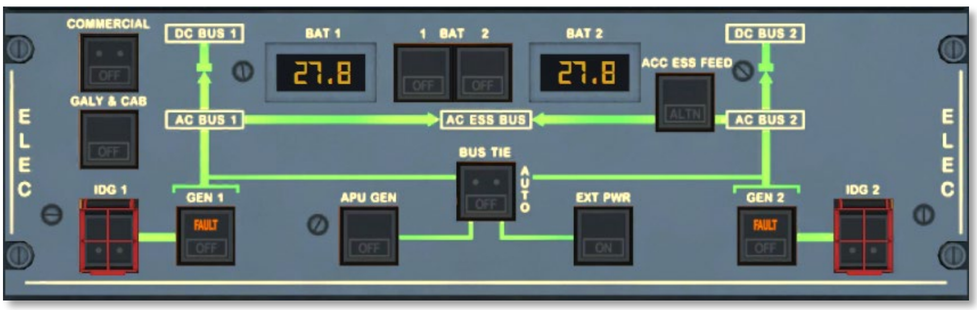
In normal operation, each engine IDG supplies one designated AC-Bus (1 or 2). The ESS (Essential Bus) ensures uninterrupted power supply in case of malfunction of one IDG.

The picture on the left shows the general layout of the electric power network, as displayed on the electric page of the lower ECAM display.

The A320 contains two batteries for emergency backup and ground operations e.g. APU start when no external power is available. In case of a complete electric power failure, the batteries are able to supply power to selected aircraft systems (e.g. flight control) for up to 30 minutes.

The minimum voltage of the batteries is 25.5V. It takes about 20 minutes to recharge the batteries. The batteries are constantly monitored and automatically charged when required. A cut-off logic makes sure they are switched off before overload or underload can hamper the batteries.

The Overhead-Panel Instruments

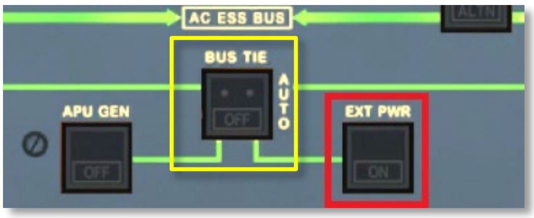


The priority of the electric power supply is as follows:

1. Engine generators (IDGs)
2. External power supply
3. APU generator (IDG)
4. Emergency generator RAT (Ram Air Turbine)
5. Batteries (2)

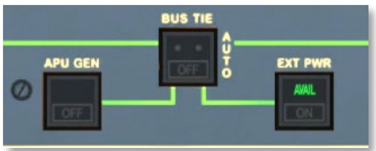
Power Supply via Auxiliary Generator

The external power supply is usually provided through the airport operator by means of a mobile or a stationary power unit. The connection to the A320 is provided via the ground power control panel (GPCP) next to the gear bay.

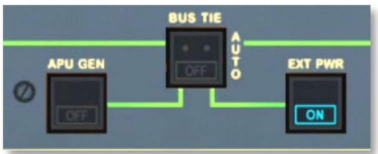


Both, the External Power and the APU power supply are connected via the AC BUS TIE. The designation TIE stands for tying-up.

If both engines are switched off, e.g. at the gate, and the APU is running, then the APU takes automatically over the entire power supply of the aircraft. Connection of the external power is always initiated by the pilot, via the overhead panel.



Once the connection is established, the **Green AVAIL** light in the EXT-PWR button is illuminated. However, this confirms only the connection to the panel but not that it is turned on.



After pressing the EXT-PWR button, the external source is switched on and supplies electrical power to the A320. As a confirmation the light in the button changes from **AVAIL** to **ON**.

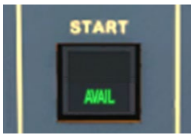
Starting the APU while the A320 is connected to an external power, does not entail a switch-over to the APU generator. Only when the external power is disconnected, then the APU generator takes over automatically.

Power Supply via APU

The start of the APU reveals another Airbus speciality.

After pressing the APU Master switch, it displays **ON**. **ON** in this particular case only means, the APU is ready to start, not that the APU is already running.

The START button also needs to be pressed to start the APU. The button also displays **ON**, and confirms the start sequence.



After the APU reaches 96% N1, the button indication changes to **AVAIL**. From this moment, the APU automatically takes over the electric power supply, provided the Airbus is not externally connected.

Power Supply via the RAT (Ram-Air-Turbine)

The RAT (Ram-Air-Turbine) is located between the two main gears. It takes over the engine supply in case of a complete failure of the electric power system.

Approximately 8 seconds are required for the deployment of the RAT, which is automatic. During this period the batteries take over the electricity supply for the aircraft. The FBW control has priority over any other electric consumer. If necessary, the RAT can also be manually deployed by the pilot.

The RAT provides 5 KVA on electric power compared to the 90 KVA of the IGS. However, it is enough to supply the FBW-control and other important systems, e. g. the Captains flight instruments. In this event, the F/O flight instruments will not be supplied and become dark. Consequently, the Captain must be the PF.

Aircraft systems such as cabin lights and galley are not powered under this emergency situation. But the emergency light strips on the floor are supported.

The propeller of the RAT is driven by the air stream and drives in turn a hydraulic pump. This pump powers the CSM/G (Constant-Speed-Motor/Generator). The CSM/G is a small hydraulic motor, who supplies the **Blue** hydraulic circuit and further drives a small electric generator.

The RAT is automatically deployed when the electric buses (AC1 and AC2) are without current.

3.4.6 The Air-Conditioning-System

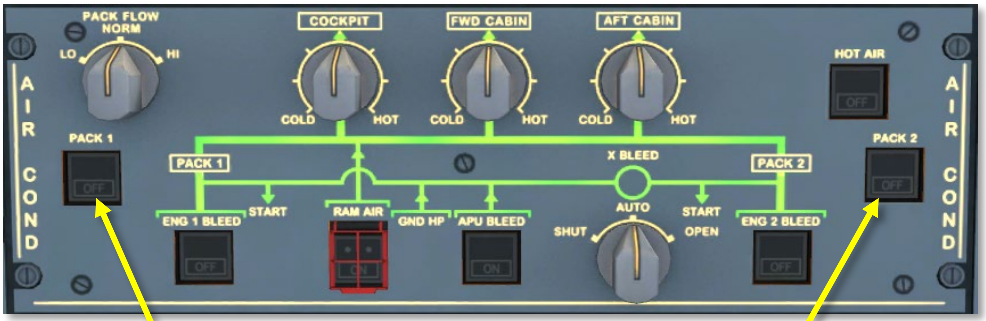
The Air-Condition system (A/C) supplies the following facilities:

- Air Conditioning
- Cabin Pressurization
- Heating system for the cargo compartments

The A/C requires bleed-air, which can be supplied be several systems, which are:

- Bleed-Air provided by the engines
- Bleed-Air provided by the APU
- Bleed Air from external high-pressure ground units at the airport

The Overhead-Panel Instruments



Control buttons for switching the packs ON/OFF.

The Air-Condition System (Packs)

The A320 features two independent A/C systems so-called Packs, which control three autonomous cabin zones. The three cabin zones are:

- Cockpit
- Forward passenger cabin (usually first or business class) and the
- Aft cabin (economy class)

The temperature of the three zones is adjusted through the corresponding rotary switches on top of the A/C panel.

The left picture shows the zone indications on the ECAM cruise page.

Each cabin zone has its own temperature management and are monitored and controlled by either the cockpit or the cabin crew respectively.

It is standard procedure to switch the A/C off for take-off to have additional thrust available. The CFM-56 engines produce about 5% more thrust with the Packs switched off.

If the Airbus is serviced by an external high-pressure system, then it is prohibited to switch on the aircraft A/C systems. Unfortunately, the A320 does not have an indication, that external pressure is connected to the Aircraft and the pilot must be attentive.

APU Bleed-Air

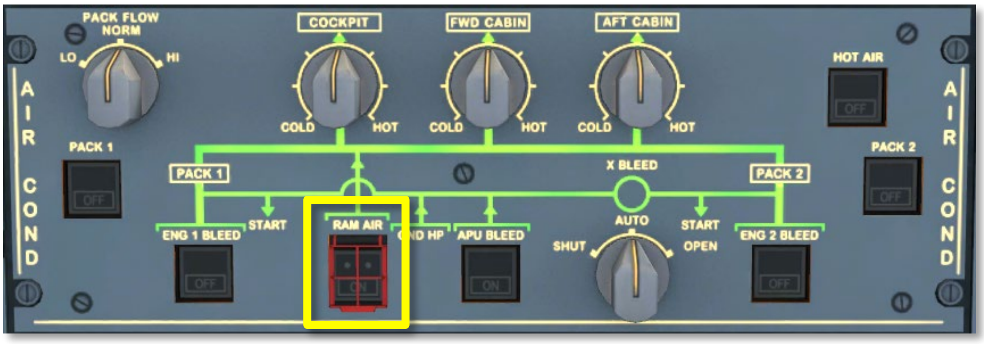
The APU load compressor is also able to provide the necessary bleed-air for the A/C and the pressure cabin. In case of an engine failure in flight, the APU can relief the remaining life engine, which then produces again about 5% more power.

RAM-Air

In the unlikely event of a total loss of the A/C and the Pressurization system, a special duct in the aircrafts fuselage can be opened by the pilot. The duct allows RAM-Air to flow into the cabin for air circulation (air ventilation). The RAM-Air is not a substitute for the bleed-air and thus cannot serve the pressurization system. The RAM-Air valve only opens after the Airbus reaches 10.000 feet (3.000 m) and the pressure in the cabin is reduced to the normal level.

In this case, the pilot must execute an emergency descent immediately to reach 10.000 feet, the safe altitude for a flight without the pressurization system in the shortest possible time.

The button for the RAM-Air activation is located at the AIR COND section of the overhead panel next to the APU bleed air button.



3.4.7 The Communication System

The FSX-Aerosoft communication panel is only useful, if the FS-pilot flies on a virtual network, like VATSIM or IVAO.

The upper panel provides selections of the communication method (VHF) and the channels (frequency).

The next panel allows the pilot to manage his/her communication externally with the ATC and internally with the crew and the Pax (PA- Public Announcement).

Below is a service panel for the flood light and the printer functions.

The lower panel houses the transponder for the data communication with the ATC. Additionally, the transponder is used to select the modes for the TCAS system.

If the navigation sources (ILS, VOR, ADF/NDB, BFO) cannot be tuned via the F-PLN- or RAD NAV-Page, the communication panel provides a back-up for these applications.

In order to use the back-up, the pilot opens the guard on the NAV button and activates the mode. Afterwards he/she selects the navigation source, e.g. ILS

Next, the pilot dials the NAV frequency into the STBY/CRS field and transfers the data to the active field using the transfer button ⟷. With the frequency transfer the STBY-field automatically becomes the CRS- field and the pilot enters the course data in the same manner.

3.4.8 The Stand-by Instrument Systems

The Integrated Stand-by Instrument systems (ISIS) provides a third source for Aircraft Attitude and Speed as well as a Navigation back-up.

The data for the ISIS Attitude Indicator (back-up PFD) is supplied by ADIRS 3.

The VOR/NDB information is from the same source as for the NDs. VOR 1 is defined by the single-line arrow and VOR 2 by the double-line arrow. The digital fields on top show the DME distances if available.

3.5 The ECAM System

As already mentioned, ECAM stands for Electronic Centralized Aircraft Monitoring System.

Upper Display - EW/D (Engine and Warning Display)

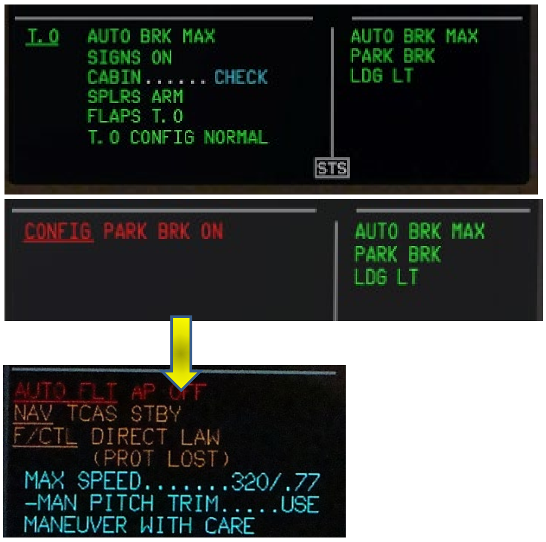
- Engine Parameter
- Fuel on Board (FOB)
- Position of Slats and Flaps
- System-generated TO and Landing Memos.

The right picture shows the EW/D for Take-off and for the IAE engines. The EW/D features EPR (Engine Pressure Ratio) on top, followed by EGT and N1.

This picture displays the EW/D for Landing and for the CFM engine. The CFM engines are using the N1 indication instead of the EPR.

In the Upper right corner the available thrust **TOGA/ CLB**, **N1-EPR** in **%** is displayed.

ECAM memo and checklist section:



- Open actions are in **Blue.**
- Confirmed actions are in **Green**.
- Alarm Information are in **Red.**
- Caution Information are in **Yellow**.

Memos are inhibited during TO and Landing – **TO or LDG INHIBIT** is indicated in the right part.

In case of malfunctions, check-list are displayed. The **Red** and **Orange** items are system information/warnings. The **Blue** items are check items, which are to be completed by the crew.

Lower Display - System Display (SD)

The lower ECAM display provides the following information:

- System Pages for the various Aircraft systems.
- ECAM Check-List procedures and status information in case of system malfunctions.
- Standard information for TAT, SAT, Time and GW on the display bottom.

From take-off thrust setting the wheel page is shown until 80 knots followed by the secondary Engine display. The Engine page is replaced by the Cruise page once the flaps are retracted. During approach, the wheel page is shown again with the gear extension.

The ECAM-Page selection is done via the ECAM-controller with the following control elements:

- 2 CLR keys: to delete/clear ECAM Information.
- RCL key: recalls stored failure information/messages.
- STS key: calls up Status Information.
- ALL key: calls up all System Pages in sequence with 1 second interval.
- T-O key: to perform the TO configuration check (Standard-Procedure).
- EMER CANC, Emergency Cancellation key, deletes all Alarms and Cautions.

The Cruise Page

The cruise page is the only page not selectable via the ECAM controller. It is automatically displayed after take-off if:

- The aircraft speed is > 80 knots
- The slats and flaps are retracted
- The A320 is in active Flight Mode.

It provides important information such as:

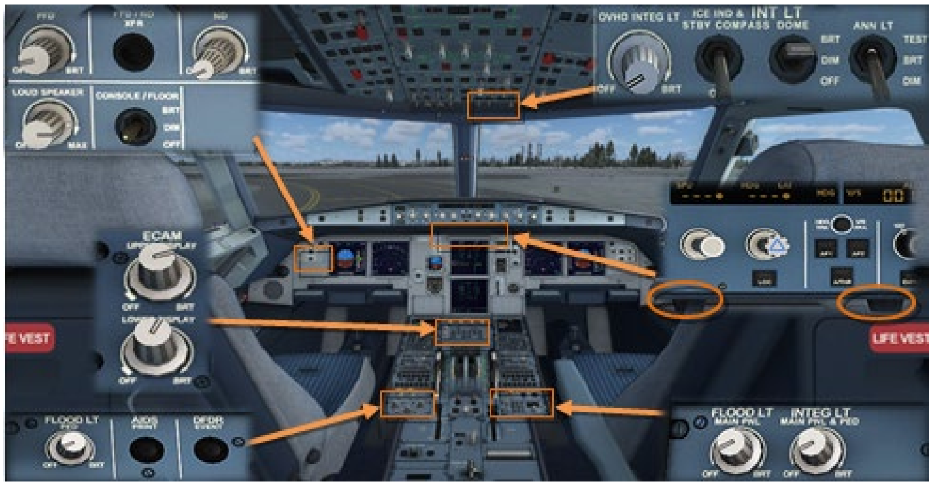
- Fuel used
- Cabin temperatures
- Landing elevation mode for A/C and Packs
- Time
- Standard information for TAT, SAT, Time and GW on the display bottom

3.6 The A320 Lighting System

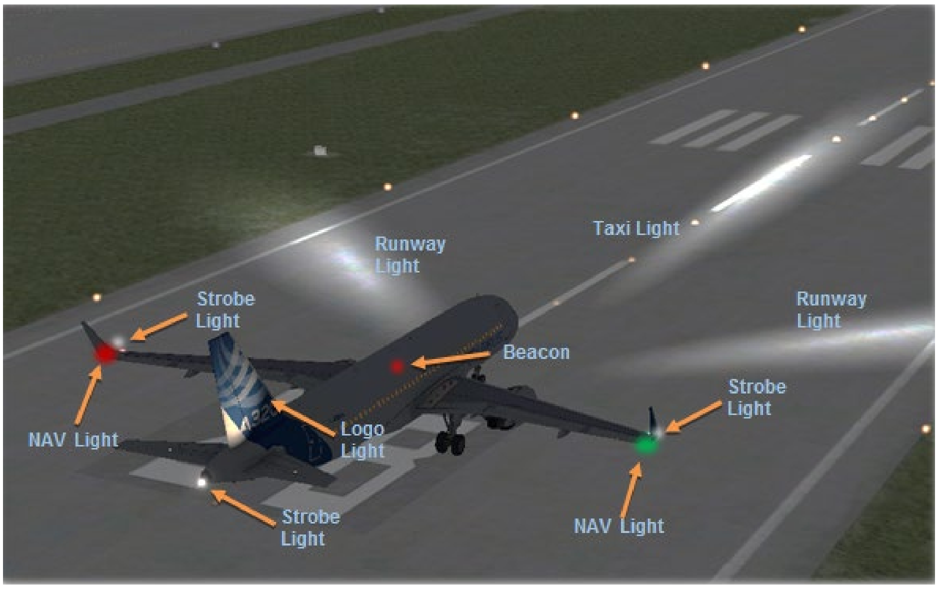
The lower part of the overhead panel houses important control functions, Including:

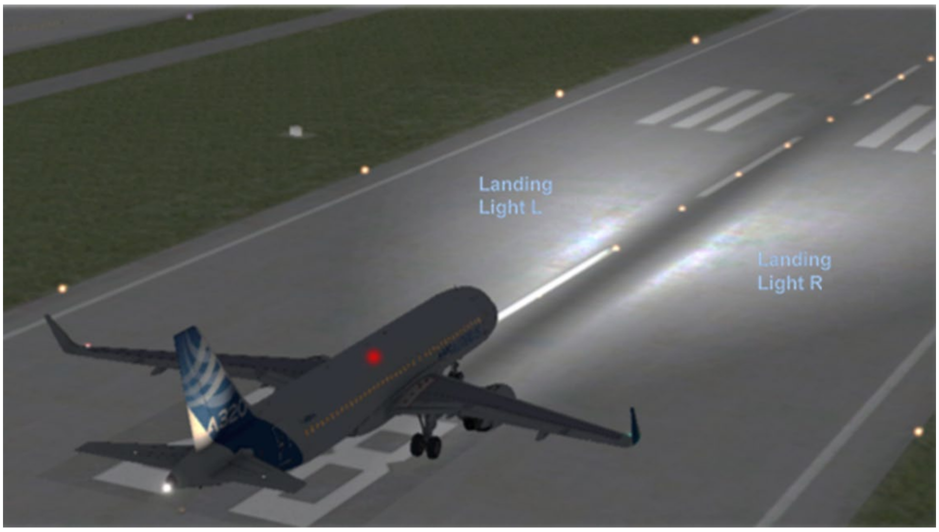
- APU control.
- Passenger information switches (SIGNS).
- Switches for the internal (INT LT) and external lights (EXT LT).

The Internal Lighting System



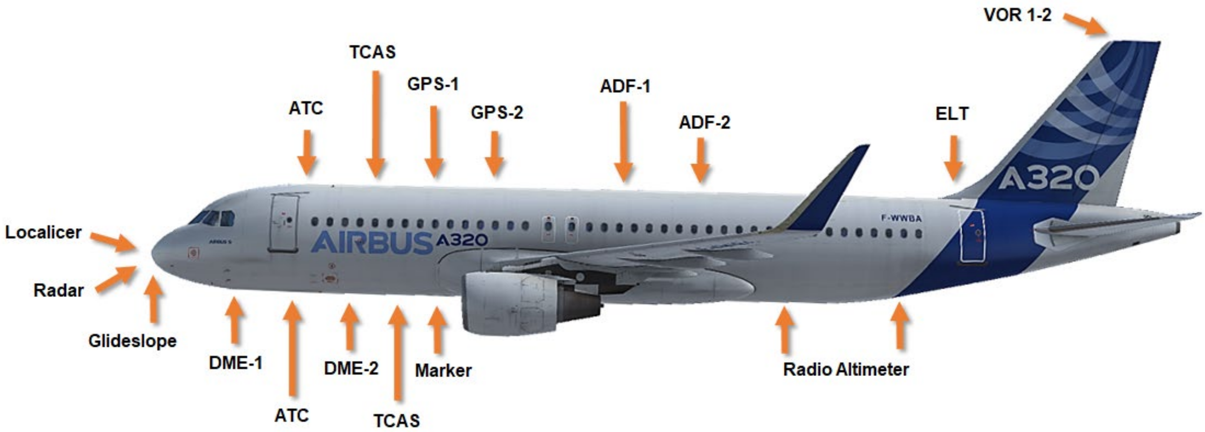
The External Lighting System





3.7 A320 External Device Locations

NAV – COMM Antennas



Probes and Sensors

3.8 The Overhead-Panel - Overview

1. Maintenance Panel
2. Fuse Panel
3. Reading lamp Cpt
4. Reading lamp F/O
5. Ceiling light
6. ADIRS
7. Fire Panel
8. Audio Panel Observer
9. Radio Panel Observer
10. Flight Controls 1
11. Hydraulic Panel
12. Evacuation Panel
13. Fuel Panel
14. Emergency Panel
15. Electric Panel
16. Flight Controls 2
17. EGWPS
18. Flight Recorder
19. Air Condition Panel
20. Ventilation / Smoke
21. Oxygen panel
22. Interphone
23. Anti-Ice Panel
24. Manual Cabin Control
25. Manual Engine Start
26. Wiper Captain - F/O
27. External Lights
28. APU Panel
29. Internal Lights
30. Signs

Chapter 4

Content

4. The Airbus AutoFlight System (AFS)

After the introduction to the A320 Aircraft-Systems, the next important step is the understanding of the Airbus brain, the Flight Management and Guidance System (FMGS). The Airbus FMGS has a very complex structure which, like any other technical device, follows a certain logical chain.

This logic must be understood by the pilot, it cannot be learned by heart. There is a famous saying about the Airbus every pilot knows “What is she doing again? “. However, this sentence does not prove that something is wrong with the Aircraft. It symbolically stands for the fact, that certain system functions may not be immediately evident to the pilot.

The principal part of the FMGS are the AutoFlight System (AFS) modes, which define the system functionality at any time during the flight. Therefore, it is of utmost importance, that the pilot familiarizes him-/herself with the logic and functions of the AFS.

4.1 The AutoFlight System (AFS)

The AutoFlight (AFS) system incorporates all necessary functions to conduct an automatic or managed flight, which are:

- Autopilot (AP) and Flight Director (FD)
- Automatic Thrust (AutoThrust – A/THR)
- Flight Management System (FMS)

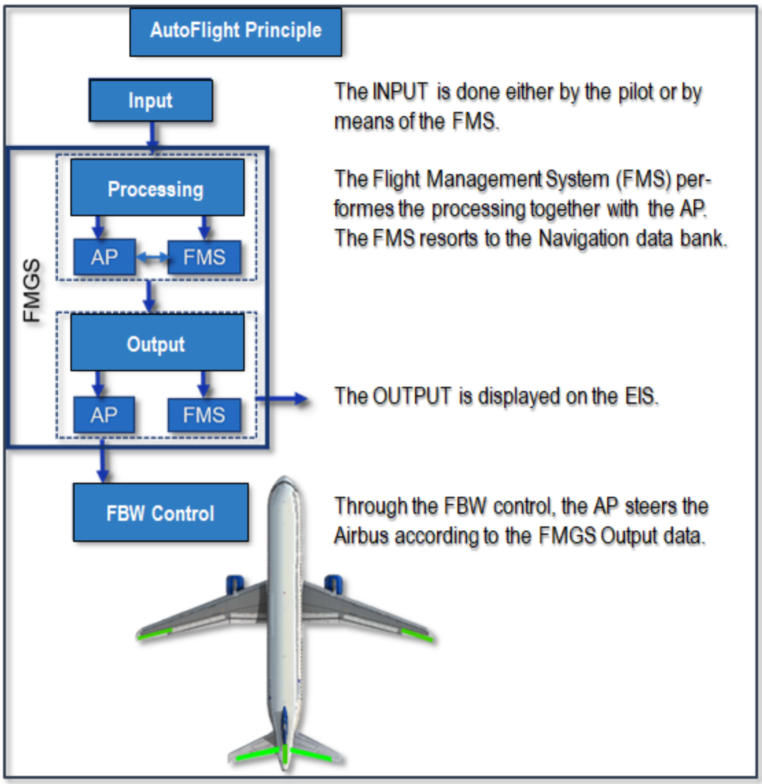
Modern Airbus aircrafts such as the A320 family fully integrate these sub-systems into the AutoFlight system.

The AFS enables the pilot to conduct the flight fully guided or automated. However, because of operational reasons, certain pilot inputs are still required, e. g. climb or descent initiation due to ATC instructions.

The Airbus AFS supports the pilot throughout the flight and releases him/her from repeated and routine tasks. Additionally, the AFS provides detailed information to the pilot with regards to the management of the flight. The AFS information are provided on the flight instruments (EIS) and/or the MCDU display.

Commercial flights need a permanent and consequent monitoring of the Aircraft performance to conduct the flight as economical as possible.

For example: the FMGC (Flight Management and Guidance Computer) calculates the optimal Climb/descend-rate and flight level for the lowest fuel consumption. To do so, the FMCG uses data put-into the MCDU by the pilot such as, temperature, wind and weights.



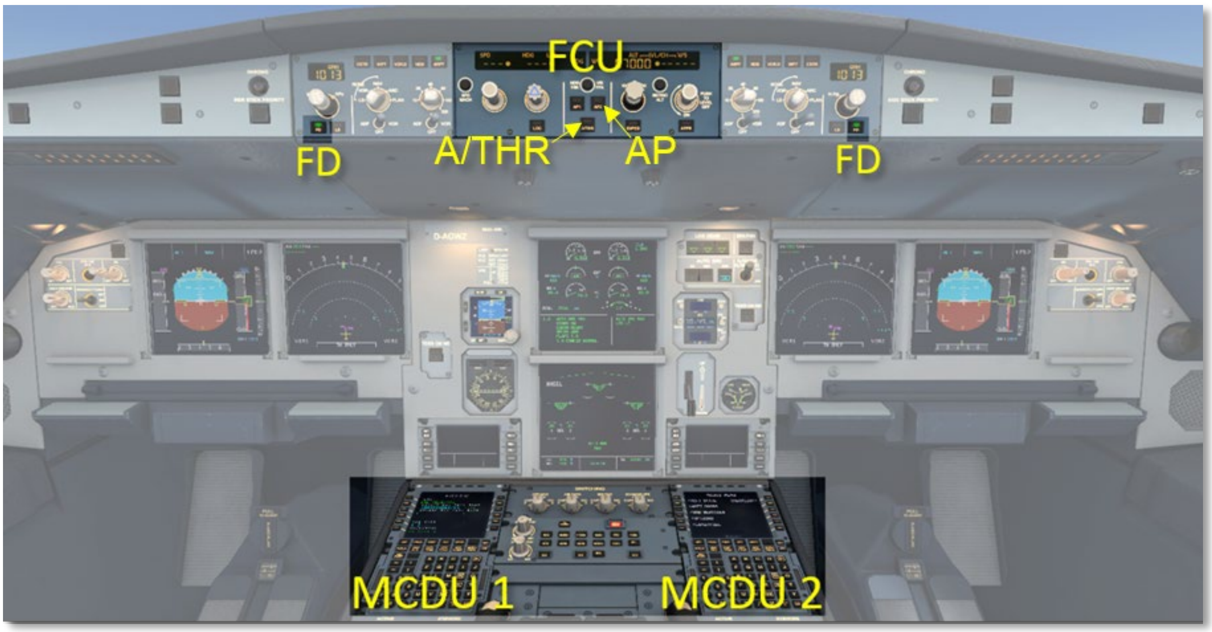
Additionally, performance related flight data are incorporated, which form the Flight Management and Guidance System (FMGS).

Performance related data concern flight time, fuel efficiency, and other factors improving the airlines operating costs.

Independent from the scale of integration, the design of the Auto-Flight-System (AFS) follows a generic structure, which is shown in the left picture.

The AutoFlight Systems consists of the following units:

1. FCU (Flight Control Unit).
2. FD (Flight Directors). The FD-buttons are on the respective EFIS controller.
3. AP (Autopilot). The AP-buttons are located in the middle part of the FCU.
4. A/THR (AutoThrust). The A/THR-button is placed in the middle part of the FCU.
5. MCDU (Multifunctional Control and Display Unit).



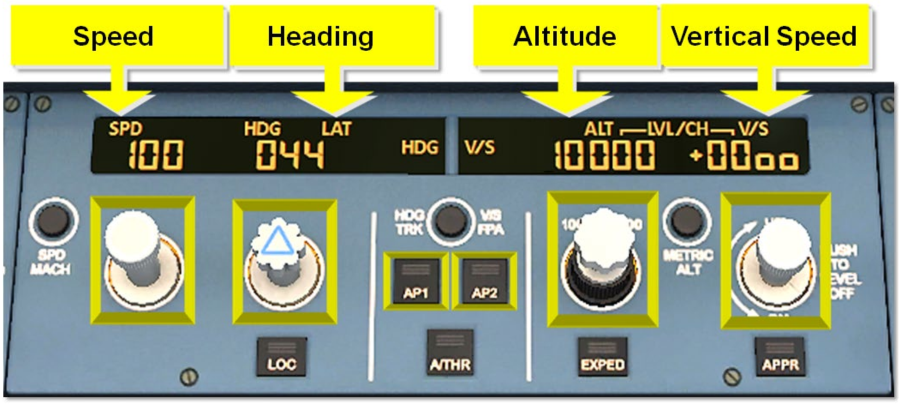
The MCDU is the input device for the FMS and also the interface for long-term flight data (F-PLN, aircraft performance.

The FCU is the input device and the interface for the short-term flight data (speed, heading, altitude vertical-speed).

The Flight Control Unit (FCU)

The FCU is the Man-Machine-Interface between the Pilot and the AFS. Four rotary-dial knobs are available to the pilot for the selection and management of:

- SPD Speed
- HDG Heading
- ALT Altitude
- V/S Vertical/Speed



Each knob has three functions:

1. Turning the knob → selecting the required value
3 Pushing the knob → engaging managed AFS mode Pulling the knob → engaging selected AFS modes

The ALT knob includes a sub-rotary knob. Turning the knob selects the altitude steps per 100 or 1000 feet.

In the middle part of the FCU-Panels, the buttons for two Autopilots (AP1/AP2) and AutoThrust (A/THR) are placed.

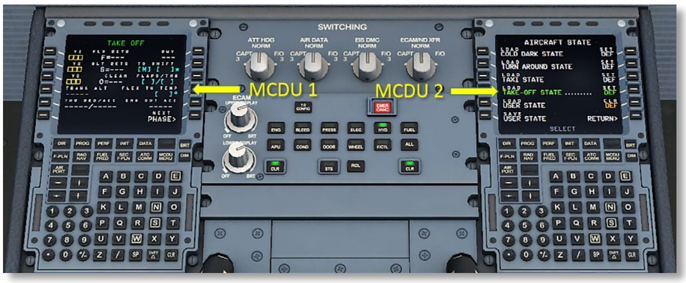
Pressing the APPR button below the V/S knob arms the approach function, e.g. for an ILS approach. The left EXPED button engages the expedite descent function with the steepest possible profile based on a VMAX of 340 knots. This function is optional and may not be available with the Add-on software.

In real life operation, either AP1 or AP2 is engaged. Only during low visibility operations (LOV), CATIII-ILS or Autoland approach, both APs must be engaged.

The buttons light **Green** when the associated function is active (switched-on).

The Multifunctional Control- and Display Unit (MCDU)

The MCDU is the input device used by the pilot to enter/manage the flight plan (F-PLN) and the aircraft performance. Being an integral part of the flight management system (FMS), it is further used for flight monitoring.



There are two MCDU devices, one for the Captain and one for the First Officer with equal functionality.

The Aerosoft Airbus Add-on software, only uses the Captain MCDU for the FMS functions. The First Officer's unit performs specific Add-on functions.

The MCDU is automatically switched-on when the Aircraft is electrically powered.

Flight Director (FD) and Autopilot (AP)

On either side of the FCU, EFIS-Control-Panels are located to manage the Captain and F/O Navigation Displays (3).

The EFIS Panels provide buttons/knobs for the following systems:

1. Flight Director (FD)
2. Landing System (LS)

3. Navigations-Displays (ND)
4. QNH entry

The Flight Directors on the PFDs are switched ON and OFF via the FD buttons on each EFIS control panel.

In real life operation, the FDs are switched-on before the take-off and remain engaged during the entire flight. The Autopilot is activated by means of the AP buttons on the FCU. Standard procedure is, that AP1 is engaged if the Captain is the pilot flying and AP2 if the F/O flies the Airbus. This procedure ensures, that both APs are alternatively operated. Eventual malfunctions can easily be detected before they jeopardise a flight.

The AP can safely be engaged after 100 feet and provide flight guidance until landing, even including the landing if an Autoland is carried-out. Performing an Autoland always require the prior acceptance by the ATC. Usually, the AP is operated together with the FDs, but can also be used individually, without an active FD.

In normal operation, flights without FD engagement are not endorsed. Most Airlines even do not allow take-offs and landings without at least one FD engaged.

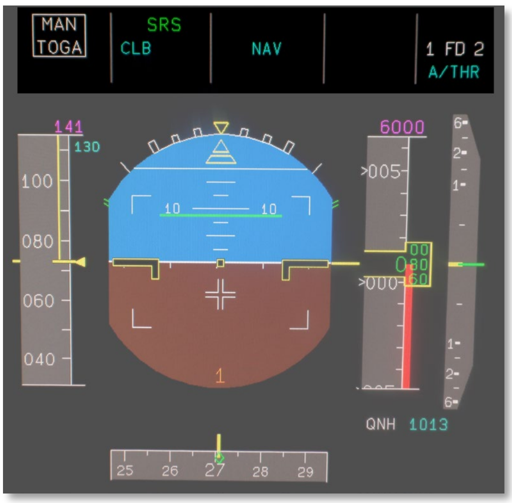
Nevertheless, Airlines encourage pilots to switch-off the AP (keeping the FD engaged) when the flight and operational conditions permit and fly the Airbus manually. This shall support the pilot to stay current with manual flight procedures.

The Flight Mode Annunciator (FMA)

The FMA informs the pilot about the active and armed AFS-Modes and the status of AP, FD and A/THR.

Pre-requisite for the display of the AFS modes is, that at least one FD or one AP is engaged. As mentioned before, FD and AP are engaged together in normal operation.

If neither FD or AP is engaged, then no modes are displayed.



The PFD with the FMA is the primary flight information display for the pilot. In case of doubt, the FMA information overrule divergent FCU readouts. For example: If the FCU and PFD display different altitude information, then the PFD prevails.

The FMA display information

MAN	SRS	RWY	CAT 3	AP1
TOGA	CLB	NAV	DUAL	1FD2
			DH500	A/THR

Column 1: AutoThrust (A/THR) Operation – TOGA take-off thrust has been set.

Column 2: Vertical Modes - the AFS commands **SRS** (Speed Reference System) as the initial climb mode. The following mode **CLB** (Climb) is armed.

Column 3: Lateral Modes - the AFS commands **RWY** (Runway) as the initial lateral Mode. The following mode **NAV** is armed.

Column 4: This column includes specific landing information.

Column 5: Both FDs and AP1 (Captain) are engaged, the **A/THR** is armed.

Line 1: The active modes are displayed in **Green**.

Line 2: The subsequent modes are armed and displayed in **Blue**.

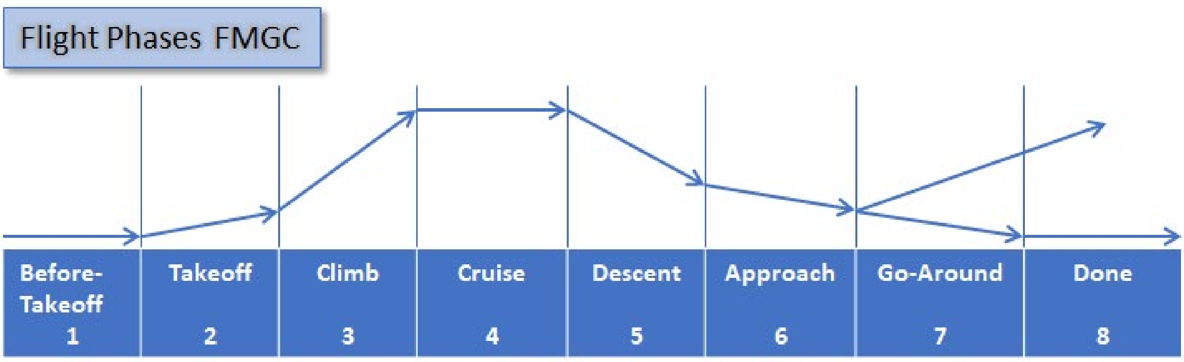
Line 3: This line is used for additional information. Information not directly linked to AFS Modes are displayed in **White**. Example: **MORE DRAG**

4.2 The Flight Phases

Not only the real Airbus pilot, but also the Flight-Simulator pilot just do not simply fly from airport A to B. He/she uses, like the professional colleagues, the Airbus AutoFlight System (AFS) to conduct the flight.

The FMGS (Flight Management and Guidance System) divides the flight into several Phases (Flight Phases) and provides flight guidance information via the AFS Modes. These modes are in effect for both, manual and automatic flight control when the FD and/or AP is engaged.

The FMGS knows eight (8) Flight Phases, which mirror the typical flight sequence.



The Flight Phases 1(Before Take-off) and 8 (Done) do not have associated AFS modes.

Monitoring of the flight progress with regards to the several flight phases is done by means of the MCDU. To do so, the MCDU facilitates specific Performance (PERF) and Progress (PROG) Pages, which provide data respective to the various flight phases.

4.3 The AutoFlight Modes - AFS Modes

The AFS contain a complex system of Modes, for which different designations are employed: AutoFlight-Modes, Guidance-Modes, FD/AP-Modes (Flight Director/Autopilot). This book uses the designation AFS-Modes (AutoFlight-System Modes).

The Principle of the AFS Modes

The Airbus AFS offers two options of flight guidance and AFS Modes respectively:

Managed AFS Modes:

- Valid Flight-Plan (F-Plan) with lateral and vertical guidance

Selected AFS Modes:

- Flight guidance information entered into the FCU by the pilot

Managed AFS Modes means: the FMGS takes the flight data from the Flight Management System (FMS) and steers the Airbus accordingly. Though, the Airbus follows the F-Plan-Profile vertically and laterally and considers (respects) Constraints (CSTR) with regards to altitude and speed.

To activate a Managed Mode, the pilot pushes the corresponding knob on the FCU, in the example the speed (SPD) knob.

The SPD window changes to dashes and the so-called managed-Dot (●) notifies the pilot of the mode change to **Managed**.

Selected AFS Modes means: the FMGS takes the flight information entered into the FCU by the pilot. The usual case is an instruction by the ATC (Air Traffic control), which requires the pilot to deviate from the original F-PLN, e.g. to fly a specific heading (HDG).

The pilot uses the SPD, HDG, ALT and V/S knob to enter the required value into the FCU. In the example the pilot dials-in the heading of 044º and activates the selected mode by pulling the corresponding HDG knob.

The value in the FCU window replaces the dashes and the managed-Dot (●) disappears to notify the pilot about the mode change to **Selected**.

Mixed operation of Managed and Selected AFS Modes is possible and frequently used, for example: managed speed- (SPD) and selected heading-mode (HDG) as shown in the picture above.

Specific to the Airbus is, that the pilot must always manually engage the climb or descent mode by pushing (managed) or pulling (selected) the ALT knob on the FCU. Even though the Navigation Display shows the Top of Climb/Descent, the Airbus will not automatically start the climb/descent. Certainly, there is always an exception from the rule: if the A320 reaches an altitude constraint (ALT-CSTR), the Airbus will level off and automatically start the new climb/descent after passing the CSTR.

As already mentioned, at least one FD and/or AP must be engaged to activate the AFS modes. The AFS-Modes are always displayed on both PFDs even if only one FD/AP is engaged. In case the flight shall be conducted manually without AFS modes, then both FDs must be switched-off. The A/THR reverts to **SPEED** mode, when both FDs are de-activated.

Whenever the conditions for the engagement of a Managed-Mode are not fulfilled and the mode cannot be engaged, the pilot must switch to the corresponding Selected Mode.

4.3.1 The AFS Mode - Systematics

Most of the AFS Modes are not limited to a specific flight phase, they are applicable to various flight phases or procedures.

The following table provides an overview of the available AFS modes and their scope of application.

	Managed Modes	**Selected Modes**
Vertical Modes	SRS CLB, DES ALT CSTR*, ALT CSTR, ALT CRZ G/S*, G/S FINAL, FINAL APP	OP CLB, OP DES, V/S, FPA ALT*, ALT, ALT CRZ V/S, FPA

	FLARE	
Lateral Modes	NAV, APP NAV LOC*, LOC	HDG, TRK
	RWY, RWY TRK, GA TRK ROLLOUT	

The AFS Modes according to their functionality

The Basic Modes

Basic MODE	VERTICAL	LATERAL
All Flight Phases	V/S	HDG

The Common Modes

COMMON MODE		VERTICAL	LATERAL
Take-off		SRS	RWY, RWY TRK
Altitude		ALT, ALT*, ALT CRZ	NAV, HDG
Approach	ILS Approach	G/S*, G/S	LOC*, LOC
		LANDING, FLARE,	ROLLOUT
	non-ILS / NPA	FINAL	APP NAV
Go-Around (GA)		SRS	GA TRK, NAV

The AFS Modes according to Flight Phases

FLIGHT PHASE		VERTICAL	LATERAL
2	**Take-off**	SRS	RWY, RWY TRK
3	**Climb**	CLB OPEN CLB V/S, FPA	NAV NAV, HDG NAV, HDG, TRK
4	**Cruise**	ALT*, ALT, ALT CRZ	NAV, HDG
5	**Descent**	DES OPEN DES V/S	NAV NAV, HDG NAV, HDG

6	Approach	G/S*, G/S V/S, FPA	LOC*, LOC NAV, HDG, TRK
7	Go-Around	SRS	GA TRK, NAV

Note: *Flight Phases 1 (Pre-Flight) and 8 (Done) do not have AFS-Modes.*

4.3.2 The Basic - Modes

Vertical Speed (V/S) and Heading (HDG) are the basic modes andbased on the so-called Raw Data..Basic modes are only available in Selected mode.

4.3.3 The Common - Modes

The Common Modes define a specific flight procedure and always contain a vertical and lateral AFS mode. These AFS modes cannot be altered by the pilot.

The Pre-Flight Phase - *Flight Phase 1*

By setting the take-off power either for maximum power (TOGA) or reduced power (FLX) the Pre-flight Phase ends.

The Take-off-Modes – *Flight Phase 2*

This Take-off-Phase consists of several steps:

Take-off-Roll, Rotation and the first Climb Phase with the SRS-Mode.

The SRS-Mode

SRS means Speed-Reference-System (SRS) and is not, as the name suggests, a Speed but a Pitch-Mode. The SRS mode commands the pitch necessary to fly a speed of V_2 + 10 knots from 30 feet/5 seconds after Rotation.

MAN TOGA	SRS CLB	RWY NAV		1FD2 A/THR

MAN FLX 54	SRS CLB	RWY NAV		1FD2 A/THR

In the first FMA column, MAN TOGA or MAN FLX is the Thrust mode of operation. They are not AFS modes and shown in White. In column 5, the **A/THR** is shown in **Blue**, which means it is armed and not yet active.

The **A/THR** is automatically armed, when the Thrust levers are set into the take-off detent (TOGA or FLX). The A/THR button on the FCU is illuminated in **Green**.

Pre-requisites for the SRS-activation: V_2 value entry into the MCDU PERF page, at least one FD switched-on and the flaps in position 1 or higher. Furthermore, at least 30 seconds must have been passed since the last landing. The V_2 input is the Trigger for the SRS- and RWY-Mode activation. The V_2 is the climb speed to safely overfly an obstacle of 35 meters even after failure of one engine (EO).

After Rotation when passing 30 feet/5 seconds, the **SRS**-Mode becomes active and the lateral Mode switches from **RWY**-Mode (Runway guidance) to **NAV**-Mode. The **NAV**-Mode requires a valid F-PLN, otherwise the **RWY-TRK**-Mode will be activated.

MAN TOGA	SRS CLB	NAV		1FD2 A/THR

In case of failure of one engine (EO), the **SRS**-Mode commands either V_2 or the actual Speed (whichever is higher), maximum V_2 +15 knots. The **SRS**-Mode ensures, that a minimum climb rate of 120 ft/min is achieved and the Pitch does not exceed 22,5º.

If the pilot selects a heading value on the FCU before the Take-off run, then the **RWY**-Mode switches to the **RWY-TRK**-Mode when passing 30 feet. The A320 flies the actual RWY track after Rotation until the pilot activates the **HDG**- or **NAV**-Mode.

MAN TOGA	SRS CLB	RWY TRK		1FD2 A/THR

The pilot has the choice to either activate the heading (**HDG**) by pulling the HDG knob or the **NAV**-Mode (F-PLN required) by pushing the HDG knob on the FCU.

MAN TOGA	SRS CLB	HDG/NAV		1FD2 A/THR

The Runway-Mode

The Runway-Mode consists of two Sub-Modes:

1. RWY-Mode: This Mode offers lateral guidance along the Runway until reaching 30 feet AGL after Rotation. The Mode requires the availability of a valid F-PLN and a Localizer (LOC) signal that will be automatically scanned by the FMGS.

MAN TOGA	SRS CLB	RWY NAV		1FD2 A/THR

The **RWY**-Mode will be de-activated when the **NAV** Mode becomes active.

RWY → NAV

2. RWY-TRK-Mode: If no LOC signal, or no active F-Plan is available, then the **RWY-TRK**-Mode will be active latest at 100 feet AGL. The **RWY-TRK** is the actual Runway Heading or the actual Heading (with a few degrees difference)

MAN TOGA	SRS CLB	RWY TRK		1FD2 A/THR

The **RWY-TRK**-Mode remains active as long as no other lateral Mode (**HDG**, **NAV**) has been activated by the pilot. The pilot may dial-in the required value in the FCU-window, to fly a specific **HDG** or activates the **NAV**-Mode if a F-Plan is available.

The Altitude Modes – *Flight Phase 3, 4*

When reaching the Thrust-Reduction Altitude (THR-RED) LVR CLB flashes in the first column. This is an information for the pilot to set the Thrust levers into the CL detent and command climb thrust.

MAN TOGA LVR CLB	SRS CLB	NAV		1FD2 A/THR

Because LVR CLB is an information or request and not an AFS-Mode, it is displayed in White. After the pilot has set the thrust levers into CL, the A/THR is automatically activated.

The MAN TOGA or FLX information is replaced by **THR CLB** (Thrust Climb-Mode). The A/THR Mode in column 5 changes from **Blue** (armed) to White (active). The active **THR CLB** Mode is displayed in column 1.

THR CLB	CLB ALT	NAV		1FD2 A/THR

By passing the Acceleration Altitude (ACC-ALT) the vertical Mode changes from **SRS** to **CLB**-Mode. Simultaneously, the Altitude-Mode is armed and the display in column 2 changes from **CLB** to **ALT**. That means, the **ALT**-Mode will be activated when the FCU altitude is reached.

The ACC-ALT in Germany is 1.000 feet or 1500 feet AGL (Above Ground Level), depending on the airline and Airport standard. Airbus defines the ACC-ALT as minimum 400 feet. However, the pilot may enter a specific ACC-ALT value into the MCDU (INIT Page).

Moreover, the climb speed changes from the initial value of V_2+10 to 250 knots, the maximum permitted speed until reaching flight-level (FL) 100 or 10.000 feet.

THR RED and ACC-ALT are defined by the Authorities and very often have the same AGL value. Only in case of a specific noise abatement procedure the two altitudes are different.

When the Airbus passes the ACC-ALT, the **ALT**-Mode will be armed automatically and displayed in **Blue**. After reaching the FCU selected altitude, the Mode becomes active and the display changes from **ALT** to **ALT**.

THR CLB	CLB ALT	NAV		1FD2 A/THR
SPEED	ALT	NAV		1FD2

				A/THR

The Climb-Modes are not part of the Common-Modes and will be explained later in a separate section.

The SRS-Mode can be de-activated before the ACC-ALT altitude by pulling the ALT-knob on the FCU. This will activate the Open Climb-Mode (**OP CLB**) and the A/THR-Mode (**THR CLB**). The new armed vertical Mode will be **ALT** (FCU-Altitude).

THR CLB	OP CLB ALT	NAV		1FD2 A/THR

The planned Cruising Altitude (CRZ-ALT) according to the F-Plan will be inserted into the MCDU (INIT Page) by the pilot. The AFS takes the entry to calculate the flight profile and for the activation of the AFS Modes. Level-off at the cruising altitude is confirmed with **ALT CRZ** on the FMA.

If no cruise altitude has been inserted into the INIT-Page, then the AFS takes the FCU-ALT as the cruise altitude when take-off power is applied. After the FCU-ALT is passed and a new altitude is selected, this altitude is taken as the new cruise altitude by the AFS. The message "**New Cruise ALT XX.XXX**" is displayed in the MCDU scratchpad.

The planned cruise altitude may be reached after several altitude steps, due to ATC instructions. This procedure is called step-climb. The FMA displays **ALT** as long as the actual altitude is below the planned cruise-altitude. It changes from **ALT** to **ALT-CRZ** when the cruise altitude according to the F-Plan and MCDU CRZ-Page is reached.

SPEED	ALT CRZ	NAV		1FD2 A/THR

Another reason for a Step-Climb may be an altitude constraint (CSTR-Constraint) which is displayed on the FMA as **ALT CSTR**.

SPEED	ALT CSTR	NAV		1FD2 A/THR

Whenever the ATC instructs to level-off at an altitude lower than the MCDU-INIT altitude, the pilot must manually adapt the cruise-altitude in the MCDU-CRZ-Page. Otherwise, the CRZ-Phase will not be activated and the Altitude-Mode **ALT** remains, see chapter 6.

SPEED	ALT	NAV		1FD2 A/THR

The Altitude-Mode knows the following variants:

ALT	ALT is the FCU selected flight level.
ALT CSTR	ALT CSTR is an altitude constraint (Constraint) and always part of a F-Plan.
ALT CRZ	ALT CRZ is the planned cruise level. ALT CRZ is shown on the FMA when the actual FCU altitude is either equal or higher as the F-Plan cruise altitude.

ALT*	ALT* is shown, when the Airbus is in transition to acquire the FCU altitude.

No value below 400 feet can be selected and no ALT-Mode be activated, if the Airbus is in Take-off or Go-Around Mode. As already mentioned, Airbus defines the ACC-ALT as minimum 400 feet and therefore, no altitudes below 400 feet are considered for the ALT-Mode activation.

The Altitude-Acquire-Mode **ALT*** is also called Capture Mode and informs the pilot, that the Airbus is levelling-off at the FCU altitude. This Mode is automatically activated by the AFS and the pilot has no access to influence, e.g. de-activate the Mode.

The **ALT*** range depends on the FCU altitude and the approaching rate (V/S and speed). The range is between 2000 and 200 feet.

The sequence of the **ALT**-Mode activation is as follows:

During the capture, when **ALT*** appears, the A/THR Mode changes from **THR CLB** to **SPEED**.

SPEED	ALT *	NAV		1FD2 A/THR

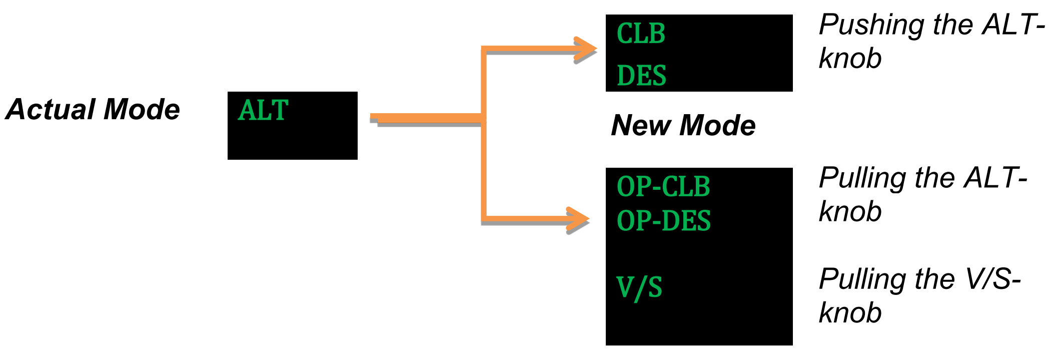
The Altitude-Modes will be activated by a defined scheme:

- During the climb or descent (**CLB**/**OP CLB** der **OP DES**/**DES**) the **ALT**-Mode is armed and shown at the FMA in **Blue** or **Magenta** (**altitude constraint**).
- If an Altitude-Constraint is part of the F-Plan, the Altitude Mode is displayed as **ALT-CSTR** in **Magenta**.
- The Altitude-Acquire-Mode **ALT *** is always displayed in **Green**.
- Once the Airbus has reached the desired altitude, the **ALT**/**ALT CRZ**/**ALT CSTR**-Mode becomes active they are all shown in **Green** on the FMA.

In Europa, the last 1000 feet to the selected FCU altitude are flown with a maximum climb rate of 1000 ft/min. Thus, a too fast approach towards Aircraft flying at the next flight level (FL) shall be avoided, as it may trigger an unnecessary TCAS (Traffic Collison) Alarm.

The ALT-Mode is automatically de-activated, if the pilot changes the FCU altitude by +/- 250 feet during the transition, when **ALT***- Mode is displayed on the FMA.

The pilot may de-activate the **ALT**-Mode by selecting another Vertical Mode as shown below.



The Approach-Mode – *Flight Phase 5, 6*

Like the Take-off-Mode, the Approach-Mode also consist of several segments: Approach, Land, Flare and Roll-out-Mode.

The A320 offers a variation of approach techniques for manual and/or automatic Landings. The most important procedures are listed below:

- ILS Approach
- LOC (Localizer) Approach, if the Glideslope (G/S) is unserviceable or not available. A good example is the LOC/DME26 Approach in Innsbruck (LOWI). No ILS-G/S is possible due to the surrounding terrain and the G/S is 3.8º instead of the usual 3º.
- NPA Approach (VOR/DME, VOR, NDB-ADF, RNAV)
- Visual Approach
- Circling Approach

ILS and managed NPA APPR-Modes are armed by pressing the APPR button on the FCU (below the V/S knob) when the Airbus is at least above 400 feet AGL.

Normally, the APPR-Mode is armed latest at the IAF (Initial Approach Fix) which is about 10 NM form the Airport.

The pilot can de-activate the APPR-Mode by pressing the APPR-button again. In case of loss of NAV signals, the APPR-Mode is automatically de-activated.

For an ILS approach, the associated Modes are **G/S** and **LOC** (Glideslope and Localizer), which are automatically activated by the AFS. The ILS signal is normally available about 25-30 NM from the Airport.

The APPR-Mode is activation sequence is as follows:

After passing 400 feet (latest 350 feet), the APPR-Mode changes to the **LAND**-Mode followed by the **FLARE**-Mode at 50 feet. After the Airbus has touched-down the **FLARE**-Mode is replaced by the **ROLLOUT**-Mode.

SPEED	LAND FLARE ROLLOUT		AP 1 2 1FD2 A/THR

Latest at the Final Approach Fix (FAF) both ILS-Modes **G/S** and **LOC** shall be active, even though they are activated independent from each other. This is entailed by the approach procedure requiring the pilot to intercept the **G/S** from below, when the Airbus is already lined-up with the **LOC**.

Localizer and Glideslope can be used independent from each other, like the LOWI LOC/DME26 Approach as mentioned before. In this case the LOC button is pressed instead of APPR. FPA (Flight Path Angle) or V/S is then the associated Vertical-Mode.

if the pilot presses the LOC-button during an ILS approach (**G/S** and **LOC** are already active), then only the **G/S** Mode is de-activated and changes to **V/S**, the **LOC**-Mode remains active. The actual V/S value, e.g. 700 ft/min, will be taken as the reference by the AFS.

The LOC-button is placed on the FCU, below the HDG-knob.

The APPR-Modes are de-activated, if the Pilot presses the APPR or LOC button again, or he/she selects another Vertical Mode. An automatic de-activation will occur, if the Airbus leaves the ILS corridor.

Any de-activation of the APPR-Mode results in a change to the Basic-Modes **HDG** and **V/S**.

SPEED	G/S V/S -700	LOC HDG		1FD2 A/THR

The approach is then no longer a precision but a so-called non-precision approach (NPA – **N**on-**P**recision **A**pproach). For a LOC NPA-Approach the FMA sequence looks as follows:

SPEED	ALT	HDG LOC		1FD2 A/THR	
SPEED	V/S -700	LOC		1FD2 A/THR	**LOC** – **V/S**- Mode
SPEED	FPA -3,3	LOC		1FD2 A/THR	**LOC** – **FPA**-Mode

Conventional NPA approaches can be flown with the Modes **HDG** / **V/S** or **TRK** / **FPA**.

Below, the FMA display for a conventional NPA-approach is shown.

SPEED	V/S -700	HDG		1FD2 A/THR	HDG – V/S-Mode
SPEED	FPA -3,3	TRK		1FD2 A/THR	TRK – FPA-Mode

The Airbus does not offer a conventional NPA-Approach with VOR-Radials as the lateral guidance. AFS controlled VOR-NPA approaches (AP or FD guided) are only possible, if the approach is stored in the FMS data-base and selectable via the MCDU-F-Plan page. A good example is the VOR28 Approach in Zurich (LSZH), see chapter 2.

There is no VOR-Approach button on the FCU, like the LOC button. If the pilot decides to manually fly a VOR-NPA-Approach, he/she must use the TRK-FPA function.

The vertical (**FINAL**) and lateral (**APP NAV**) Approach-Modes of an AFS guided NPA are simultaneously armed when the A320 overflies the IAF (Initial Approach Fix) on course/track and particularly the correct altitude (max. +/- 200 feet). Before reaching the IAF the pilot must enter the MDH/MDA into the MCDU PERF-APPR page.

SPEED	ALT FINAL	NAV APP NAV	MDH500	1FD2 A/THR

When overflying the FAF (Final Approach Fix) with the start of the final descent, the **FINAL APP**–Modes become active and the Airbus will descent towards the Runway. No Land and FLARE Mode is available, as the final landing is carried-out manually by the pilot.

SPEED	FINAL APP		1FD2 A/THR

If the NPA is flown with the AP, the AP will not automatically dis-engage at the MDA (Minimum Descent Altitude) or MDH (Minimum Descent Height). At the MDA -50 feet or when passing 400 feet AGL (latest at 350 feet) the message "**Disconnect AP for Landing**" will be displayed on the PFD

Difference between MDA / MDH and DA / DH

- MDA is the minimum altitude for NPA approaches – Minimum Descent Altitude = MSL
- MDH is the minimum height for NPA approaches – Minimum Descent Height = AGL
- DA is the minimum altitude for ILS approaches – Decision Altitude = MSL
- DH is the minimum height for ILS approaches – Decision Height = AGL

The Go-Around Mode (GA) – Flight Phase 7

The Go-Around-Mode (GA) combines the vertical **SRS**- with the lateral **GA-TRK** or **NAV**-Mode. The pilot activates the GA-Mode by setting at least one thrust lever into the TOGA detent with the flaps in position 1 or higher.

One thrust lever is sufficient, because the GA procedure can also be executed with one engine inoperative (EO).

Similar to the **RWY TRK**-Mode, the Airbus takes the actual heading as reference for the **GA TRK**-Mode. Newer AFS versions switch to **NAV**-Mode and activate the Missed-Approach part of the F-Plan.

MAN	G/S	LOC		1FD2
TOGA				A/THR
	SRS	GA TRK		1FD2
	CLB	NAV		A/THR

When the GA is initiated by the pilot, the **SRS**-Mode flies V_{APP}+15 knots or the actual Speed (whichever is higher) and not V_2, as for the take-off. V_{APP} is the approach speed with flaps in configuration 3 or Full. If the approach is conducted with flaps 3, the pilot must select F3 on the GWPS panel (Overhead panel).

Even if the approach was conducted manually with the FDs off, the FDs are automatically switched on and the GA-Modes are available. The same applies for a manual approach with the Bird activated, the FDs will replace the Bird symbol.

As for the take-off, the **SRS**-Mode will automatically change to **OP CLB** when passing the ACC-ALT. Usually the ACC-ALT for the GA is equally 1.000 feet or 1.500 feet AGL (Above Ground Level) or minimum 400 feet. However, a specific GA ACC-ALT can be inserted into MCDU INIT-page.

Contrary to a normal take-off, the target speed after the ACC-ALT is the **GD** (**o**) Speed. The **Green Dot**-Speed is not only the speed with the best drag-lift ratio, it is also the initial approach speed. After the GA initiation the pilot normally opts for a second approach and the **GD**-speed allows for an immediately configuration of the Aircraft for the approach.

The DONE Phase - *Flight Phase 8*

After landing, when the Airbus is at least 30 seconds on the ground, the FMGS switches to the Pre-Flight Phase (Flight Phase 1) and the next flight can be prepared.

4.3.3 The Basic - Modes

The Basic Modes (Basic Flight Information) are **V/S** for the vertical and **HDG** for the lateral flight guidance, regardless if the Airbus is in climb, level or descent.

SPEED	V/S +0	HDG		1FD2
				A/THR

SPEED	V/S +800	HDG		1FD2
				A/THR

SPEED	V/S -700	HDG		1FD2 A/THR

If the FD and/or AP is activated during manual flight, the basic modes HDG and V/S are displayed on the FMA. The actual value for HDG and V/S are used as reference data and displayed on the FMA and FCU windows as well. A so-called Mode Reversion occurs, when the basic modes are activated through the AFS.

4.3.4 The Vertical Modes

The vertical and lateral AFS-Modes are, together with the A/THR-Modes, the primary means to control the aircraft during a typical line operation.

The Vertical-Modes control the climb and descent and include the Managed Modes Climb (**CLB**), Descent (**DES**). The and the Selected Modes are Open-Climb (**OP-CLB**), Open-Descent (**OP-DES**) and Vertical Speed (**V/S**).

As already mentioned, the pilot must always initiate a climb or descent. The AFS initiates a climb or descent automatically only after a constraint (**CSTR**).

Die Climb Modes – Climb (CLB) und Open-Climb (OP-CLB)

Both Climb Modes are Pitch Modes, where the A/THR System commands Climb Power and the AFS controls the Pitch. The necessary pitch is calculated by the FMGC according to the speed either set by the pilot (selected speed) or pre-defined in the F-Plan (managed speed).

The only difference between the Climb-Mode (**CLB**) and the Open-Climb-Mode (**OP-CLB**) is, that the **CLB**-Mode considers all altitude and/or speed constraints included in the F-Plan. Moreover, the **CLB**-Mode includes the Acceleration Segment and the Speed Limit of 250 knots below FL100. The **CLB**-Mode is a Managed Mode requiring an active F-Plan.

Contrary, in **OP-CLB**-Mode, the A320 climbs directly to the FCU selected altitude without considering altitude and/or speed constraints. However, the **OP-CLB**-Mode considers the Speed Limit (SPD-LIM) of 250 knots below FL100, if operated together with Lateral-Mode **NAV**. That means, the **OP-CLB**-Mode does not consider the speed limit, if used with the selected **HDG**-Mode.

CLB-Mode is a managed Mode and armed when the take-off power is set, simultaneously with the **SRS** activation. The mode is automatically activated when the Airbus passes the ACC-ALT.

After Rotation (30 feet/5 seconds) the FMA shows the following information:

MAN TOGA	SRS CLB	NAV		1FD2 A/THR

SPD	HDG	ALT	LVL/CH	V/S
--- ●	--- ●	4500	●	----

After passing the ACC-ALT, the FMA information have changed as follows:

THR CLB	CLB	NAV		1FD2
	ALT			A/THR

SPD	HDG	ALT	LVL/CH	V/S
- - - ●	- - - ●	4500	●	- - - -

Below the LVL/CH labelling, the Dot (●) indicates that the Managed-Mode-**CLB** is active. The selected initial climb altitude is 4500 feet.

To activate the CLB-Modes, the following pre-conditions must be met:

- Active Flight Plan (F-Plan).
- The selected FCU altitude is higher than the actual altitude.
- The **NAV**-Mode is active.
- The Modes **G/S**, **LAND** (ILS), **FINAL** (NPA) and **GA** are not active.

Whenever the pilot decides to climb to a higher altitude, he/she must perform two steps:

1. Selecting a new altitude with the ALT knob, which is higher than the actual altitude, e.g. 4500 to 7000 feet.
2. Pressing the ALT knob to activate the **CLB**-Mode.

Dashes in the V/S window indicate, that the managed **CLB**-Mode is active and the climb rate is automatically adjusted to fly the optimum speed according to the F-Plan, usually 250 knots below FL100.

The managed **CLB**-Mode can only be used together with the managed **NAV**-Mode. No mixed Mode (Selected-Managed or vice versa) is possible.

THR CLB	CLB	NAV		1FD2
	ALT			A/THR

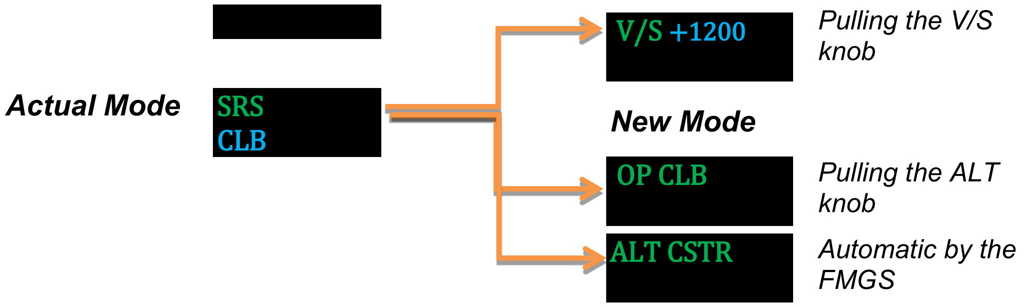
If the F-Plan contains an altitude constraint (CSTR), the **CLB**-Mode will automatically be armed and replaced by the **ALT-CSTR**-Mode. Synchronously, the A/THR changes from **THR CLB** to **SPEED**-Mode and the **CLB**-Mode is armed.

SPEED	ALT CSTR	NAV		1FD2
	CLB			A/THR

After passing the altitude constraint (**ALT-CSTR**), the **CLB**-Mode is automatically re-activated and the Airbus climbs to the selected altitude. This is the only condition for an automatic **CLB**-Mode activation. In all other cases, the pilot must manually engage the **CLB**-Mode.

THR CLB	CLB ALT	NAV		1FD2 A/THR

When the pilot selects another vertical mode (**OP-CLB** or **V/S**) or passing an altitude constraint (ALT-CSTR), the **CLB**-Mode is no longer armed as shown in the example below.



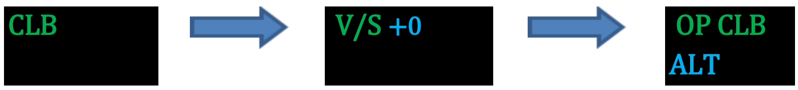
Furthermore, an active **CLB**-Mode is cancelled, if the pilot changes the lateral Mode from **NAV** to **HDG** by pulling the HDG-knob. The **CLB**-Mode changes to **OP-CLB**-Mode, because no mixed Mode (managed **CLB** and selected **HDG**) is possible.

If and when ATC-instructions or other operational reasons require an immediate level-off, the pilot pushes the V/S knob to perform the necessary Mode change.

With a push on the V/S-knob, the FCU window shows a V/S of 0 and the vertical Mode changes from **CLB** or **OP-CLB** to V/S **0**. The FCU-ALT remains unchanged.

After the conditions no longer exists, e.g. new ATC-instructions, the pilot pushes or pulls the ALT-knob to initiate a climb to the FCU-ALT.

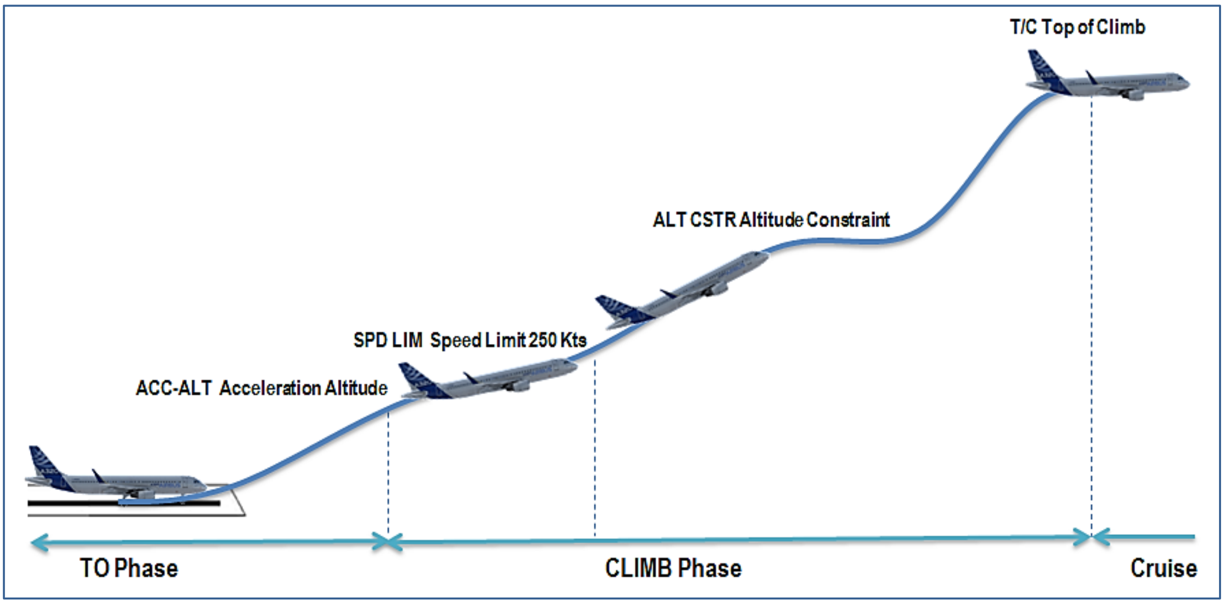
The FMA sequence looks as follows:



A Step-Climb is quite usual due to altitude constraints (ALT-CSTR) or ATC-instructions, which may require a short level flight between the various step-altitudes.

Another reason for a step-climb maybe the aircraft performance, especially for long distance flights. In this case, the amount of fuel and the resulting high take-off weight only enables the aircraft to climb first to a lower than the planned flight-level (FL). That means, the aircraft needs to reduce its gross-weight (GW) by burning fuel in order to climb step-by-step to the planned flight-level.

Short and medium range Aircrafts such as the A320 family, are able to climb straight to the planned flight-level.



OP-CLB-Mode is a selected CLB-Mode and all altitude (**ALT-CSTR**) and speed constraints (**SPD-CSTR**) are no longer considered.

A selected-managed mixed-Mode with the vertical **OP-CLB**- and lateral **NAV**-Mode is possible and also includes the speed-limit (SPD-LIM) of 250 knots below FL100. However, speed constraints (SPD-CSTR) are still not taken into consideration. When the **OP-CLB**-Mode is active together with the selected lateral HDG-Mode, then the SPD-LIM 250 knots is not followed.

In order to activate the **OP-CLB**-Mode two steps are necessary:

1. The Pilot dials the new altitude using the ALT knob, which must be above the current altitude, e.g. 7000 feet.
2. The Pilot pulls the ALT knob to activate the **OP-CLB**-Mode.

If the Pilot pulls the HDG knob, the lateral Mode changes from the managed Mode **NAV**-to the selected Mode **HDG**. Hence, the vertical Mode automatically changes from **CLB** to **OP-CLB**. The A/THR remains in the **THR CLB**-Mode and the **ALT**-Mode stays armed.

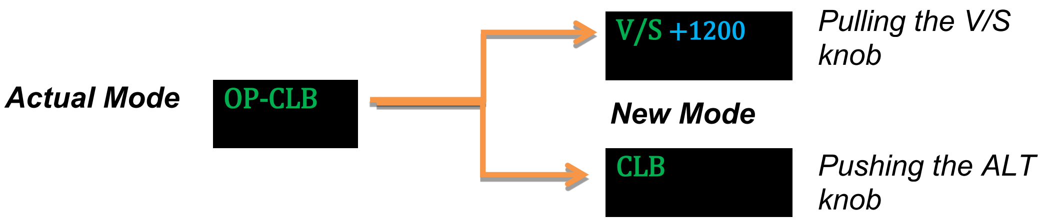
Dashes in the FCU V/S window indicate, that the **OP-CLB**-Mode is active. Because **OP-CLB** is a selected Mode, the so-called managed dot is not shown in the LVL/CH window. **The OP-CLB**-Mode can be activated at 100 feet after lift-off.

On the FMA and FCU, the following information are provided to the pilot:

THR CLB	OP CLB ALT	NAV		1FD2 A/THR

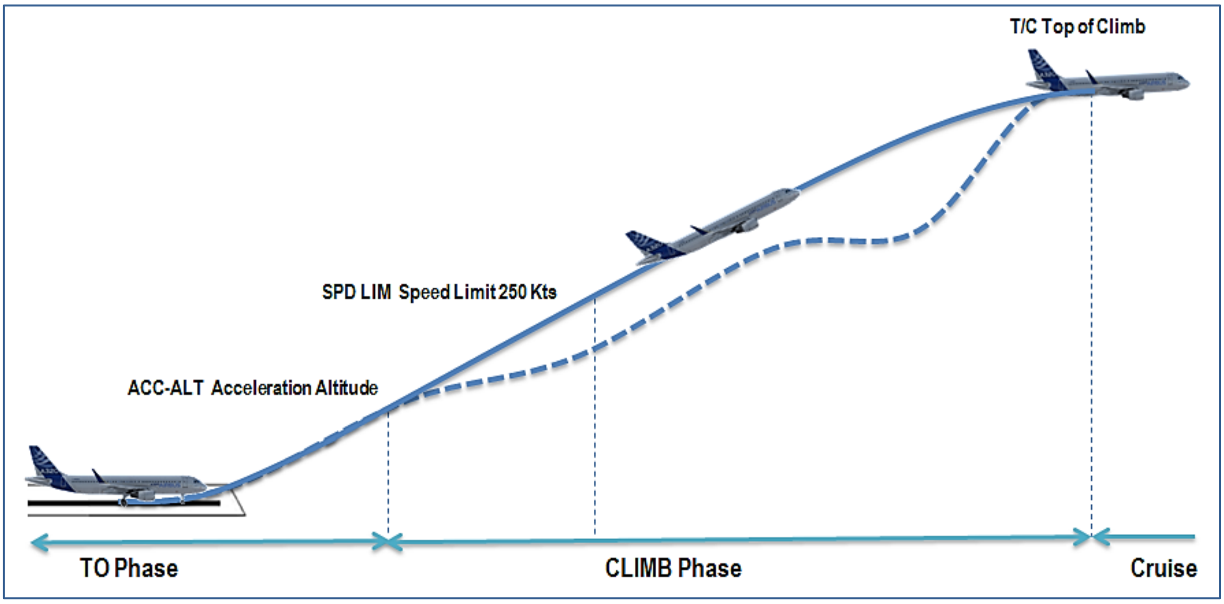
SPD	HDG	ALT	LVL/CH	V/S
- - - ●	- - - ●	7000		- - - -

When the pilot selects another vertical Mode, the **OP-CLB** is de-activated.



If the pilot pushes the ALT knob, the **OP-CLB**-Mode switches to the **CLB**, pre-supposed of an active F-Plan with **NAV**-Mode armed. The A/THR remains in the **THR CLB**-Mode.

The following graphic shows the difference between the **OP-CLB**- (straight line) and the **CLB**-Mode (dotted line).



The Vertical-Speed-Mode (V/S)

The V/S-Mode is a selected Mode, if the ATC occasionally may require a specific climb ratee. In order to activate the V/S-Mode, the pilot must perform two steps:

1. Select the target V/S by rotating the V/S-knob. With the first rotation (just one klick) the actual V/S is displayed in the V/S window. Afterwards, rotating the knob to the right will increase, rotating left reduce the V/S-rate.
2. Ppulling the knob to activate the V/S-Mode.

The change to the selected V/S-Mode must be performed within 45 seconds, otherwise the actual Mode remains active, either the selected **OP-CLB** or the managed **CLB**-Mode.

When the V/S-Mode is activated, the A/THR (if active) automatically switches from **THR CLB** to **SPEED**-Mode and the V/S has priority over speed. That means, if the V/S is too high, the Aircraft speed will decrease, even when the engines produce full climb power.

The V/S window shows the selected rate and the dashes and managed dot (below the LVL/CH indication) are no longer indicated. In the SPD window, the managed dashes may still be shown, if the A/THR remains active.

When the V/S-Mode is active, the FMA shows the following information:

SPEED	VS +1200 ALT	NAV		1FD2 A/THR

It is possible to activate the V/S-Mode during the SRS Phase after passing 100 feet. The actual V/S rate will be taken as target.

The Descent Modes - Descent (DES) and Open-Descent (OP-DES)

In principle, the Descent Modes are the opposite to the Climb Modes.

1. With an active **CLB**-Mode the A/THR commands maximum **CLB-THR**, while the Thrust setting for the **DES**-Mode is **IDLE**.
2. The FD commands maximum climb-rate for the **CLB**- and maximum sink rate for **DES**-Mode, both in accordance with the FMGS-calculated vertical profile.

For both Descent Modes, **DES** and **OP-DES**, the Aircraft Pitch defines the descent rate based on **IDLE** power. That means, the A/THR system sets **IDLE** power and the FMGS commands the necessary Pitch to fly the calculated descent speed (vertical profile).

Like for the climb modes, the only difference between the **DES** and the **OP-DES**-Mode is the consideration of altitude and speed constraints. The **DES**-Mode also includes the Deceleration Segment (DECEL) and the SPD-LIM of 250 knots below FL100.

The **DES**-Mode is a managed Mode and requires an active F-Plan.

With the **OP-DES**-Mode active, the A320 will descent straight to the FCU selected altitude. However, the **OP-DES**-Mode considers the SPD-LIM of 250 knots below FL100, if operated together with the managed **NAV**-Mode. The SPD-LIM will not be considered, if the **OP-DES**-Mode is active with the selected **HDG**-Mode.

Any **DES**-Mode must always be manually activated by the pilot. If the pilot misses to initiate the descent, the Airbus will then fly beyond the ToD (Top of Descent) point. Nevertheless, the Airbus will still follow the lateral F-Plan.

To activate the **DES**-Mode, the following pre-conditions must be fulfilled:

- Active Flight Plan (F-Plan).
- The FCU selected altitude must be lower than the actual altitude.
- The **NAV**-Mode is active.
- The Modes **G/S**, **LAND** (ILS), **FINAL** (NPA) and **GA** are not active.

To activate the **DES**-Mode the pilot must perform two steps:

1. Select the new altitude by rotating the ALT knob, e.g. from 7000 feet to 4.500 feet.
2. Pushing the ALT knob to activate the **DES**-Mode.

The FCU V/S window shows Dashes to indicate, that the managed **DES**-Mode is active. Below the LVL/CH indication, the managed Dot (●) is illuminated.

The FMA shows the following information after activation of the **DES**-Mode:

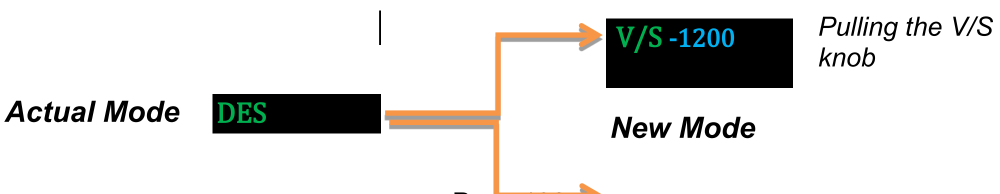
THR IDLE	DES ALT	NAV		1FD2 A/THR

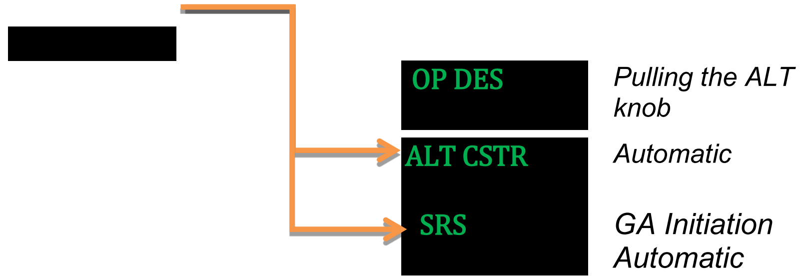
Under certain circumstances, e.g. the descent has been initiated before the ToD, the descent profile will be shallower than normal and idle power is not be sufficient. In this case, the A/THR remains in **SPEED**-Mode, until the calculated descent profile is followed.

On the FMA the following information are shown:

SPEED	DES ALT	NAV		1FD2 A/THR

Similar to the **CLB**-, the **DES**-Mode will be de-activated if the pilot selects another descent mode, or in case of an altitude constraint. Moreover, the **DES**-Mode is automatically de-activated and superseded by the **SRS**-Mode, if a Go-Around (GA) is initiated by the pilot.





Furthermore, the **DES**-Mode will be de-activated automatically, if the pilot changes from the managed **NAV** to selected **HDG**-Mode by pulling the HDG knob. The resulting Mode change is from **DES**- to the **V/S**-Mode. The reason why the **DES**-Mode reverts to **V/S** and not **OP-DES** is to keep the actual descent rate. Changing to **OP-DES** could result in an unwanted and substantial increase of the descent rate.

The A/THR-Mode changes to the **SPEED**-Mode.

When the Airbus intercepts an altitude constraint (ALT-CSTR), the **DES**-Mode is automatically armed.

SPEED	ALT CSTR DES	NAV		1FD2 A/THR

After passing the ALT constraint, the **DES**-Mode is automatically re-engaged and the Airbus continues the descent to the FCU altitude.

SPEED	DES ALT	NAV		1FD2 A/THR

This is the only procedure, where the **DES**-Mode is armed, similar to the **CLB**-Mode. Neither the **DES** or the **CLB**-Mode can be armed by the pilot.

The AFS, or more precisely the FAC, calculates the sink profile from the 1.000 feet point backwards to the ToD (Top of Descent), considering all F-Plan data. The DECEL point, where the Airbus starts reducing the initial approach speed of 250 knots to the final approach speed VAPP is considered

The DECEL point is also the beginning of the aircraft configuration for the approach (flap and gear extension). The speed reduction is calculated, that the final approach speed VAPP is reached at 1000 feet above the Runway Touch Down point. The sink profile is calculated by the FMGS considering the actual wind information (wind pages and APPR page) and the vertical and lateral F-Plan data.

If a level-off is required during the descent, e.g. 5500 feet according to an ATC instruction, the pilot only needs to push the V/S knob. By pushing the V/S knob, the FMGS immediately commands a vertical speed of 0 ft/min.

The **DES**-Mode reverts to **V/S**, but the original FCU altitude selection, e.g. 4500 feet, remains unchanged.

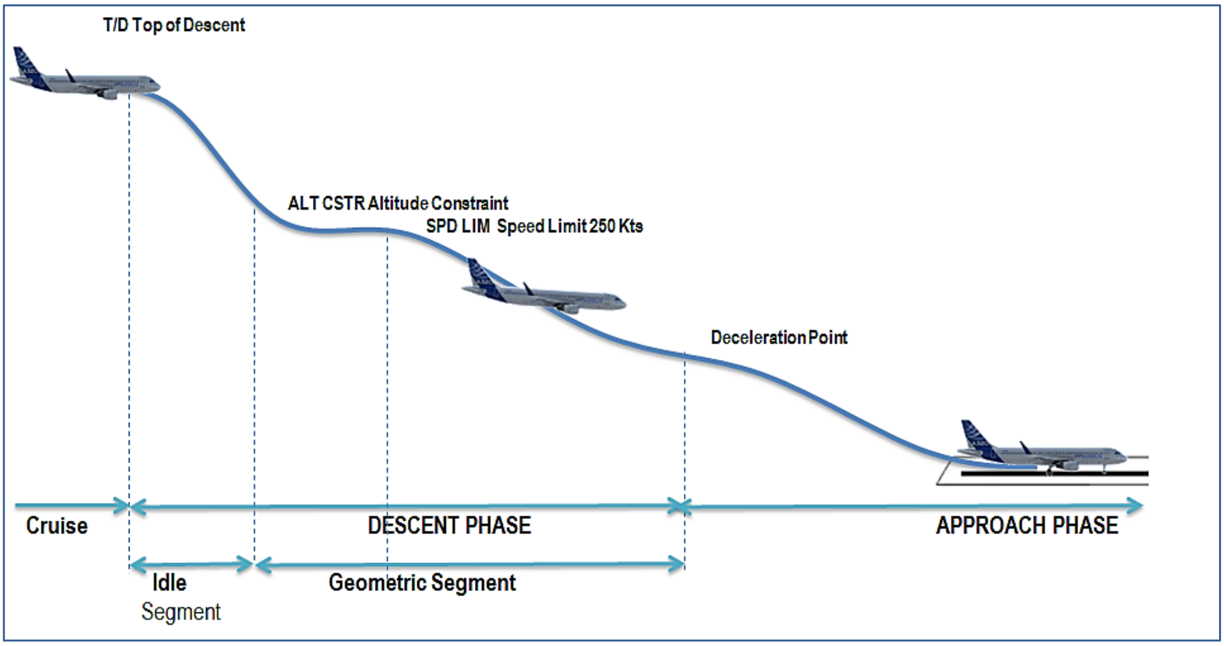
When the level-off is no longer required, the pilot may continue the descent by pushing the ALT knob and re-activating the **DES**-Mode. The V/S window shows Dashes and the managed Dot (●) to confirm the mode change.

On the FMA the procedural sequence looks as follows:

DES ALT	→ V/S +0 ALT	→ DES ALT

During this procedure the ALT value in the FCU-ALT-window does not change. The actual level-off ALT can only be seen on the PFD (ALT tape). This is one of the possibilities for a so-called step descend.

The Descent Phase is divided into segments according to the vertical FMS concept.



The geometric segment of the descent is always located between two defined waypoints (WPT). An IDLE segment, as the name already indicates, is part of the descent where the Airbus flies with **IDLE** engine thrust.

A descent with several geometric segments (steps) is standard procedure to follow altitude constraints, according to the design of the approach (STAR-Standard Terminal Approach Route), as well as ATC instructions.

The OP-DES-Mode is, like the **OP-CLB**, a Selected Modeand neither considers altitude (ALT-CSTR) nor speed constraints (SPD-CSTR).

However, if the selected **OP-DES** is operated together with the managed **NAV**-Mode (mixed-Mode operation), then the Speed-Limit (SPD LIM) of 250 knots below FL100 is considered. The other speed constraints (SPD-CSTR) as per F-Plan are still neglected. When the selected **OP-DES** is used together with the selected **HDG**-Mode, then SPD LIM is also not considered.

To activate the **OP-DES**-Mode, the pilot must perform two activities:

1. Selecting the new altitude by rotating the ALT knob, which must be below the actual altitude, e.g. from 7000 feet to 4500 feet.
2. Pulling the ALT knob to activate the **OP-DES**-Mode.

The FCU will show (Dashes) in the V/S window to indicate that the **OP-DES**-Mode active. There is no managed Dot (●) below the LVL/CH, because it is a selected mode.

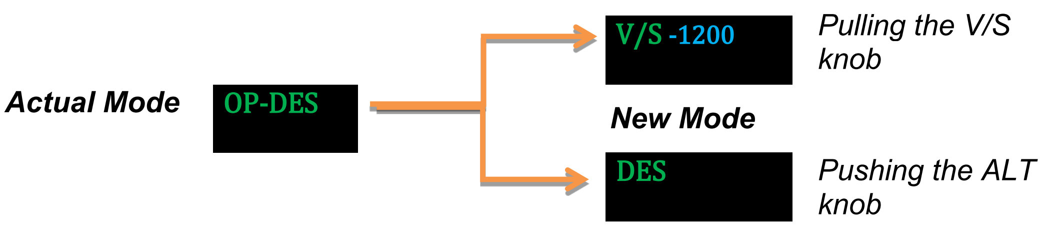
On the FMA and FCU the **OP-DES**-Mode is indicated as follows:

THR IDLE	OP DES ALT	NAV		1FD2 A/THR

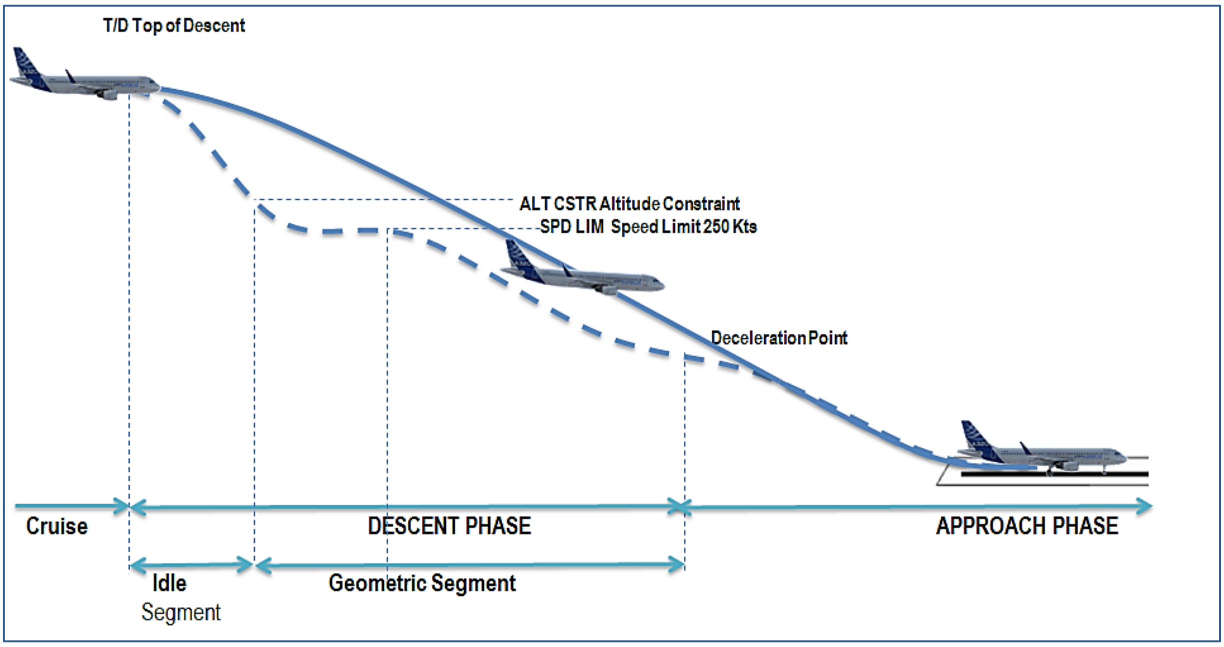
SPD	HDG	ALT	LVL/CH	V/S
- - - ●	- - - ●	4500		- - - -

The **OP-DES**-Mode is automatically de-activated, if the pilot selects another vertical mode, e.g. pushing the ALT knob to change to the managed **DES**-Mode. Pre-requisite is a valid F-Plan and the **NAV**-Mode must be active. The A/THR usually remains in **THR IDLE**-Mode, but this depends on the F-Plan leg. The leg may require additional thrust and consequently the A/THR reverts to the **SPEED**-Mode.

The **OP-DES**-Mode will be de-activated, if another vertical Mode is activated.



The following graphic shows the difference between the **OP-DES**- (straight line) and the **DES**-Mode (dotted line).



The Vertical-Speed-Mode (V/S)

Whenever a specific Descent Rate is required, e.g. ATC instruction or pilot decision (e.g. too high on the profile), the pilot dials the desired rate into the FCU V/S window. With the first klick on the V/S knob, the actual V/S value will be shown. Afterwards, the pilot selects the descent rate by rotating the V/S knob (+ to the right / – to the left), e.g. -1200 ft/min.

Below the LVL/CH indication, no managed Dot is shown, as **V/S** is a selected mode.

The Minus-sign (hyphen) in front of the V/S-value indicates a negative or descent rate. If no sign is shown, then the selection is automatically plus, or a climb rate value respectively.

The mode change must be confirmed within 45 seconds by pulling the V/S knob, otherwise the previous mode remains active. The V/S window again shows the Dashes to confirm the previous mode. If the previous mode was **DES** then the managed Dot (●) below the LVL/CH indication illuminates. In case of the **OP-DES**-Mode the Dot is not shown.

The A/THR always reverts from **THR IDLE** to the **SPEED**-Mode when the **V/S**-Mode is activated, but remains in managed mode, if active.

On the FMA the V/S-Mode is confirmed as follows:

SPEED	VS -1200 ALT	NAV or HDG		1FD2 A/THR

4.3.5 The Lateral Modes

The following lateral Modes are available:

- Heading (HDG) or Track (TRK)
- NAV (Navigation-Flight Plan-Mode)

The Heading (HDG) – Track (TRK) Mode

The **HDG** or **TRK**-Mode is a Selected Mode which steers the Airbus along a pilot desired flight path.

The heading is the Aircraft's flight path related to magnetic north (compass course) and is influenced by the actual wind conditions. Track (TRK) is the heading corrected by the wind influence, the wind correction angle.

The change-over push-button from **HDG** to **TRK** and vice versa, is located in the middle section of the FCU above the two AP buttons.

Pressing the button once changes the mode from HDG-V/S to TRK-FPA. Pressing of the button again, changes back to HDG-V/S.

When the pilot switches from HDG-V/S to TRK- FPA, the Bird (FPV-Flight Path Vector) will be shown on the PFD. The Bird will disappear if the pilot switches back to the HDG-V/S modus.

The **HDG**-Mode can either be operated with the **V/S**- or **OP-CLB**-**OP-DES**-Mode, the **TRK**-Mode with **FPA**- or the **OP-CLB**-**OP-DES**-Mode.

The **HDG**-Mode is automatically activated if the Airbus enters a F-Plan Discontinuity (**NAV** to **HDG**). A Discontinuity is an interruption of the F-Plan track or an open section, see chapter FMS. As already mentioned, the vertical Mode changes from **CLB**- to **OP-CLB** and during the descent from **DES**- to the **V/S**-Mode. If the Airbus is in level flight (**ALT**- or **ALT CRZ**-Mode), no vertical mode change occurs.

Furthermore, the **HDG**-Mode is automatically activated, if the pilot leaves the Localizer segment during an ILS or LOC approach.

The most common **HDG** activation is the manual activation by the pilot (HDG Select). Simultaneously, the vertical mode changes from **CLB** to **OP-CLB** or **DES** to **V/S**-Mode.

To manually activate the **HDG**/**TRK**-Mode, two activities must be performed by the pilot:

1. The pilot selects the HDG/TRK, by dialing the desired value with the HDG knob. e.g. 044°.
2. The pilot pulls the HDG knob to activate the **HDG** or **TRK**-Mode.

With the first klick on the HDG knob, the actual HDG/TRK value will be shown. Afterwards, the pilot selects the descent HDG/TRK by rotating the HDG knob accordingly (+ to the right / – to the left). The manged Dot (●) disappears.

All further HDG/TRK changes are performed by simply dialing-in the desired value with the HDG knob. No repeated pulling of the HDG knob is necessary. The mode change must be confirmed within 45 seconds by pulling the HDG knob, otherwise the previous mode remains active.

The **HDG/TRK**-Mode is de-activated by pushing the HDG knob, which also activates the managed **NAV**-Mode. In this case the managed Dot (●) will be shown after the HDG value to confirm that **NAV** is armed. Pre-requisite for the **NAV**-Mode activation is an active F-Plan and the crossing of the HDG with the F-PLN course.

Otherwise pushing the knob has no effect and the A320 remains in **HDG**-Mode.

Synchronisation of the HDG - FCU window

If the selected **HDG**-Mode is active, then the actual heading is always shown in the HDG window of the FCU. By rotating the HDG knob the pilot selects a new HDG, which is immediately followed by the FD/AP, with a bank rate of 25º. In case the A320 is flow manually by the pilot, the blue triangle (HDG bug) is shown on the PFD and the pilot must steer the Airbus accordingly. The FD is normally engaged and commands the necessary Sidestick inputs to fly the new HDG.

If the managed **NAV**-Mode is active, then the first klick with the HDG knob synchronises the FCU window with the actual HDG, e.g. 80º. Only when the pilot pulls the HDG knob the **HDG** mode will be activated and the actual HDG is the target.

SPEED	ALT	NAV		1FD2 A/THR

SPD	HDG	ALT	LVL/CH	V/S
- - - ●	080 ●	4500	●	- - - -

The managed Dot (●) right to the HDG value indicates, that the managed mode is still active. That means, that the A320 still flies according to the active F-Plan.

The pilot must confirm the mode change within 45 seconds, by pulling the HDG knob, otherwise the pilot inputs will disappear and the A320 remains in managed **NAV**-Mode.

Hence, the FCU window will again show the dashes and the managed Dot (●) to indicate the managed lateral **NAV**-Mode:

SPD	HDG	ALT	LVL/CH	V/S
--- ●	--- ●	4500	●	----

Take-off Procedure

If the pilot selects a Pre-Heading before the take-off (Preset-Function), the HDG value will be shown in the FCU-HDG window. The managed Dot (●) next to the HDG value informs the pilot, that **HDG** is Preset and a F-PLN is available.

SPD	HDG	ALT	LVL/CH	V/S
--- ●	044 ●	4500	●	----

The Preset-Function can be executed before or during the take-off until a height of 30 feet RA. After rotation, the **RWY**-Mode will be de-activated and the lateral Mode changes to the **RWY-TRK**-Mode. The Airbus continues on the **RWY-TRK** prior to further pilot action.

MAN	SRS	RWY		1FD2
TOGA	CLB	RWY TRK		A/THR

The pilot activates the **HDG**-Mode by pulling the HDG knob and simultaneously arms the **NAV**-Mode.

MAN	SRS	HDG		1FD2
TOGA	CLB	NAV		A/THR

Pushing the HDG knob cancels the **HDG**-Preset and activates the **NAV**-Mode, pre-condition of an active F-Plan. Without an active F-PLN, pushing the HDG knob will have no effect and the A320 remains in the **RWY-TRK**-Mode until the **HDG**-Mode is activated.

MAN	SRS	NAV		1FD2
TOGA	CLB			A/THR

ATTENTION must be given to this procedure when the pilot flies the A320 manually and diverts from the **RWY-TRK**.

If the pilot activates the AP while the A320 flies in **RWY-TRK**-Mode, then the **RWY-TRK** is the target and not the actual HDG. That means, the A320 will immediately turn from the actual heading to the **RWY-TRK**.

This can be a frightening procedure, if it happens within a mountainous terrain and the two values differ substantially from each other.

Go-Around (GA) Procedure

The Preset-Function is also available during a Go-Around (GA), if either of the following Modes is active: **LOC***, **LOC**, **LAND**, **FINAL APP** or **GA**.

If the pilot selects a specific HDG, then, like for the take-off, the HDG value is shown in the FCU window, until the pilot activates the **HDG**-Mode. This function is specifically helpful during a GA and assist the pilot in this often-hectic flight phase.

The Navigation-Mode (NAV)

The NAV-Mode is the Managed Lateral Mode and only available with an active and valid flight plan (F-Plan).

When the pilot initiates the take-off roll (setting take-off power), the **NAV**-Mode is automatically armed and becomes active (**NAV**) when the A320 passes 30 feet (AGL).

There are two ways of activating the NAV-Mode:

- Automatically after lift-off when passing 30 feet
- If the pilot pushes the HDG knob when the Airbus is actually in **HDG**-Mode

In order to manually activate the **NAV**-Mode, the pilot pushes the HDG knob and the **NAV**-Mode is immediately activated if the Airbus flies within 1NM of the F-Plan track.

In the FMA the mode change is illustrated as follows:

SPEED	ALT	HDG NAV		AP1 A/THR

If the Airbus is more than 1 NM away from the F-Plan track, the pilot must fly a HDG which intercepts the F-Plan track, otherwise the message "NO NAV INTERCEPT" will be shown on the MCDU.

In the following example the A320 flies an actual heading of 153º, which is almost parallel to the F-PLN track. Pushing the HDG knob will have no effect until the pilot selects a heading of e.g. 185º that crosses the F-PLN track. This will arm the **NAV**-Mode.

SPEED	ALT	HDG NAV		1FD2 A/THR

The FCU displays the new heading value of 185º and the manged Dot (●), informing the pilot that the **NAV**-Mode is armed and NAV-Intercept is possible.

On the ND, the left **Green straight Line** is the actual heading of 153º.

The **Green dotted Line** is the F-PLN TRK.

The **Blue triangle** is the newly selected heading of 185º, that crosses the F-PLN-TRK. The right **Green straight Line** is the new heading.

Because the A320 flies in HDG-Mode the pilot does not need to pull the HDG knob but just select the desired new heading.

The **NAV**-Mode is armed, when the Airbus flies in **HDG**-Mode (185º) and the pilot pushed the HDG knob.

During an approach in **NAV**-Mode and on F-Plan track, the pilot arms the APPR-Mode by pressing the APPR button on the FCU. When the Airbus captures the localizer, the **NAV**-Mode automatically switches to **LOC**-Mode.

This procedure is valid for an ILS Precision Approach, as well as for a Non-precision (NPA) **LOC**-Approach.

The **NAV**-Mode is de-activated when:

- the pilot pulls the HDG knob, hence activating the **HDG**-Mode
- the pilot selects an OPEN-Mode (**OP-CLB**, **OP-DES**)
- the pilot uses the PRESET-Function for take-off and GA
- the **LOC**-Mode is automatically activated
- the Airbus enters a F-PLN discontinuity
- NAV accuracy is degraded

4.4 The AutoThrust (A/THR) - Modes

The Aircraft Speed is controlled either by Pitch (AP/FD) or Thrust ((A/THR).

Both, the AP/FD and the A/THR system cannot control the speed via Pitch and Engine Thrust at once. Thatmeans, either Pitch or Thrust is the main means of speed control.

The inter-activity of AP/FD and A/THR is straight forward and comprises the following operating modes:

1. The AP/FD Modes control the pitch according to the target speed. The corresponding A/THR Mode is **SPEED**.

SPEED — In **SPEED** Mode, the A/THR holds the speed as calculated by the AFS or selected by the pilot, by adjusting the engine power accordingly.

2. The AF/FD Modes command the maximum climb/minimum descent rate via the pitch, the A/THR sets maximum/minimum engine thrust. The corresponding A/THR Mode is thrust-**THR**. The **THR-**Mode is divided into:

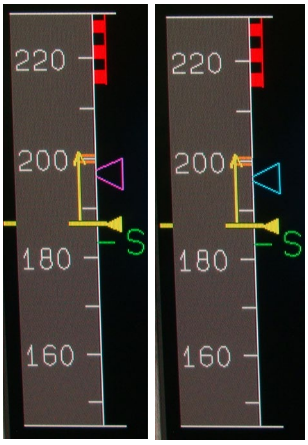
THR CLB — Maximum Climb Thrust-**THR CLB**, to fly the optimum climb rate.

THR IDLE — Idle thrust-**THR IDLE**, to fly the optimum descent rate.

3. In case whether AP and/or FD are active, the A/THR always controls the target speed. The corresponding A/THR Mode is **SPEED**.

SPEED — The A/THR holds the target speed as selected by the pilot in the FCU-SPD-window.
If the pilot switches AP and FD OFF, the managed A/THR Mode will automatically change to selected Mode. The actual Aircraft speed becomes the target speed and is illustrated by the **Blue** speed bug (**Triangle**) on the PFD.

Like the AFS Modes, the A/THR system also distinguishes between Managed und Selected Modes (thrust operation modes).



1. The Managed Mode controls the target speed as calculated by the FMGS and is illustrated by a **Magenta Triangle** on the PFD.
2. The Selected Mode sets the necessary engine thrust to fly the pilot selected target speed and is illustrated by a **Blue Triangle** on the PFD.

The examples show a FMGS calculated target speed of 198 knots (**Magenta Triangle** on the far-left picture) and a pilot selected speed of 198 knots (**Blue Triangle** on the left picture).

The **Yellow Speed Trend Arrow** indicates, that the speed is increasing and will reach 200 knots within 10 seconds. The speed trend will change when the pilot either adjusts pitch or power.

4.4.1 The A/THR in Managed-Mode

As already mentioned, the Managed A/THR Mode sets the necessary engine thrust to fly the target speed as calculated by the FMGS. Speed constraints of the F-Plan will be taken into consideration as well as the speed limit (SPD LIM) of 250 knots below FL100.

A F-Plan can contain several speed constraints but only one SPD LIMeach, for climb and descent.

The Speed window shows Dashes **- - -** as the confirmation, that the A/THR is controlled via the FMGS.

The managed Dot (●) indicates, that the A/THR is active in **Managed** Mode.

4.4.2 The A/THR in Selected-Mode

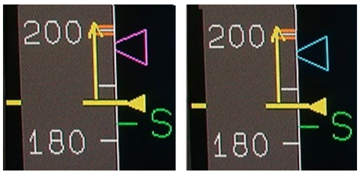
The **selected** A/THR-Mode always takes the target speed information from the FCU SPD window.

If the A/THR is operated in **Managed** Mode and the pilot needs to change to **Selected** Mode (e.g. ATC instruction), the following steps are required:

1. With the first klick of the SPD knob, the actual speed will be shown in the FCU SPD window. The managed Dot (●) confirms, that the A/THR is still in Managed Mode.

2 The pilot either accepts the actual speed as the target. Or he/she dials-in the required speed value, by rotating the SPD knob accordingly (+ to the right / – to the left).

3 Only when the pilot pulls the SPD knob, the A/THR changes from **managed** to **selected** mode and the speed bug from **Magenta** to **Blue**. Simultaneously, the A/THR adjusts the engine power to fly the selected speed. The manged Dot (●) disappears.



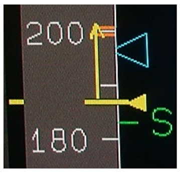
Any further change of the target speed isdone by simply dialing the required speed value into the SPD window. A repeated pulling of the SPD knob is not required.

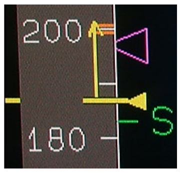
The mode change must be done by pulling the SPD knob within 10 seconds, otherwise the A/THR remains in managed mode. The speed value will be erased and replaced by the Dashes to confirm the managed mode is still active with the previous FMGS target speed.

If the pilot wishes to switch back to the managed mode, he/she pushes the SPD knob as shown in the next picture. The mode change occurs immediately and the Dashes replace the speed value in the FCU SPD window, precondition of an active F-Plan.

The speed indication on the PFD changes back from **Blue** to **Magenta**.

The managed Dot (●) in the right picture confirms, that the A/THR is now again in **Managed** Mode.





4.4.3 The A/THR Speed-Mode (SPEED)

In **SPEED**-Mode, Managed or Selected, the A/THR controls the target speed by setting the engine thrust as required.

During Level Flight, the A/THR is always either in **SPEED** or **MACH**-Mode depending on the Flight Level-FL (transition approximately FL270). The Aircraft pitch remains stable (usually between 2-3º) and the A/THR controls the FMGS calculated speed by adjusting the engine thrust.

Airbus has introduced a so-called Soft-Altitude-Function allowing the altitude to fluctuate by +/-50 feet (e.g. wind influence) without the need for thrust adjustment. Avoiding small and permanent thrust changes improves the Pax comfort and also reduces fuel consumption.

The descent is usually flown with IDLE thrust, but under certain circumstances some engine thrust may be necessary. For example: if ATC instructs to descent before the ToD (Top of Descent), the shallower descent profile (lower sink rate as calculated by the FMGS) requires some engine thrust to fly the normal descent speed (e.g. Mach 0.78).

For example: if ATC instructs to descent before the ToD (Top of Descent), the shallower descent profile (lower sink rate as calculated by the FMGS) requires some engine thrust to fly the normal descent speed (e.g. Mach 0.78).

FMGS Reference - MANAGED	**FCU Reference - SELECTED**
SPD, ECON-SPD/MACH, SPD LIM (Flight Plan)	SPD / MACH (Pilot Selection)

The V/S Mode

Whenever the Airbus is operated in selected **V/S**-and A/THR-Modes, the V/S rate is the deciding factor.

Example 1: If the pilot does not follow FD commands the V/S climb-rate may be too high for the available thrust. In this case, V/S the speed decreasesuntil V_{LS} is reached and the Alpha-Floor-Protection (AF) activated. Bevor the AF protection sets-in, the pilot must either increase the thrust (if possible) or reduce the Aircraft pitch.

Example 2: A similar scenario applies if the pilot does not follow the FD commands and the sink-rate is becoming too high. The result will be a speed increase (even with IDLE Thrust) until V_{MO}. Before the high-speed protection sets-in, the plot can only increase the pitch, which in turn reduces the sink-rate and speed. The thrust is already at IDLE and cannot be reduced further.

4.4.4 The A/THR Thrust-Mode (THR-Thrust)

The climb and descent rate as well as the aircraft speed are controlled via the Aircraft pitch, when the A/THR is active in THR-Mode.

During the climb phase, the Airbus follows the F-Plan and flies the climb speed as calculated by the FMGS. The A/THR sets maximum climb thrust and the pitch is automatically adjusted for the **CLB**- or **OP-CLB** Mode.

When reaching the selected altitude (**ALT**, **ALT CRZ**), the A/THR always changes from **THR-CLB** to the **SPEED**-Mode. The mode change occurs when the Airbus intercepts the FCU selected altitude and **ALT*** is shown on the FMA.

During the descent, the A/THR controls the descent rate also via the aircraft pitch. Normally, when the **DES**- or **OP-DES**-Mode is active, the A/THR is commanding **IDLE** thrust. The mode change occurs with the initiation of the descent phase and the A/THR-Mode changes from **SPEED** to **THR-IDLE**-Mode.

The **THR**-Modes are available for **Managed** and **Selected** operation.

In normal operation, the A/THR is operated together with the lateral **NAV**-Mode and the vertical **CLB**/**DES**-Modes. That means, SPD LIM and all Speed constraints contained in the F-Plan are considered for all flight phases.

A mixed operation with **managed** A/THR- and **NAV**-Modes together with the **selected** **OP-CLB**/**OP DES**-Mode is possible. The SPD LIM will be met, but altitude constraints are not taken into consideration.

Furthermore, a mixed operation of the managed A/THR Mode with the selected HDG/TRK and the selected **V/S**, **OP-CLB**, **OP-DES** is also possible. No altitude or speed constraint, but the SPD-LIM is condidered.

THR CLB THR IDLE	OP CLB OP DES	HDG		1AP2 1FD2 A/THR

4.4.5 The Selected A/THR Mode

If, e.g. for a training flight, no F-Plan has been entered, then the A/THR can only be operated in **Selected** Mode, or the pilot sets the thrust manually. The following three steps have to be performed by the pilot:

1. The Pilot selects the desired target speed in the FCU SPD window.
2. The Pilot presses the A/THR button to arm the A/THR. The button illuminates in **Green**.
3. The Pilot sets the thrust levers into the CL detent to activate the A/THR.

When the A/THR is activated any further Speed selection is simply done by dialing the desired speed value into the FCU SPD window using the SPD knob. There is no need to pull the SPD knob.

ATTENTION must be given to the SPD value before pressing the A/THR button as the default value is 100 and may still be shown in the SPD window.

When the pilot overlooks the 100 indication in the SPD window, the Airbus will reduce the thrust to IDLE once the A/THR is activated. If undetected by the pilot, the speed will decrease until VSL, which will trigger the low speed protection.

***Note**: The default value for the altitude at take-off is also 100.*

The control range of the A/THR is limited, if the thrust levers are set outside the CL-detent, into the manual thrust control sector. A Master Caution Warning (Single Chime) will sound every 5 seconds, until the thrust levers are set back into the CL-detent or the A/THR is de-activated. Simultaneously, **THR LVR** is shown on the FMA as a further indicator (attention getter).

THR LVR

During the approach, the call-out RETARD will sound when the Airbus passes through 20 feet. This call-out is a reminder that it is time to set the thrust levers to idle. Simultaneously, **THR IDLE** is shown on the FMA as a further indicator (attention getter).

THR IDLE

The call-out RETARD occurs in 20 feet or 10 feet, if the approach is flown in Autoland mode (AP and A/THR active).

4.5 The Thrust Levers as Selectors

The Airbus thrust levers operate very differently from the known Boeing AutoThrottle procedure. The Airbus thrust levers do not move according to thrust changes and stay in the CL-detent for most of the flight.

This procedure appears a bit misleading, because CL can only mean Climb. But the thrust levers remain in this detent for the level-, descent- and approach segments. But for all that, the Airbus A/THR is a useful and clear-cut device and just needs some adaptation by the pilot.

The Airbus Thrust levers have two functions:

1. To select the engine thrust manually, the thrust levers can be moved by the pilot in the traditional way, within the defined manual thrust area.
2. Hardware detents are allowing the pilot to select several operation modes.

A unique feature is, that Airbus not only used the thrust levers to command the engine thrust, they are also used as a Mode-Selector.

The following operation modes are available:

1. The TOGA-detent commands maximum thrust. TOGA means Take-Off Go-Around operation. The corresponding operation mode is TOGA.

   MAN
TOGA

   Manual take-off power MAN TOGA indicated on the FMA.

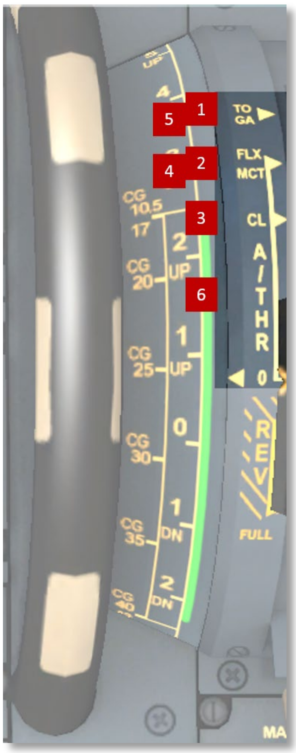
2. The FLX/MCT-detent commands a reduced take-off thrust according to a so-called Flex-Temperature which must be entered into the MCDU-PERF-Page. The insertion procedure of the Flex-Temperature is explained in chapter 1. The corresponding operation mode is FLX/MCT.

   MAN
FLX XX

   Manual Flexible take-off thrust MAN FLX is shown on the FMA.

3. The specific operation modes TOGA and FLX-MCT are only available for the Take-off and the Go-Around phase.The CL-detent commands maximum climb power as calculated by the FMGS. Without inputs in the PERF-Page the average climb thrust is about 83 - 88% N1, depending on the Aircraft configuration and weight. The corresponding A/THR operation modes are **THR-CLB** (Climb) or **THR-IDLE** (Descent).

4. In case of an engine out (EO) situation, the thrust lever of the life engine is set into the FLX/MCT-detent to provide the maximum continuous thrust.
5. To fly a Missed Approach, the pilot must set at least one thrust lever into the TOGA-detent to activate the GA-Mode.
6. The area between the CL-detent and 0 is the range for the manual thrust control.
   If required, the pilot can temporarily limit the A/THR, when he/she moves the thrust levers out of the CL detent. Setting the thrust levers back intothe CL-detent will re-activate the normal A/THR operation.



4.6 Summary of the AFS - Modes

Flight Phase	Flight Description	VERTICAL	LATERAL
1	Pre-Flight	----	----
2	Take-off	SRS	RWY - RWY TRK - NAV
3	Climb	CLB OPEN CLB V/S - FPA	NAV HDG NAV - HDG
4	Cruise	ALT* / ALT	NAV - HDG
5	Descent	DES OPEN DES V/S	NAV HDG NAV - HDG
6	Approach	G/S* / G/S V/S - FPA	LOC* / LOC HDG, TRK
7	Go-Around	SRS	GA TRK – NAV
8	Done	----	----

Note: *ALT* / ALT means: ALT * Mode followed by ALT Mode.*
NAV - HDG means: Either NAV or HDG Mode.

Some important AFS Mode Conditions:

- At least 1 FD and/or 1 AP must be active to use the AFS Modes.
- The AFS Modes can be activated, armed or de-activated.
- There are Managed (FMS) and Selected (Pilot) Modes.
- The Flight Guidance is similar for FD and AP.
- The Flight Phases are divided into 8 typical phases.
- The Basic Modes are V/S and HDG.
- The Managed Modes CLB and DES can only be used with the Managed Mode NAV.
- The Selected Modes OP-CLB and OP-DES can be used with the Selected Mode HDG as well as with the Managed Mode NAV (Mixed Mode).
- Mode change from NAV to HDG implies change from CLB to OP-CLB-Mode
- Mode change from NAV to HDG implies change from DES to V/S-Mode.
- FCU-HDG input must be confirmed within 45 seconds.
- FCU-V/S input must be confirmed within 45 seconds.
- FCU-SPD input must be confirmed within 10 seconds.
- Check of active AFS-Modes and values is done on the PFD/ FMA and not on the FCU.
- Manual flight without AFS-Modes only provides A/THR in SPEED-Mode.
- If the AFS does not react according to the pilot’s expectation, change to manual flight control is recommended.

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Chapter 5

Content

5. The Flight Planning

Three Navigation methods are of importance:

1. Conventional Navigation: Ground based Navigation Systems (NavAids) such as VOR, DME, NDB. This way of navigation is still in use to define Approaches and Airways. The disadvantage of this method is a low design flexibility limiting the traffic volume.
2. Area Navigation (RNAV): RNAV Airways are based on waypoints that are defined by coordinates (longitude and latitude). Beyond that, ground-based NavAids are still part of the design, especially within the Airport terminal area (RNAV Overlay).
3. RNP (Required Navigation Performance): RNP procedures require a specific accuracy of the Navigation equipment on board, ground and in space. Compared to RNAV, RNP procedures demand certified board equipment allowing precise Navigation. Thereby, the already reduced width of Airways through RNAV could further be scaled down, increasing the flexibility and traffic volume. On the other hand, RNP improves the accuracy of the NPA (Non-Precision Approach) coming close to ILS approaches.

The Airbus Flight Management System (FMS) contains the following functions:

1. Flight Plan-Management
2. Management of Radio Navigation
3. EFIS-Management (Electronic Flight Instrument System)
4. Performance Management (Predictions)

Following, the focus is aimed at the preparation and management of a professional Flight Plan.

5.1 The Flight Plan

The FMS strings together several legs of a flight, to form an integrated Flight Plan (F-Plan/F-PLN). This method is called Flight Plan Sequencing. In the process, it is not important, if the direction of the flight segment is based on Heading or a defined Course / Track.

The main component of the FMS is the FMS navigation data-base. That means, all required data (NDB, VOR/DME, WPT, Airways, Airports, etc.) for the F-Plan preparation are stored in the data-base. Eventually missing navigation data (e.g. waypoints-WPTs or runways-RWY) can be manually inserted by the pilot and stored. The FMS data base is regularly updated (every 4 weeks), to cover for the permanently changing navigation requirements.

The integrated F-Plan includes the lateral as well as the vertical flight profile. Regardless, if the Airbus is operated in managed or selected mode, the position is permanently checked and updated by means of the GPS and the INS (Inertial Navigation System). However, the FMS also uses ground-based NavAids as an additional source for the checks.

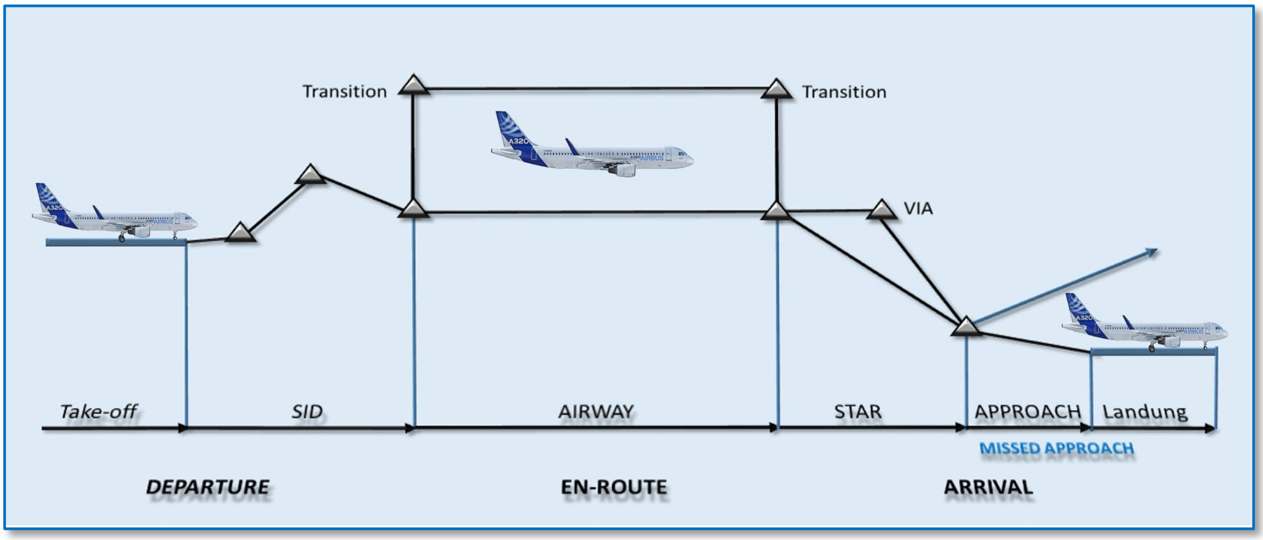
The FMS offers three ways to prepare and initialize a Flight Plan:

1. The desired Flight Route is stored in the FMS data base (CO RTE) and the pilot knows the ID code. With the insertion of the ID, the Flight Plan will be loaded into the MCDU.

2. The desired Flight Route is stored in the FMS data base (CO RTE) and the pilot does not know the ID code. The pilot inserts the City-Pair (Departure/Destination) into the INIT page and receives a selection of stored CO RTE Flight Plans.
3. No corresponding CO RTE is stored in the FMS data base. The pilot inserts the City-Pair (Departure/Destination) into the INIT page and receives NONE (no CO RTE). Afterwards the pilot prepares the Flight Plan manually by means of the MCDU.

The Flight Plan is broadly divided into three main sections:

- Departure (SID)
- En-Route and
- Arrival (STAR)



SID: Standard Instrument Departure Routes are standardized departure routes, which are stored in the FMS data base. The SID starts with a so-called runway waypoint (RWY-WPT) located on the runway track, shortly after the runway end.

The flight is than guided via waypoints and/or NavAids to a specific waypoint where the SID route ends and the flight enters the first Airway or en-route leg. The SID also contains the MSA (minimum sector altitudes), altitude and speed constraints as well as the speed limit (SPD LIM) of 250 knots below FL100.

En-Route legs of are defined by the ATC (Air Traffic Control), the authorities and the airline operations. This part of the Flight Plan is stored as Company Route (CO-RTE) in the FMS data-base. However, the pilot can always manually insert, or string together, a Flight Plan using the stored NavAids and airways of the FMS data-base.

STAR: Standard Terminal Arrival Routes are the counterpart to the SID and define standardized arrival procedures for the approach. STARs are as well stored in the FMS data-base. The STAR begins at a specific waypoint on the last airway and guides the flight via waypoints and/or NavAids to the FAF (Final Approach Fix).

Transitions are changeover routes in case the SID or STAR do not end/begin directly at an airway. They are common in the USA, but relatively seldom deployed in Europa. For example: Milano and Zurich are using Transitions within the departure sector.

5.1.1 The Airway System

Within the en-route section, that means the flight route between the departure (SID) and the arrival sectors (STAR), the Airbus flies along defined airways (AWY). These are a kind of highways in the air. To put it in simple words: SIDs are the entry to the Air Highway and STARs are the exit.

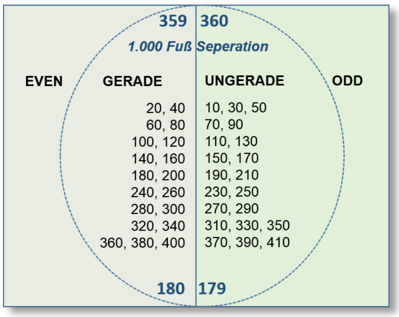
Airways are classified as follows:

Identifier	Designation
A-B-G-R	Regional Airways – non RNAV
L-M-N-P	Regional RNAV Airways
H-J-V-W	Local Airways – non RNAV
Q-T-Y-Z	Local RNAV Airways. These Airways can also be part of a SID or STAR.

Each Airway is usually labelled with a three-digit number (100 to 999). Additionally, Airways of the Upper-Airspace are marked with the prefix U (Upper). The Upper Airspace begins at FL245 (24.500 feet).

Example: LIMC-EDDM (Milano-Munich): `OSKOR UM985 TAGIP UT876 GUNGO UY246 TISAX UT102 IVKAL T102 IRBIR`. UM985 is a regional RNAV Airway of the Upper-Airspace, UT102 a local RNAV Airway of the Upper-Airspace and T102 a RNAV Airway of the Lower-Airspace, in this case also part of the Munich approach. The STAR to EDDM begins at the WPT IRBIR.

The preparation of a Flight Plan must take into consideration the lateral part (WPT, AWY), as well as the vertical part with the planned Cruise Altitude (CRZ-ALT). The cruise altitudes are classified into even and odd according to the course of the airway (AWY). The vertical separation is normally 1.000 feet.

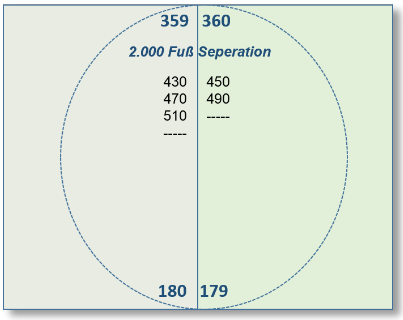


As the left picture shows, aircrafts with a course (magnetic North) between 0º (360 º) to 179 º are flying at odd altitudes (70, 90, 110 …). Aircrafts on a course between 180º and 359 º are flying on even altitudes (60, 80, 100 ….).

Altitudes above the transition altitude are designated Flight Levels (e.g. FL240). Below the transition altitude, altitudes are specified in feet (e.g. 4000 feet). The transition altitude in Germany is 5000 feet. Therefore, the FL altitude readout starts, when the Airbus flies at least 5000 feet.

When passing the transition altitude, the pilot changes the barometric representation from the actual value (airport QNH, e.g. 1.009 hPa) to the standard value of 1.013 hPa. The A320 informs the pilot of the impending action with a STD prompt on the PFD. From the transition altitude all aircrafts must select the standard QNH to secure a proper separation.

For all flight levels between FL50 and FL410 the vertical separation is 1.000 feet. from FL410 onwards, the separation is increased to 2.000 feet. Beginning with the next FL430, the division between even and odd is no longer valid and the aircraft separation is by magnetic course only.



5.1.2 The Area-Navigation (RNAV)

Area Navigation is the term used, when aircrafts fly along defined airways (form the departure Airport A to the destination Airport B.

These days, RNAV is the common term for Navigation, in which R stands for Area and NAV for Navigation. Until the turn of the Millennium, airways have been established using ground-based navigation equipment such as VOR (VHF Omnidirectional Radio Range) and NDB (Non - directional Beacon) to define waypoints.

With the availability of GPS (Global Positioning System) the waypoints could be defined by coordinates (longitude and latitude) and located anywhere within the area. This allowed the Authorities to arrange the airways more directly, which reduced flight time and fuel consumption. Furthermore, the aircraft separation could further be reduced, resulting in a substantial increase in traffic volume.

In the past, the usage of GPS was hampered by the inaccuracy of the aircraft on-board equipment. Consequently, the defined airway width of 5NM could not always be safely met.

RNP (Required Navigation Performance) is the answer to this problem. Even though the airway width is still 5NM, but the on-board equipment must now be certified to have the accuracy to safely fly within the boundaries. Thereby, the airways can be located closer to each other. This allows a better usage of the Airspace increasing the traffic volume again. Another important distinction between RNP and RNAV is, that the RNP system informs the pilot if the navigation accuracy of the on-board equipment is degraded.

Often, the term RNAV Overlay is used on navigation charts. That means, one navigation method overlays another. With other words: An Overlay-Approach can either be flown with GPS (WPT) or with conventional NavAids (VOR, DME, NDB) with exactly the same procedure.

What is a Waypoint (WPT)?

Waypoints (WPT) are positions in space defined by longitude and latitude (coordinates). The coordinates for the Munich Airport, for example, are N 48 21.23_E 11 47.17. The representation of a waypoint always includes a name, e.g. DM050 and a Symbol  and is also called

Intersections (IN). In addition, initial altitudes and speeds, so-called constraints, are assigned to waypoints, the pilot must adhere to. Example: Within the departure area of Munich (EDDM) the Airbus must pass the first WPT 1900 at an altitude of 1900 feet or higher and WPT DM050 at a speed of 210 knots.

Other important Navigation Methods

PBN (Performance Based Navigation) is the generic term for all navigation methods, which are based on Satellite signals and specific on-board equipment. RNP and RNAV belong to this group of navigation systems.

GNSS (Global Navigation Satellite System): Beside the GPS (USA) other Satellite Systems emerged, such as GLONASS (Russia) and Galileo (Europe). The GPS consist of more than 24 Satellites whose orbits have been calculated so that always a minimum of 5 Satellites are available for navigation (one also says, they are visible). Modern GPS equipment is able to receive all different Satellite signals and use them for navigation. The A320 FMS can receive and display up to 10 Satellite information (MDCU Data-Pages).

Satellite Navigation is only as good as the accuracy of the signals is. The signal constantly needs to be monitored and corrected (augmented). The ICAO Standard defines three methods of GNSS Augmentation Systems:

1. SBAS (Satellite Based Augmentation System) is an extension of the GPS and ensures, that the positions of the Satellites and consequently their accuracy are constantly corrected. WAAS (Wide Area Augmentation System) is the corresponding system in the USA, in Europa it is EGNOS (European Geostationary Navigation Overlay Service). EGNOS can work together with either GPS or GLONASS and with the future Galileo system. SBAS is only as precise as an ILS CAT-I approach.
2. GBAS is a ground-based System for precision approaches and is designed to replace the ILS and MLS (Microwave Landing System) in future. The first GBAS system in Germany has been installed in 2014. The coverage is approximately 35km and the system can support up to 50 different approaches with one ground-station. In the USA, GBAS is known under the term of LAAS (Local Area Augmentation System). There are some GBAS approaches in operation and confirm with ILS CAT-II requirements.
3. ABAS (Aircraft Based Augmentation System) integrates the GNSS information with on-board information like Altitude, Course and Speed.

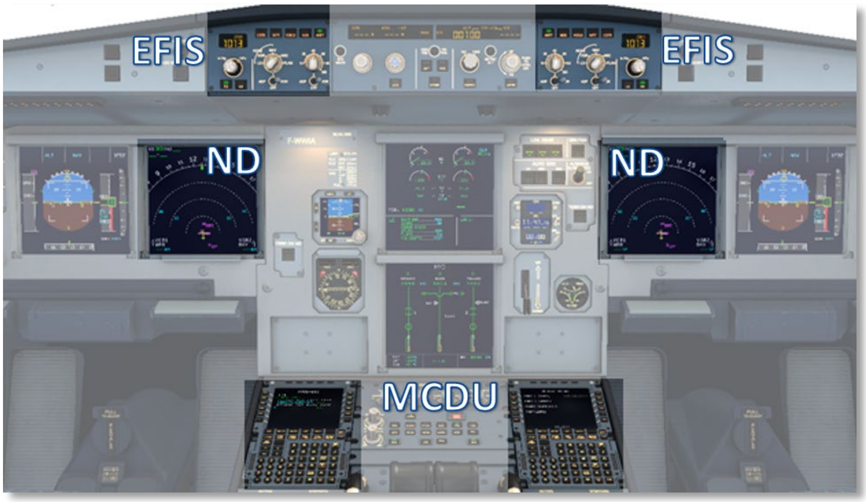
RAIM (Receiver Autonomous Integrity Monitoring) is designed to control the Integrity of the received signal. RAIM is required, because it may take up to two hours before a false GPS signal is detected and corrected by the Satellite itself. In Europa approximately 70% of all flights in 2014 have been operated with GNSS and RAIM. In case RAIM is not available, AIM (Aircraft Autonomous Integrity System) becomes active. AIM integrates the GNSS and the INS (Inertial Navigation System) signals to verify the GNSS data.

In order to identify the position of the Aircraft, signals of four Satellites must be received. A fifth Satellite is required to assist, if the information is false. And a sixth Satellite to determine, which Satellite information is false.

5.2 The Navigations-Display (ND)

The Navigation Display (ND) compliments the Primary Flight Display (PFD) with navigation specific information.

The ND is part of the Electronic Flight and Information System EFIS and controlled via the EFIS controller and the MCDU (Multifunctional Control and Display Unit).



For each ND (Captain and F/O), an EFIS controller is located on the Glareshield, just above the ND.

The pilot uses the EFIS controller to select the desired display mode and range of the ND. The ND presentation includes all navigation information of the Flight Plan as well as from conventional NavAids such as VOR and NDB (ADF).

One ND and one EFIS controller form a system unit for each crew member (Captain and F/O), which are operated independently from each other. Therefore, different and variable navigation information and display modes can be shown on the NDs of Captain and F/O (Co-Pilot).

The MCDU is also duplicated, one MCDU for the Captain and one for the F/O. Like the ND different pages and information can be shown on the MCDU.

5.2.1 The EFIS Controller

The EFIS controller is the primary means to control the Navigations-Displays (ND) and provides the following functions:

- Selection buttons for navigation data shown on the ND, with the following choices:
  - CSTR - Constraints (Altitude and Speed)
  - WPT (Waypoints)
  - VOR.D (D = Doppler)
  - NDB (ADF)
  - ARPT (Airports)

Only one selection at a time is possible.

- Rotary switch for display modes, e.g. PLAN
- Rotary switch for the range selection, e.g. 20 NM

Additional control facilities are provided for:

- Selection of NavAids (VOR und ADF), VOR 1 and 2 or ADF 1 and 2
- Selection of barometric pressure (QNH) and display mode (Hg, hPa)
- On- Off switch for the Flight Director (FD) and the Landing System (LS)

5.2.2 The ND Display-Modes

(1) Flight path and Course/Heading

(2) Ground speed.
The ground speed in the left picture is only 10 knots, because the Airbus is on Taxi to Runway 26L. No TAS (True-Air-Speed) is shown (**- - -** Dashes), because it is only displayed in flight.

(3) Wind-direction and wind-speed.
The wind direction is 260º with a wind speed of 12 knots. Both values are shown in digital figures. The wind direction is supported by an arrow, pointing towards the aircraft position.

The Wind data on ground are only shown, if the Airbus is faster than 100 knots. In the above picture the wind data are engrafted to provide an example.

(4) In the right corner the following information are displayed according to the actual aircraft position: TO-Waypoint/ILS/VOR, Course (in the picture TO-WPT 1900 and 260°), the distance (3,2 NM) and the ETA (Estimated Time of Arrival) at the Waypoint (2,01 minutes). The exact time is only displayed in flight.

(5) Left and right (bottom) show the data for the selected conventional NavAids - NAV1 and NAV2. The displayed data include the navigation method (VOR, ADF), the Nav-ID/Frequency and for the VOR the DME distance in NM.

In the example, the ND is presented in PLAN-Mode with a range of 20NM. For this chapter, only the PLAN mode is relevant. The other display modes will be discussed in chapter 6.

5.3 The FMS – Input- and Control Systems

The Flight Control Unit (FCU) has been discussed in chapter 4 and its basic knowledge is presupposed.

As a reminder, the FCU is used as the pilot interface for the Selected Mode operation. It is also the control device for Managed-Selected mode change, by means of the four rotary switches (Pull-Push function).

5.3.1 The MCDU

The actual version of the Multifunctional Control und Display Unit (MCDU) is provided in LCD technology. This technology permits the presentation of more information (compared to the previous CRT type) and a good readability even under difficult conditions (solar irradiation).

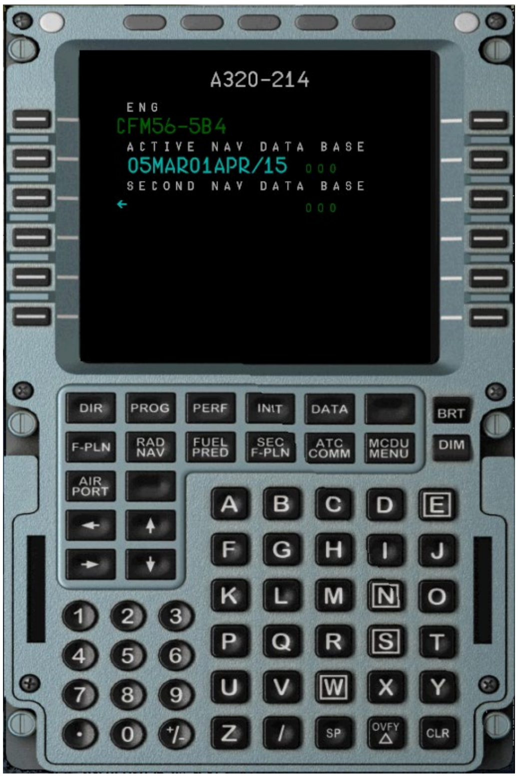
The MCDU provides the interface for the input of the following Flight Information:

- Flight Performance Data
- Flight Plan (F-Plan) data
- Wind Data

Additionally, the MCDU is used as an information tool for flight monitoring including:

- Flight Phases
- Flight Progress
- Flight Predictions

Both MCDU's are automatically powered-up when the aircraft's electric system is switched on, e.g. external power.



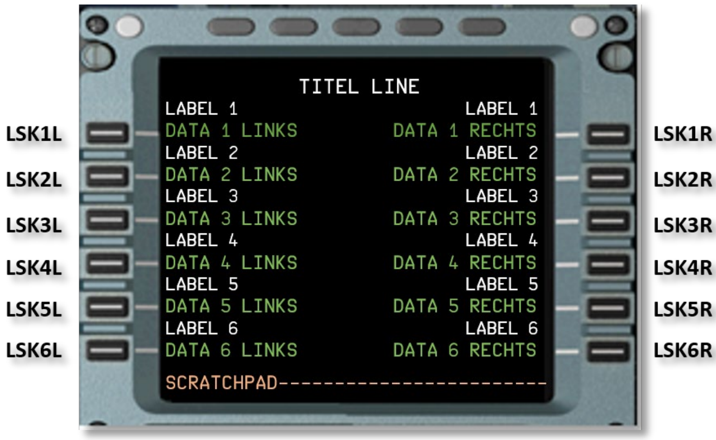
The first MCDU page informs the pilot of the actual status of the FMS and the data base version. The pilot must verify, if the FMS version is up to date.

In the example the actual version is of 5th March, which was current when the German version of the book was written. Today, this FMS version is hopelessly outdated.

The engine type is the CFM56-5B4. That means the aircraft used is an A320-214 version.

The MCDU Display

The MCDU is used to enter and monitor the Flight Plan (F-Plan) but also provides predictions about the flight progress and monitoring respectively. To do this, the MCDU display contains 14 rows which can display 24 characters that are divided into three sections:



1. Row 1 is the **Title Line**, providing additional general systems information. The pilot has no access to this line.
2. Rows 2-13, each containing two data fields (left and right).
   Each row (line) has a Data- and a Label-Line, latter is located on top of the data line. The Label-Line contains specific Information, concerning the Data-Line and cannot be altered by the pilot.

Two Selection keys are assigned to each Data-Line, known as Line-Selection-Key or LSK in short. LSK1L is the first selection key located top left and LSK6R the last left key at the bottom of the display.

3. Row 14 is the „ Scratchpad “. Any input by the pilot is first shown on the pad before it is inserted using the corresponding LSK.
Row 14 is further used to notify the pilot with system related Messages, as long as they concern MCDU and/or FMGS functions. Pilot inputs are shown in **White**, system messages in **Orange**.
In order to delete Information on the Scratchpad, one touch on the CLR key is sufficient to delete the whole information. However, if the pilot wishes to correct his/her input, one touch on the CLR key will only delete the last character (number or letter).

The Keyboard of the MCDU

The Keyboard unit is also divided into three sections:

- Part 1 includes the so-called Page Keys that allow the direct selection of dedicated Menu-Pages. Directly below the Page Keys, the Slew Keys ↑↓← → are located.
- Part 2 provides input keys for letters A – Z, the forward slash- and the function-keys SP, OVFY and CLR (clear-delete).
- Part 3 provide the numeric keys 1 - 0 which are complemented by the function keys (**.**) +/–.

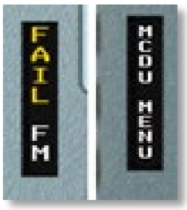
5.3.2 The Information Panels

For completeness of the information, the information panels (annunciators) are also explained in brief. These panels are only used to inform about FMS and/or MCDU malfunctions.

On top of the MCDU several visual display indications are located with regards to the following system/malfunctions status:

FM1	-	Failure in Flight Management System1
IND	-	Independent Mode is active
RDY	-	Ready (system is active). The internal MCDU test-routine after power-on was successful
FM2	-	Failure in Flight Management System 2

Left and right of the keyboard unit, information displays are arranged providing additional status information:



FAIL - MCDU is out of service

FM - FMS 1 (Captain) or FMS 2 (FO) is not the active System, but an important message is available

MCDU - another system requires access e.g. MENU an ACARS message/call

5.4 The Flight Plan Presentation

In order to provide a clear presentation of the Flight Plan, Airbus uses graphical and colour elements to display the F-Plan on the ND and the MCDU.

5.4.1 The MCDU Display Colour Codes

Variable colours are assigned to functions that assist the pilot to clearly identify the meaning of information, data and/or messages.

Information and Actions	Colour Code	Presentation
Title - Comments - Messages, Take-Off (Runway) Waypoint Destination Airport	White	INIT LOWS
Modifiable Data Auto Scan Navigation Frequencies	Blue	EDDM/EDDM
Active Data, not modifiable	Green	VR 143
Mandatory field, Input required Important Message Missed Constraints	Amber	COST INDEX ☐☐☐
Constraints Maximum Altitude at Waypoint	Magenta	250/FL100
Active Flight Plan Active Heading or Track	Green Waypoints	WS835Δ
Temporary Flight Plan	Yellow Waypoints	DM059
Secondary Flight Plan	White Waypoints	DM058Δ
Missed Approach Alternate Airport	Blue Waypoints	WS831

5.4.2 The ND Symbols and Colour Codes

	Position where the Airbus Levels-Off from climbing, according to the FCU altitude selection. The symbol is used for Managed (CLB - Climb) as well as Selected (OP CLB - Open Climb) Mode.
	Position where the Airbus Levels-Off during climb, according to the MCDU (F-Plan) defined Altitude (Constraint). This function is only available in Managed Mode (CLB - Climb).
	Position where the Airbus Levels-Off from descending, according to the FCU altitude selection. The Symbol is used for Managed (DES - Descent) as well as Selected (OP DES - Open Descent) Mode.
	Position where the Airbus Levels-Off during descent, according to the MCDU (F-Plan) defined Altitude (Constraint). This function is only available in Managed Mode (DES - Descent).
	Position where the climb starts, if the CLB Mode is armed.
	Position where the climb starts, if the CLB Mode is not armed.
	Top of Descent (Start of Descent) if the DES Mode is armed.
	Top of Descent (Start of Descent) if the DES Mode is not armed.
	Intercept Point where the descent merges with the calculated vertical profile (FMGS F-Plan - Managed). The Symbol is **Blue**, if the DES-Mode is armed.
	Intercept Point where the descent merges with the calculated vertical profile (FMGS F-Plan - Managed). The Symbol is **White**, if the DES-Mode is not armed.

The ND Colour Codes

Active Flight Plan Active Heading or Track Not active Flight Plan (HDG Mode active)	**Green straight Line** **Green dotted Line**	
Temporary Flight Plan	**Yellow dotted Line**	
Secondary Flight Plan	**White straight Line**	
Missed Approach Alternate Airport	**Blue straight Line** **Blue dotted Line**	

The Flight path of the SEC-PLN is displayed in White, but the Waypoints are shown in **Green**.

5.4.3 The ND Display Modes

The ND allows the selection of various modes for the presentation of the Flight Plan. Depending on the length of the flight, the whole flight rout may be shown on the ND. Usually, the forward looking (towards the flight path) ARC-presentation is used to operate the flight.

For the input of the Flight Plan the PLAN Mode on the ND is selected via the EFIS controller. It offers a graphical view ranging from 10NM to 320NM. However, the range selection of 20 or 40NM has been found most suitable for the Flight Plan preparation.

Presentation in PLAN Mode

Active Flight Plan

Temporary Flight Plan

Secondary Flight Plan

Presentation in ARC Mode

Active Flight Plan

Non-active Flight Plan

Temporary Flight Plan

Secondary Flight Plan

The secondary only shows those parts of the Flight Plan in White which are different from the active Flight Plan. The waypoints are still displayed with **Green** diamonds (rhombus).

5.5 The Initialization of the Flight Plan

A flight from Munich to Salzburg (EDDM-LOWS) has been selected as the primary route for the FMS and FMGS training. Even though the route is very short, with only 59 NM or 110 km, it provides the required scope for Flight Plan preparation and the execution of the flight.

The input of data for a FMS-operated flight, can be divided into two main sections:

Part 1 Navigation-Data	**Part 2 Performance-Data**
Status Page INIT A Page F-PLAN Pages SEC. F-PLAN Page RadNav Page	INIT B Page PERF Pages

The following sequence of MCDU-inputs has proven to be effective:

STATUS Check of the data-base Version.

INIT **A** Input of Departure and Destination Airport, Cost Index and planned Cruise Altitude.

F-PLAN Input of Flight Route, SID and STAR. Cross Check of the Flight Plan. If no company route (CO-RTE) is available the en-route Waypoints and Airways need to be manually inserted by the pilot.

SEC PLAN Copy of the active Flight Plan as back-up, or Input of an alternate F-Plan. The alternate F-Plan will be required in case of an important change of the Flight Route, e.g. returning to the departure Airport in case of an engine problem. Another reason may be a diversion to another destination Airport due to local weather conditions.

RAD NAV Check of the required NavAids and if necessary, hard-tuning of VOR, NDB (ADF), ILS. The pilot input has priority over the Auto Scan function. The VOR or ADF ID will be displayed in large letters to distinguish from Auto Scan.

INIT **B** Input of ZFW/ZFCG, Block Fuel.

PERF Input of the TO-Speeds into the PERF-TO-Page. Pre-selections of CLB/CRZ speeds can also be made in the corresponding PERF pages.

PROG Check of Flight Route, planned Cruise Altitude and GPS Accuracy. “GPS PRIMARY” must be shown on the MCDU Scratchpad and the ND.

The performance data are entered at the end of the exercise (before final checks). Otherwise the FMS would make an internal calculation (prediction) for each input and substantially prolong the procedure.

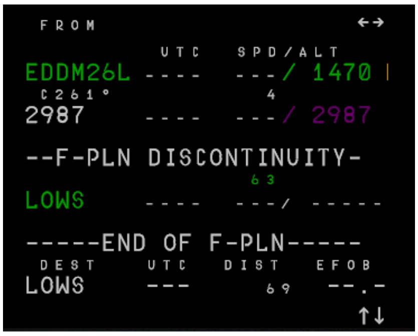
5.5.1 The Waypoint (WPT)

Flight Plans are generally based on Waypoints (WPT) and ground-based navigation equipment (NavAids). Waypoints are so-called Intersections (INT), runways, e.g. 26L and airports, e.g. EDDM (Munich).

Waypoints are further classified as TO WPT (next waypoint) and FROM WPT (last/previous waypoint).

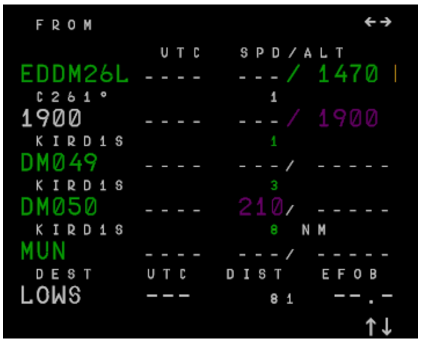
The FROM-WPT (WPT in the first line) is, like any other waypoint, displayed in **Green** on the ND and MCDU. The TO-WPT (WPT in the second line), meaning the next WPT, is displayed in **White** on both the ND and the MCDU. The destination (arrival) airport is also shown in **White**.

A specific departure or runway waypoint is assigned to each runway and serves as an important reference and the first TO-WPT.



In case that no SID has been inserted, this is the point where the pilot must observe the specified altitude and make a turn at the earliest.

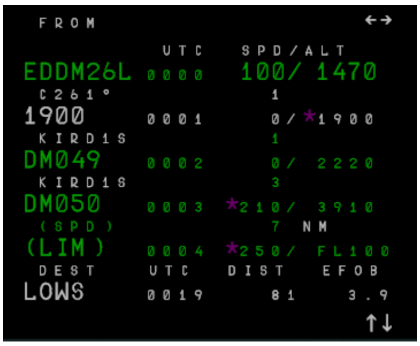
For a departure from RWY26L at EDDM, WPT 2987 corresponds with an Altitude of 3.000 feet (rounded) or 1.500 feet above ground (AGL). 1.500 feet is also the Standard ACC-ALT as well as the traffic pattern altitude.



After Insertion of the SID the first waypoint is now WPT 1900 and represents an Altitude Constraint with **1900** feet.

Related to a field (runway) altitude of 1.470 feet, the minimum flight altitude is 430 feet above ground (AGL) before turning to the first SID waypoint (DM049).

All altitude values are based on a QNH of 1013 hPa.
No predictions are displayed at this moment.



Only when all Performance Data such as Weight, Speeds, Cost Index and the planned Cruise Altitude are inserted, predictions are calculated by the FMS.

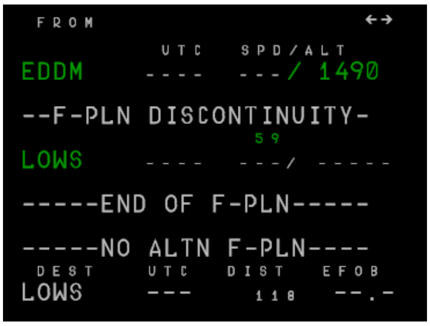
With the availability of predictions, the information changed from capital characters in **Magenta** (**1900** at WPT-1900 and **210** at WPT-DM050) to a **Magenta Star** (*).

Magenta means the Constraint (CSTR) will be met. A **Yellow Star** (*) means the CSTR will not be met.

All information is based on to the actual FMS calculation. The predictions are constantly calculated by the FMS and can significantly change during flight.

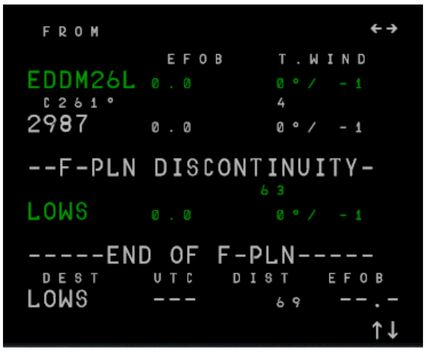
5.5.2 The Flight Plan Page

Like the INIT, the F-PLN Page consists of an A and B page.



The first picture shows the F-PLN A-Page. Beside the airports and waypoints, UTC (Universal Time), speed (SPD) and altitude (ALT) are displayed.

The fields are displaying **- - -**, because no predictions are available yet.



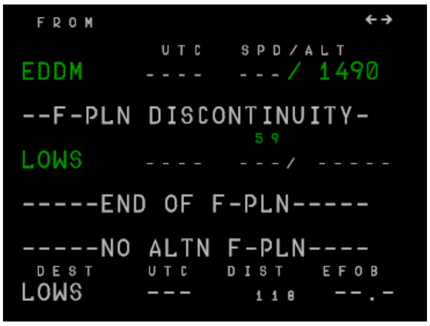
The second picture shows the F-PLN B-Page. Again, airports and waypoints are shown, plus EFOB (Estimated Fuel on Board) and wind data.

For EFOB and wind the value 0 is displayed, because no predictions are available yet.

In the 1st Label line either the course to the next WPT (here 261°) or the SID-Airway-STAR ID and the distance between the FROM and the TO WPT is shown. The course 261° is equal to the runway course and 4 means 4NM from RWY end to the WPT.

The value 63 (below the DISCONTINUITY) means 63NM as the distance form RWY end via WPT 2987 to the destination airport LOWS (direct course).

Altitudes on the MCDU F-PLN Page may differ, depending on the actual position of the Aircraft, e.g. Gate, Apron, Runway.

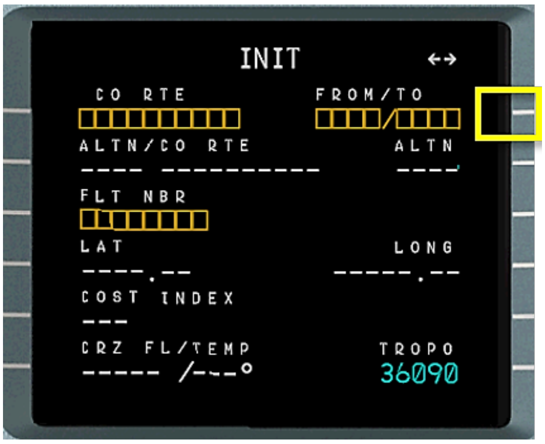


Usually the Flight Plan is inserted when the aircraft is parked at the gate or apron. This is the reason why the F-PLN page shows an altitude of 1490 feet. The FMS rounds the airport altitude from 1487 to 1490 feet.

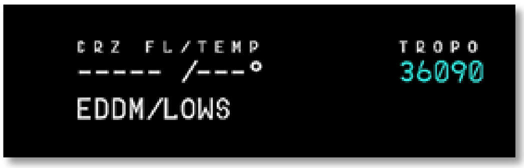
When the departure runway 26L is inserted, the altitude changes from 1490 feet (airport-altitude) to 1470 feet (run-way-altitude).

5.6 Entry of the Flight Plan

The INIT-A Page is called up by pressing the INIT key.



The ND displays the present position (PPOS), as well as where the aircraft nose points (172º).



Then, the City-Pair (Munich-Salzburg) EDDM-LOWS is entered into the Scratchpad and inserted by pressing LSK1R (FROM/TO).

An intermediate page is shown with the stored Flight Plans (Company-Routes) corresponding to the city-pair. In this example, no CO-RTE is available (NONE).

The actual FMS version (2) does not display the page, if no CO-RTE are stored.

The pilot presses the RETURN key (LSK6L) and returns to the INIT Page with the City-Pair and additional input fields (**Yellow fields**).

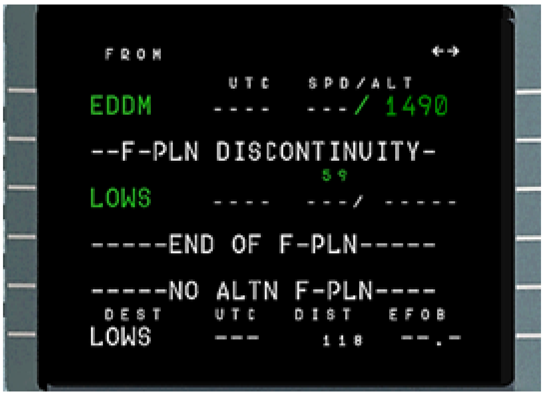
The ND now shows the departure Airport EDDM next to the Aircraft symbol.

For the Flight Plan Initialization, the ND mode will be changes from ARC to PLAN by means of the EFIS controller.

The ND now shows the destination Airport LOWS as the next WPT in the middle of the display.

In the upper right corner, the destination Airport LOWS and the direct course from the actual position is shown. The actual position is on the apron and the corresponding course is 122°, with a flight distance of 59NM. Course and distance will differ when the Airbus enters the departure Runway.

The estimated time is shown as 00:00, because the Aircraft is parked. The arrival time can only be calculated after engine start.



Afterwards the F-PLN-page is called-up by pressing the F-PLN key.

The page shows the departure and destination airports with a F-PLN Discontinuity. No SID, STAR and Route are shown yet.

The altitude shown on the right is the airport (field) altitude of 1.490 feet.

In the INIT-A Page the data for cost-index (CI) and planned flight level are entered by the pilot. The data are first written into the Scratchpad and inserted into the INIT fields via LSK5L and 6L.

Because it is a training flight, the field FLT NBR can be left blank. However, T123 (T for Training would be a possibility.

Now, the F-PLN Page contains additional flight information such as top of climb T/C and top of descent T/D based on the planned FL110 (INIT A-page). DECEL is the deceleration point (where the speed reduction to the VAPP starts at the latest).

The altitude in the right corner is still the field altitude of EDDM.

The F-PLN DISCONTINUITY (DISCON) can, but must not be deleted at this moment.

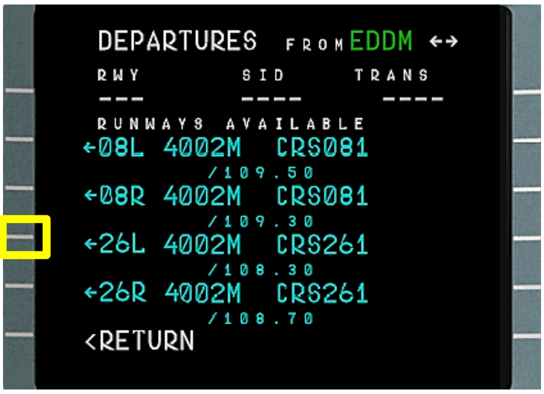
In case the DISCON is deleted, the ND will show the direct route to LOWS. The DECEL point is always calculated when the flight rout is available.

Pressing LSK1L (next to EDDM in the picture above), the LAT REV page of EDDM will be shown.

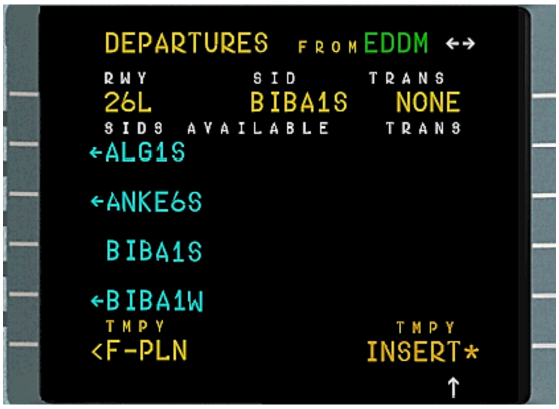
Pressing again LSK1L opens the departure page with a selection of the available runways (RWY).

Via LSK4L the pilot chooses 26L.

The ND displays runway 26L with the first Waypoint 2987.



The next page offers the available SID for RWY 26L.



The first four SID's are offered. The desired SID (according to the departure chart) is not shown.

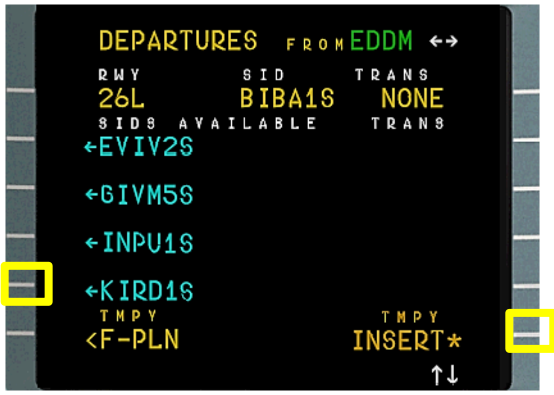
Using the Slew-Key ↑ the pilot can call-up the next four selections.

This page offers the SID-KIRDI1S (see picture below), whichwill be used for departure.

If the pilot presses the Slew-Keys ↑ again, additional SIDs are shown, if available.

Pressing LSK5L selects the SID KIRD1S and the departure route is shown as temporary F-PLN (TMPY) on the ND.

Temporary F-PLNs are displayed as **Yellow dotted Lines**.



The ND now shows the SID as TPY-F-PLN with a **Yellow dotted Line**.

The SID is confirmed and inserted by pressing LSK6R (**TMPY INSERT**), see picture above right.

As long as the DISCON is not deleted, the ND shows both, the direct course (**green**) as well as the selcted SID (**Yellow**).

When the SID is confirmed, the direct course and the DISCON will be deleted automatically.

In line 1, the information changes from EDDM to EDDM26L and the altitude (ALT) from 1490 feet (airport) to 1470 feet (runway-RWY).

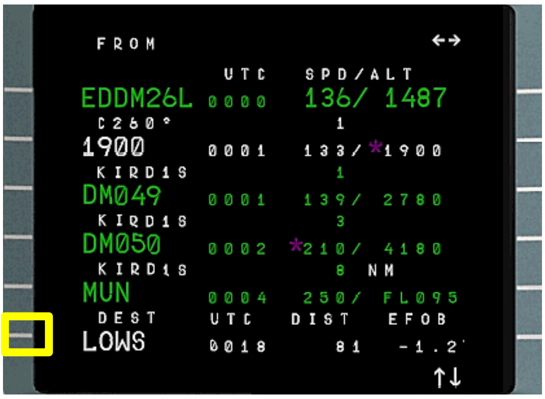
The ND now shows the SID as the active route in **Green**. The range of the ND in the example is 40NM (2x20NM).

By repeatedly pressing the Slew-Key ↑ the WPT MEBEK will be moved to the second line of the F-PLN page.

The whole SID up to WPT KIRDI, as well as the destination Airport LOWS are displayed on the ND.

Pressing LSK6L selects the destination airport LOWS. Subsequently, the ARRIVAL page is chosen via LSK1R.

Because of the short distance of the training flight no en-route airway need to be inserted. The SID directly connects with the STAR.



The selected approach-ILS15 (RWY15) is offered on the first ARRIVAL page and selected via LSK3L.

If necessary, the next page can be opened via Slew-Keys ↑ which offers additional approaches.

After selection of the ILS15 approach, STAR routes corresponding with the ILS15 approach are displayed

Like for the SID, a STAR with the same ID KIRDI is offered.

Pressing LSK4L selects KIRDI and LSK6R (confirms the choice.

The ND now shows the complete Flight Route from EDDM to LOWS as a temporary Flight Plan (TMPY F-PLN).

The already confirmed SID is shown as a **Yellow/Green** line. The newly selected STAR is displayed as a **Yellow dotted Line**.

The Flight route is now complete and displayed on the ND as a **Green contin-ues Line**.

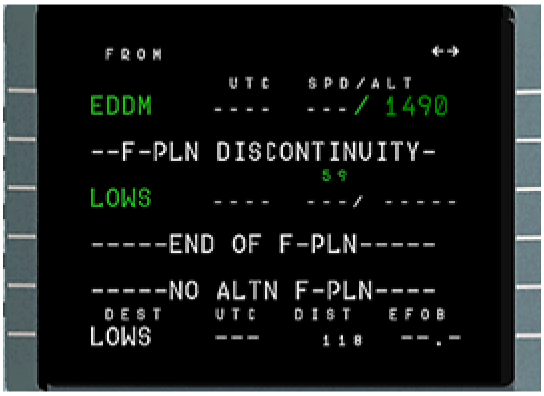
The SID and STAR directly connects at WPT-KRDI without an airway.

The newest FMS data-base does not include STAR KIRDI any longer. Instead STAR BAGSI has to be used with either the airway T107 or a straight course between WPTs KIRDI and BADIT.

5.6.1 Deletion of Entrees

The picture below shows the first F-PLN page. By pressing the INIT key, the page can be opened again and the City-Pair overridden if required.

If the Departure page has been opened via the LSK1L, then the pilot can go back to the previous page using the Return function.



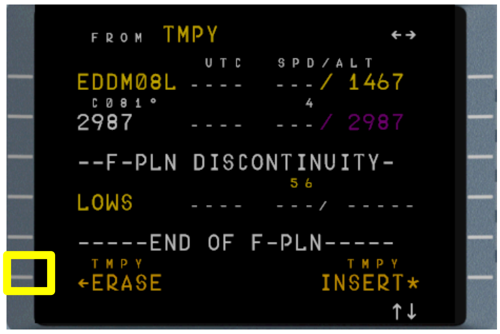
However, if the pilot has already inserted data, then they need to be deleted before a new page can be opened.

In the example, the pilot inadvertendly inserted Runway 08L. The corresponding departures-page opens, which does not offer a return function.

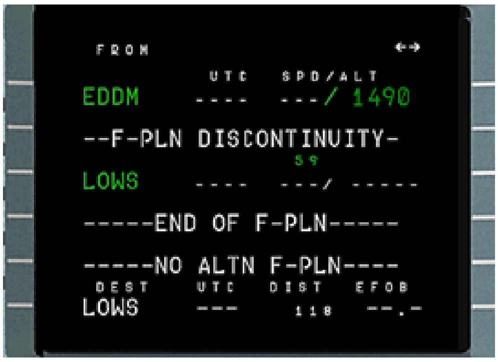
First the TMPY-Flugplan is selected via the LSK6L.

The TMPY-Page (temporary Flight Plan page) opens. This page is similar to the first input-page with one exeption. The data are shown in **Yellow (TMPY)** instead of **Green (F-PLN)** characters.

Pressing LSK6L will delete the TMPY Flight Plan.

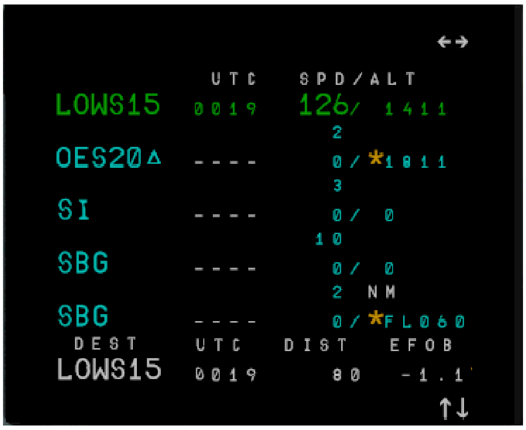


The previous input-page opens again and the correct runway selection can be done.



5.6.2 The Missed Approach Course (MA)

The Missed-Approach course is part of the approach information taken from the FMS data-base. The pilot does not need to enter the information but can alter the MA course manually, if required by the ATC.



In order to display the **Blue** MA course, the first MA-WPT **OES20** must be the TO-WPT (second line on the MCDU-Display).

The **Blue** MA course is then shown on the ND. However, the U-Turn is only shown on the ND after the GA initialization.

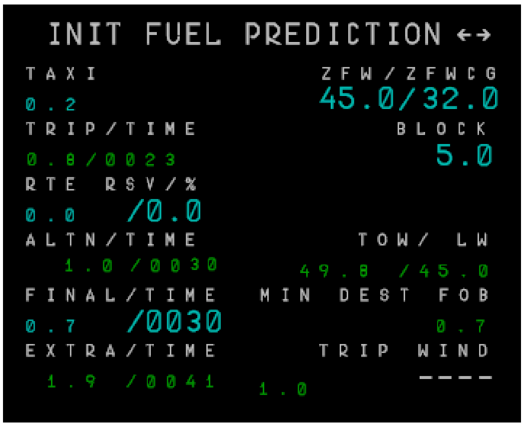
LOWS is located very close to the mountain ridge and the Go-Around for RWY15 (southerly direction) requires a U-Turn procedure to WPT-SI (NDB).

After the U-Turn, the MA-course passes the NDB-SI towards the VOR-SBG for a left turn holding.

With the selction of the GA the MA course becomes the active Flight Plan and all information (ND-MCDU) change from **Blue** to **Green**.

5.7 Entry of Performance Data

After all information/data concerning the Flight Plan are inserted into the INIT-A, INIT-B pages, the aircraft performance data are next to be entered.



Pre-requisite for the calculation of performance data is the availability of weight and fuel data, which must be entered manually into the INIT-B Page.

The Take-off Page shows the FMS calculated F, S und 0 Speeds. The -0- Speed is the **GD**-Speed.

TRANS, THR RED and ACC/ALT refer to the EDDM terminal area and are taken from the FMS database.

Take-off Speeds and the FLEX Temperature are calculated by the pilot, using an external program, and manually entered into the page.

For the short training flight, the take-off weight (TOW) is 50 tons, which is 23 tons below the maximum take-off weight (MTOW). In order to avoid early rotation, due to the light TOW, a slight forward trim setting has been chosen.

The THS setting is done via the trim wheel on the pedestal. Inputs for Flap and THS (Trim) setting have no effect on the FMS calculation. However, they are important check-items before take-off.

TO Shift (second line on the right) defines the unused section of the Runway. In the example 1180 meter of the Runway are not used due to chosen runway entry point (taxi way).

Runway EDDM26L	4.000 m total Runway length
Entry B13	3.800 m – 200 m
Entry B12	2.820 m – 1180 m

Using the entry B12 the Take-off Runway Available (TORA) is reduced by 30%. With a relatively light take-off weight of 50 tonnes, no performance adjustments, such as for the V1 speed, are required.

5.8 Printing the Flight Plan

For a length of time, hard copies of the Flight Plan have been available in the briefing room for the TO Briefing. This procedure has changed as terminals and notebooks are used for the briefing instead of paper. However, for the FS-pilot hard copies are still the media of choice.

The format of the printed Flight Plan depends on the airline but follows to a great extend international standards and is called Operational Flight Plan (OFP). An OFP includes the complete Flight Plan plus information concerning altitude, speeds, selected performance data of the aircraft type and flight time.

An important line of the OFP is the signature line, where the Captain's signature confirms the correctness of the Flight Plan.

A manual input of the F-PLN is a rare occurrence in real flight operation. With LSK2R (**INIT REQEST***), the F-PLN (prepared by Flight OPS) is transferred into the MCDU using the ACARS data connection. Nevertheless, the Captain must check the F-PLN for correctness.

The transferred F-Plan may include last minute adaptions, for example a new TO runway, due to a change in wind direction. After checking, the F-PLN is printed-out via the on-board printer. Also, this procedure is changing today as modern Electronic Flight Bags (EFB) make hard copies obsolete.

A similar function is available for the wind data, called ***Wind-Request*** via LSK3R on the wind-page. The wind data are also automatically loaded into the wind page using the ACARS-data connection. The * means, the function is actually available.

There is also a difference between the CO-RTE which is stored in the FMS data-base and the OFP. The CO-RTE includes the en-route F-PLN (Airways, Waypoints), but no runways, SID and STAR, which depend on the actual weather conditions. The OFP or ATC F-PLN covers the whole flight from the departure to the arrival runway.

The following Standard-Flight Plan corresponds with the format of the Airbus MCDU print-out and is a subset of the OFP. The Flight Plan covers the training flight from EDDM-LOWS.

The wind data used in the Flight Plan are fictitious but match a nice sunny day in the Munich area with a light southerly wind.

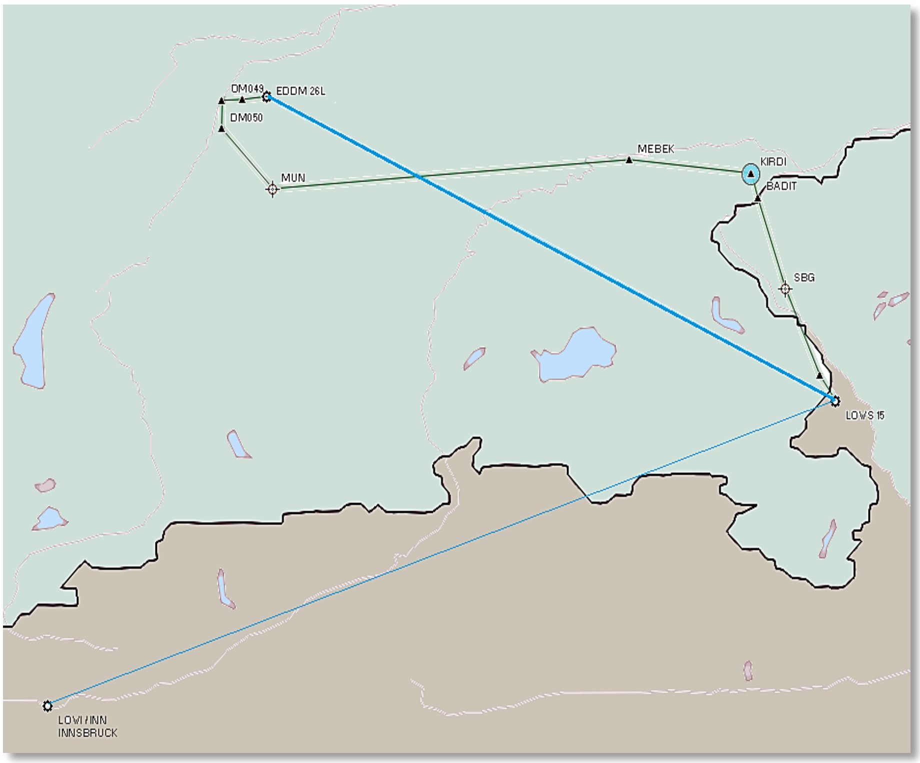
EDDM 121020Z 21005KT CAVOK 18/15 Q1012 NOSIG

LOWS 121020Z VRB06KT 9999 22/14 Q1014 TEMPO

The METAR for EDDM data read as follows:

- 12. Day of the month, 10.20 Z (UTC time, meaning 11.20 local Munich time).
- Wind from 210° with 5 knots. VRB (LOWS), means, the wind changes frequently the direction.
- Visibility CAVOC (**Cl**ouds **A**nd **V**isibility **OK**), minimum 10km, no clouds below 5.000 feet, LOWS 9999, means no clouds with unlimited visibility. If CAVU is mentioned, that means **C**louds **A**nd **V**isibility **U**nlimited.
- 18º with dew point 15º. Dew point is the temperature where the air condenses and develops fog.
- Q is the QNH, the Air Pressure at the airport related to the ISO Standard-Temperature scheme. The measuring unit is Hectopascal hPa. QFE is the actual air pressure at the airport.
- NOSIG refers to the expected changes of the weather situation. NOSIG (**No Sig**nificant Change) means no short-term weather changes expected. LOWS and TEMPO means, temporary weather changes are expected. The weather may alter momentarily and returns back to the previous state. This is in line with the variable wind conditions.

The picture below shows the Flight Route of the training flight EDDM-LOWS (Munich-Salzburg) with the alternate LOWI (Innsbruck) in graphical representation.



The thick **Blue** Line is the direct route between EDDM and LOWS after insertion of the City-Pair into the INIT-Page.

The thin dark **Green** Line is the flight route according to the Flight Plan including SID und STAR.

The thin **Blue** Line is the Flight Route to the ALTERNATE LOWI.

5.8.1 The Content of the Flight Plan

The printed Flight Plan is divided into four parts, which are printed out independently from each other (4 print outs).

Part 1: Flight Plan Initialization Data

Part 2: Take-off Performance Data

Part 3: Wind Data

Part 4: Flight Plan. It is the complete Flight Plan including parts 1 – 3.

Note: *Additional Remarks/Explanations are provided in Italic, to make it easy for the reader to understand and evaluate the real Flight Plan data.*

Part 1: INITIALIZATION

FLT NUMBER	: T123	FROM/TO	: EDDM/LOWS
CO RTE	: NONE	ALT	: LOWI
ALT CO RTE	: _ _ _ _ _ _ _ _		

PRIMARY F-PLN

DEP RWY	: 26L
DEP PRC	: KIRD1S
VIA	: ----,---
CSTR:	DM050, 210 /_ _ _ _
CSTR:	MEBEK, 250 /_ _ _ _
CSTR:	OES80, _ _ _ /+4000
CSTR:	OES20, _ _ _ /+1811
CSTR:	SBG, _ _ _ /+6000
ARV PRC	: KIRD
APP PRC	: ILS15
ARV RWY	: 15

Departure Runway is 26L with SID - KIRD1S.
No VIA, because no airway is included.
CSTR are constraints as part of SID or STAR.
The planned STAR is KIRD.
The planned approach is an ILS approach to runway 15 (approach from the North).

PERFORMANCE DATA

COST INDEX	: 30	ZFWCG	: 32.0
CRZ ALT	: FL110	ZFW	: 45.0
TRANS	: 5000	BLOCK	: 5.0
TROPOPAUSE	: 36090		

Performance are according to inputs in INIT-A and INIT-B pages.

Part 2: TAKE-OFF DATA

TOW	: 59.0	TO SHIFT	: _ _ _ _
TOCG	: 30.8		
SAT	: +22	MAG WIND	: 278° /005

Take-off according to the pilot calculation and input into the TO-PERF and INIT-A pages. No TO-SHIFT (Take-off Shift).

MAX TO		FLEX TO	
TEMP	: _ _ _	FLX	: F72
FLAP	; _	FLAP	; 1
THS	: _ _ _ , _	THS	: 08D
V1	: _ _ _	V1	: 118

TO will be performed with reduced TO-Power-setting (FLEX 72). Therefore, no data for MAX TO are included.
TO Speeds according to pilot calculation with external program.

VR	:	_ _ _	VR	:	125
V2	:	_ _ _	V2	:	128

THR RED ALT : 2.470
ACC ALT : 2.470 BARO : H1012

EO ACC ALT : 2.970

Altitudes for Thrust Reduction (THR RED) and Acceleration (ACC-ALT) are taken from the FMS data-base.

Note: *EO ACC ALT is the acceleration altitude in case of Engine Out (EO) operation.*

Part 3: WIND DATA

Note: *As already mentioned, wind data are fictitious.*

CLIMB WIND
_ _ _ _ _ _ _ _ _
T. WIND / ALT
210° / 005 / GRND
240° / 006 / 3000
280° / 010 / FL070

Wind data are inserted via INIT-A Page under LSK WIND (see chapter 6).

LOWS wind is the present information at take-off and may need to be modified via the performance-page APPR (Approach) during flight.

DESCENT WIND
_ _ _ _ _ _ _ _ _ _
T. WIND / ALT
310° / 015 / FL110
260° / 010 / FL070
220° / 008 / 3000

DESCENT wind is important for the proper calculation of T/D (Top of Descent) by the FMGS.

DEST DATA
_ _ _ _ _ _ _ _ _ _
QNH : 1014
TEMP : +22
MAG WIND : 190° /005
TRANS FL : FL065

Destination data can be inserted according to the data available at take-off. However, they must be checked during flight and altered if required.

TRANS FL Flight Level) is the altitude to change from STD (Standard) to airport QNH.

ALTERNATE WIND
_ _ _ _ _ _ _ _ _ _
T. WIND / ALT
270° / 012 / FL100

Alternate wind is the prediction for the en-route wind to the alternate airport.

Part 4: THE FLIGHT PLAN

After insertion of the Flight Plan data, the FMS calculates a preliminary Flight Plan using predicted values. The wind calculations are based on the fictitious data according to part 3. At the end of part 4, fuel calculations are included based on the data of the INIT-B page. All values are in tonnes.

The pilot developed flight-plan has been stored as CO_RTE EDDMLOWS03.

A/C TYPE	:	A319	ENG TYPE	:	CFM56
FLT NUMBER	:	T123	FROM/TO	:	EDDM/LOWS

CO RTE : EDDMLOWS03
ALT CO RTE : _ _ _ _ _ _ _ _ _
ALT : LOWI
COST INDEX : 30

CRUISE FL/STEP

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _
CRZ FL 1 : FL110

FLIGHT PLAN DATA

	DIST	TIME	CRZ FL
DEST _ LOWS	78	00:18	FL110
ALTN ----------	-------	-- , ---	FL ---

DEP RWY : 26L
DEP PRC : KIRD1
ARV PRC : KIRD
APR PRC : ILS15
ARV RWY : 15

PREFLIGHT FLUGPLAN

PREDICTED VALUES								
WPT	TIME	SPD/ALT	FOB	T: WIND	TAS	SAT	CRS	DIST
EDDM26L	00:00	130/ 1470	4.8	210/005	133	+12	261	1
1900	00:01	144/ 1900	4.7	230/005	148	+11	261	3
DM049	00:02	210/ 3600	4.6	240/006	221	+08	178	3
DM050	00:02	210/ 6300	4.5	270/010	230	+03	143	8
MUN	00:04	265/11000	4.3	310/015	310	-07	082	30
MEBEK	00:09	266/10350	4.1	310/015	308	-05	095	10
KIRDI	00:11	250/ 7500	4.1	280/010	280	+00	166	2
BADIT	00:12	250/ 7000	4.0	280/008	277	+02	163	10
SBG	00:14	222/ 4000	4.0	250/006	236	+09	176	2
OES80	00:15	162/ 4000	4.0	250/006	172	+09	154	3
OES49	00:17	149/ 3000	4.0	240/005	157	+11	154	2
LOWS15	00:19	132/ 1470	3.8	220/005	137	+14	154	2
OES20	--,--	--- / -----	--,-	--- / ---	---	---	334	3
SI	--,--	--- / -----	--,-	--- / ---	---	---	334	10
SBG	--,--	--- / -----	--,-	--- / ---	---	---	356	2
SBG	--,--	--- / -----	--,-	--- / ---	---	---	356	0

The Clock has not been started yet, therefore only the calculated flight time (in minutes) to the WPTs are shown. The flight time between EDDM and LOWS is calculated with 19 minutes.
At OES20 the MA (Missed Approach) part of the Flight Plan begins.

FUELPREDICTIONS

TAXI	:	0.2	*Fuel consumption for Taxi to Runway.*
TRIP (DEST)	:	0.8	*Fuel consumption for the flight EDDM-LOWS (Trip Fuel).*
RSV	:	0	*Reserve fuel is not considered for the short training flight.*
ALT	:	1.0	*Fuel consumption for the flight to the alternate LOWI.*
FINAL	:	1.1	*Fuel consumption for a holding during the approach*
EXTRA	:	1.9	*Difference between the calculated Fuel consumption (3.1) and the Fuel on Board (FOB 5,0).*

INFLIGHT FLIGHT PLAN

During the flight the pilot can prepare intermediate Flight Plans, e.g. between WPTs MEBEK and KIRDI, in order to monitor the flight progress. For example: at each WPT the actual fuel consumption can be checked against the predicted value of the original Flight Plan. Large deviations can be detected early and counter measures be discussed and implemented.

The Flight Route from EDDM to WPT MEBEK has already been flown. Therefore, the values shown are actual and accurate Flight Data (Historic Values).

The Flight Route from WPT KIRDI to LOWS is the remaining part of the training flight and the data shown are Predicted Values.

HISTORIC VALUES								
WPT	TIME	SPD/ALT	FOB	T: WIND	TAS	SAT	CRS	DIST
EDDM26L	00:00	130/ 1470	4.8	210/005	133	+12	261	1
1900	00:01	144/ 1900	4.7	230/005	148	+11	261	3
DM049	00:02	210/ 3600	4.6	240/006	221	+08	178	3
DM050	00:02	210/ 6300	4.5	270/010	230	+03	143	8
MUN	00:04	265/11000	4.3	310/015	310	-07	082	30
MEBEK	00:09	266/10350	4.1	300/015	308	-05	095	10
PREDICTED VALUES								
KIRDI	00:11	250/ 7500	4.1	280/010	280	+00	166	2
BADIT	00:12	250/ 7000	4.0	280/008	277	+02	163	10
SBG	00:14	222/ 4000	4.0	250/006	236	+09	176	2
OES80	00:15	162/ 4000	4.0	250/006	172	+09	154	3
OES49	00:17	149/ 3000	4.0	240/005	157	+11	154	2
LOWS15	00:19	132/ 1470	3.8	220/005	137	+14	154	2

POSTFLIGHT FLUGPLAN

After termination of the Flight, the pilot can print-out a Flight Plan with the real and accurate data of the entire flight. Time and Fuel consumption are calculated from the Gate at EDDM until the Gate at LOWS. The general Flight Plan data such as the A/C Type are unchanged and therefore not repeated.

HISTORIC VALUES								
WPT	TIME	SPD/ALT	FOB	T: WIND	TAS	SAT	CRS	DIST
EDDM26L	18;22	130/ 1470	4.8	210/005	133	+12	261	1
1900	18:23	144/ 1900	4.7	230/005	148	+11	261	3
DM049	18:24	210/ 3580	4.6	240/006	221	+08	178	3
DM050	18;25	210/ 6300	4.5	270/010	230	+03	143	8
MUN	18:26	265/11000	4.3	310/015	310	-07	082	30
MEBEK	18;32	266/10370	4.1	300/015	308	-05	095	10
KIRDI	18;34	250/ 7480	4.1	270/010	280	+00	166	2
BADIT	18:35	250/ 6960	4.0	270/008	277	+02	163	10
SBG	18:36	222/ 4000	4.0	240/006	236	+09	176	2
OES80	18:38	162/ 4000	4.0	230/006	172	+09	154	3
OES49	18:39	149/ 3010	4.0	210/005	157	+11	154	2

LOWS15	18:41	132/ 1470	3.8	190/005	137	+14	154	2
OES20	--,--	--- / -----	--,-	--- / ---	---	---	334	3
SI	--,--	--- / -----	--,-	--- / ---	---	---	334	10
SBG	--,--	--- / -----	--,-	--- / ---	---	---	356	2
SBG	--,--	--- / -----	--,-	--- / ---	---	---	356	0

FUEL AND TIME SUMMARY

START-UP		SHUT-DOWN	
FUEL	: 4.8	FUEL	: 3.8
WEIGHT	: 47.5	WEIGHT	: 46.3
TIME	: 18:20	TIME	: 18:46
TO TIME	: 18:22	LOG TIME	: 18:41

5.8.2 The Printed Flight Plan

There are two ways to print-out the Flight Plan:

1. Automatically via the AOC function (Airline Operational Control).
2. Manually by the pilot.

The AOC print-out is defined by the airline and determine what kind of report is printed at which time. In this event, the Operation Centre sends a command, e.g. to print-out the actual wind- and/or fuel consumption-data.

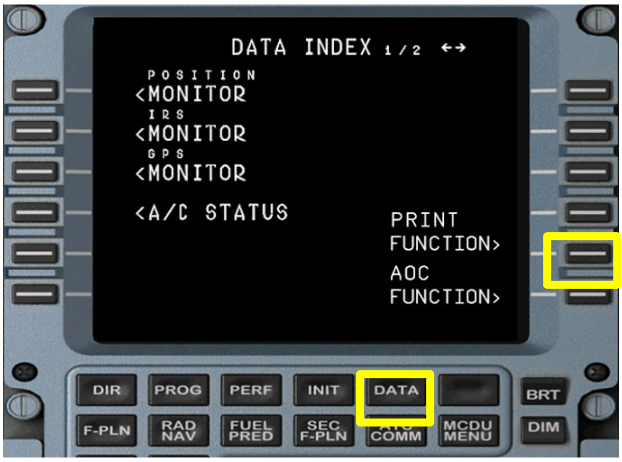
The pilot can print out the Flight Plan at any time at his discretion. The following print options are available to the pilot:

Print Option	Flight Phase
• F-PLN Initialization (Part 1)	Pre-flight
• TO DATA (Part 2)	Pre-flight, Take-off
• WIND DATA (Part 3)	Pre-flight, Take-off, Climb, Cruise, Descent, Approach, Go-Around
• PREFLIGHT (Part 4)	Pre-flight
• INFLIGHT	Take-off, Climb, Cruise, Descent, Approach, Go-Around
• POSTFLIGHT	DONE
• SEC F-PLN	Take-off, Climb, Cruise, Descent, Approach, Go-Around

The pilot calls up the Print Function via the DATA-Key of the MCDU. The MCDU Display opens the Data Index-Page with the available options.

Via LSK5R the first page of the Print Functions is selected. Prints concerning Part 1 to 3 can be initiated.

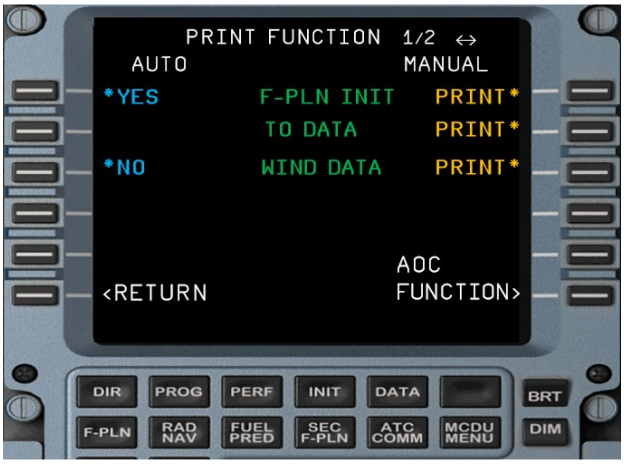
Note: *The Aerosoft Airbus Add-on software does not provide functions for PRINT, AOC and IRS Monitor.*



AUTO is the automatic function (AOC).

MANUAL means, the pilot initiates the print.

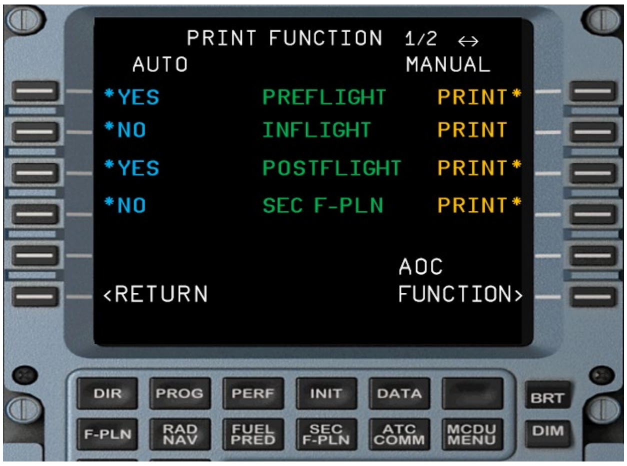
The variables under AUTO mean:
Yes with *, the function is available and can be modified by the pilot.
No and *, the function is available but cannot be modified by the pilot.
Yes and No are not shown, the function is not available.



By pressing the Slew Keys → the second page of the print functions will be shown. All variants according to part 4 can be printed.

The * Symbol under MANUAL means, the function is available and the corresponding print can be initiated.

Note: *The pictures have been modified by the Author and do not represent the actual pages of the Aerosoft Airbus MCDU.*



5.9 Checking the Flight Plan

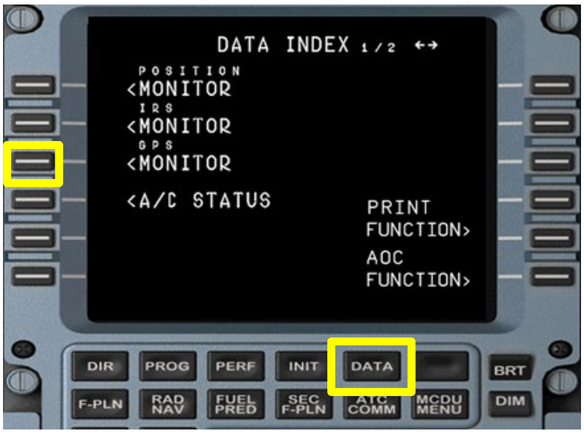
After completion of the F-PLN preparation, the F-PLN shall be thoroughly checked by the pilot in command. The check covers several MCDU pages and shall be done using the graphical representation of the ND.

The check is carried-out in three stages:

1. Checking the GPS availability and accuracy.
2. Checking the F-PLN on the MCDU and ND. The ND is set to PLAN by means of the EFIS controller. A suitable display range of the ND for the training flight is 80 NM which shows the complete flight route from EDDM to LOWS.
3. Checking the performance data.

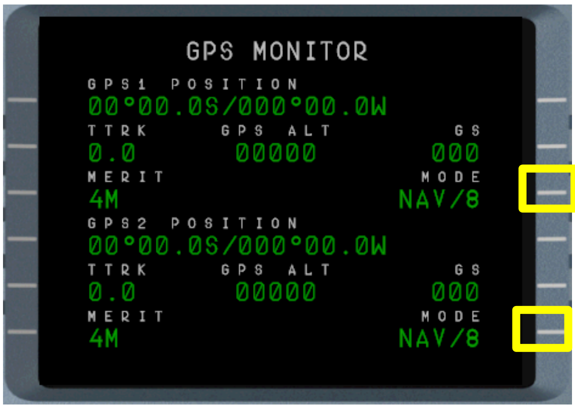
5.9.1 GPS Availability

Pressing the DATA key will open the DATA-INDEX- page.



Subsequently, the pilot presses LSK3L to open the GPS-Monitor page.

The lines 3R and 6R show the number of available Satellites, which are identified by the FMS.



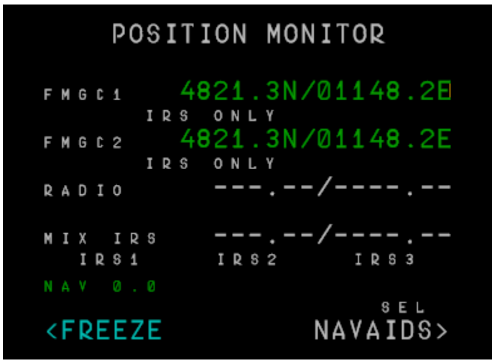
In the example, 8 Satellites are identified and usable.

The GPS accuracy is checked on the PROG pages, which is selected via the PROG key.

In display line 6, the message ACCUR HIGH must be shown providing an accuracy of 1.0 NM that is required for the take-off. Line 5 must show - GPS PRIMARY.

The PROG page further allows to check the distance and Bearing to LOWS, as shown in line 4 (LSK4R). This check ensures that no significant input error occured. Otherwise a bearing and/or distance deviation would alert the pilot .

Additionally, the pilot can open the Position Monitor page via LSK5L (<GPS) and check if both Flight Guidance Computer FMGC 1 and 2 show the same actual aircraft position.



The Positions displayed on the Position Monitor page can be cross-checked with the airport position, shown on the INIT page (see next picture).

The Position data on the Position Monitor (aircraft) and INIT (airport) may slightly differ. This is because, the INIT data is taken from the FMS data-base in the first instance. The aircraft however, is usually not parked exactly in the middle of the airport, but somewhere at the gate or apron.

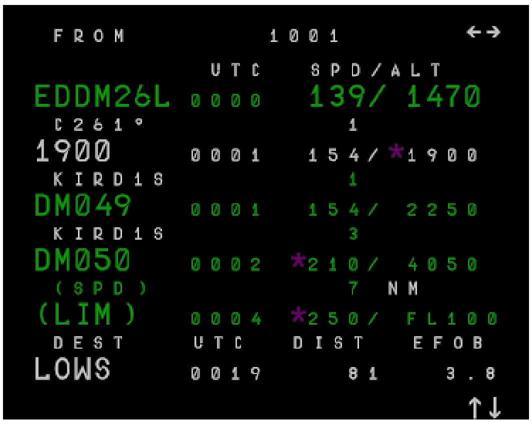
Once the Aircraft is on take-off position, both FMGC shall read the same.

5.9.2 The Flight Plan Check

On the INIT page, the identification data for the City-Pair, Cost-Index und FL can be checked as well as the airport coordinates.

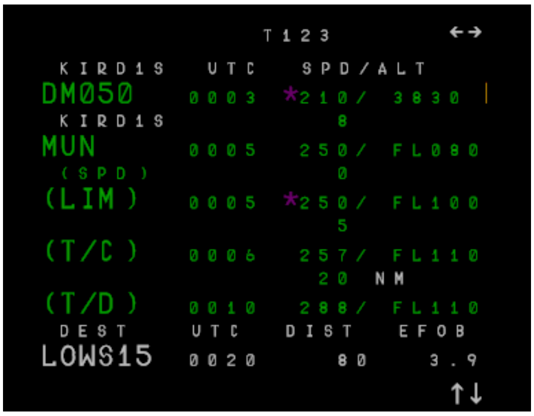
These data are especially important for the Flight Plan calculation.

Subsequently, the F-PLN-A page is opened via the F-PLN-key.



By repeated pressing of the Sley-Key (↑) any WPT can be moved in the middle of the ND to check location and constraint. On the F-PLN page this WPT is shown in the seconde line.

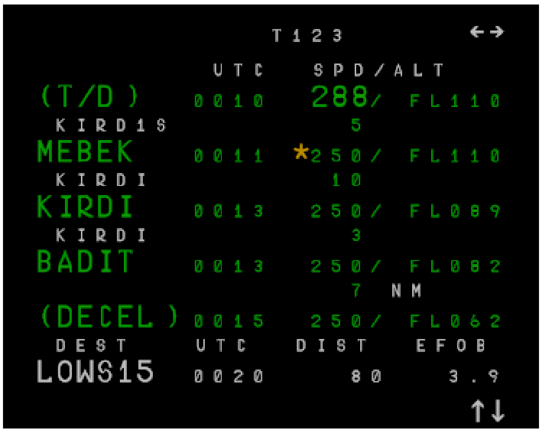
The T/C is only shown after take-off power is set.



The FMGS needs the weight and take-off speed data to calculate the climb rate and the corresponding T/C. The T/C is constantly updated by the FMGS according to the actual climb performance of the Airbus.

In case of changes either by the FMGS or the pilot, the T/C will change its position on the ND accordingly (forward/backwards).

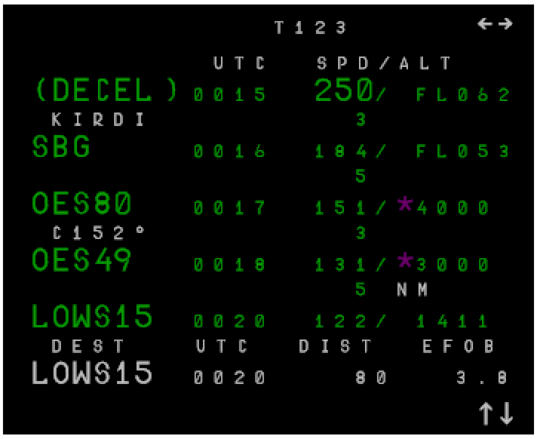
For a short flight like EDDM-LOWS it is generally possible that T/C and T/D meet at the same position. However, such a ballistic Flight profile is very unusual.



In the right picture the T/D is for FL110.

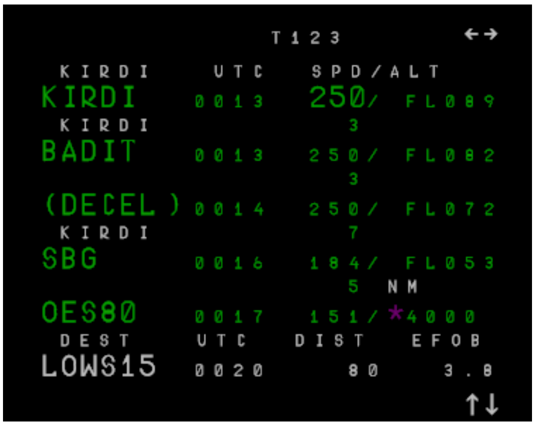
If the pilot enters FL130 instead of FL110, then the T/D moves to the left (closer to EDDM). Because of the longer descent segment, the descent must start earlier.

Consequently, the T/D moves back to the right (closer to LOWS) if FL110 is inserted again. The descent segment is shorter.



When pressing the Sley-Key (↑), the whole approach including the STAR, will be displayed. WPT OES80 is the IAF and OES49 the FAF. The ILS approach begins at the FAF.

In order to display the complete Route, the ND range must be set to 80NM (2x40NM).



To finally display the Route, the pilot uses the Slew-Key to scroll the F-PLN page and bring WPT KIRDI in the middle of the ND.

Now he/she can do a plausibility check of the Flight Route and the Flight Plan.

For better readability, only the first CSTR of the SID, the deceleration point and the last CSTR of the STAR are displayed.

In the upper right corner of the ND the first TO-WPT after take-off, WPT 1900 at 3.3 NM, is shown. It can further be seen, that the A320 is still parked on ground at EDDM.

In the lower ND section the auto-scanned NavAids VOR MUN and WLD are indicated.

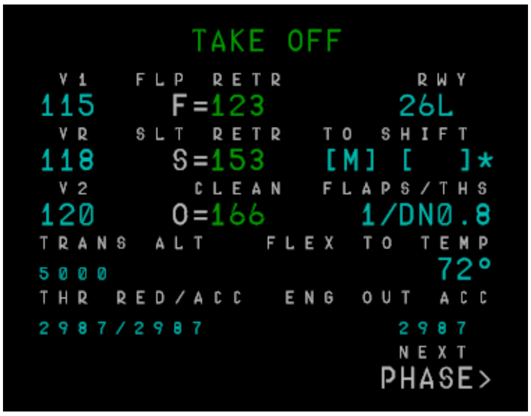
5.8.1 Checking the Performance Data

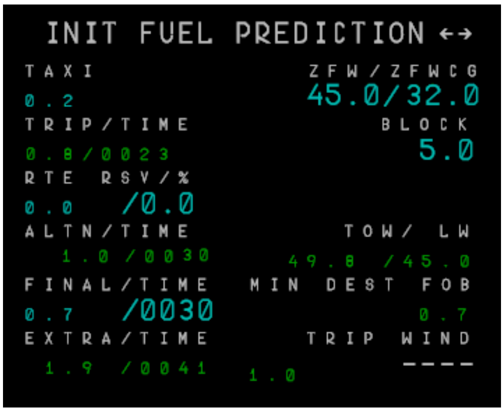
A thorough check of the Take-off-Performance-, the Fuel Prediction- and INIT-page is essential for the safe conduct of the flight. Several incidents have proven, how easy it is to make a mistake when entering these important data. One example which often occurred is the confusion of ZFW and TOW.

If the ZFW is taken instead of the TOW, the external speed calculation program will calculate lower take-off speeds, which in the better case will only lead to a tail strike. The experienced FS-pilot will certainly detect and correct such discrepancies.

On the INIT page the Cost-Index and CRZ-FL, which is essential for the F-PLN calculation, can be checked.

These pages are called-up via the corresponding page-keys PERF, FUEL PRED and INIT.





As long as the engines are not started, Fuel and Weight inputs are done on the INIT-B page.

Once the first engine is started, no input into the INIT B page is possible. Last minute modification must then be made on the FUEL PREDICTION (Fuel Pred) page. This page is available to the pilot during the entire flight.

Note: *ZFW and ZFWCG are wrongly shown on the FUEL-PRED page of the Aerosoft Airbus Add-on Software. The corresponding field on the Aerosoft MCDU shows ZFWCG / ZFW instead of ZFW / ZFWCG). The picture above has been manually modified to show the correct arrangement.*

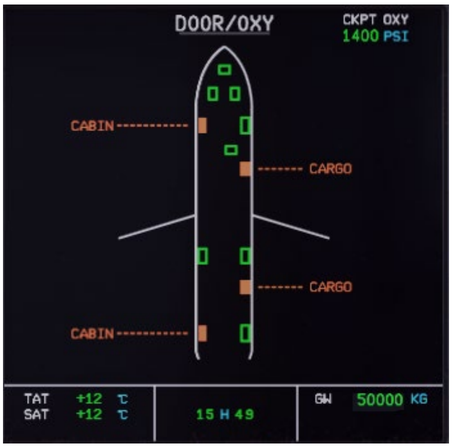
The INIT-B page is a speciality of the A320 family. All other Airbus aircrafts only provide the Fuel-Pred page and <u>no</u> INIT-B.

A further source of information is the ECAM Displays.

In the upper ECAM Display, the actual Fuel quantity (FOB – Fuel on Board is shown. The data is constantly updated by the FMGS during the entire flight.

The actual GW (Gross Weight) is shown on the lower ECAM Display in the bottom right corner.

GW and TOW (Take-off Weight) should not be mixed-up. Due to the fuel burn during taxi, the TOW will slightly be less than the actual GW when the Aircraft is parked at the Gate or Apron.



Chapter 6

Content

6 The Flight Management and Guidance System (FMGS) – Part 1

Flight Management Systems, in short FMS, are electronic Systems for Flight Navigation and Flight Guidance. The FMS supports the lateral and vertical Navigation and also improves the pilot's flight management capabilities through detailed and graphical representation of Flight Data on the Navigation Display (ND).

Modern Flight Guidance Systems integrate the FMS with the AutoPilot (AP) and AutoThrust (A/THR) functions to form the „Flight Management and Guidance System" (FMGS). The Airbus FMGS further includes the Flight-Profile-Management, which calculates the best possible climb and descent profile and provides data for the Fuel- and Time-Management.

6.1 The Navigations-Display (ND) – Part 2

The basic principle of the ND has been explained in the previous chapter together with the preparation of the Flight Plan (F-PLN). In this chapter, additional information is provided with relation to the Flight Guidance.

6.1.1 The ND-Display Modes

Via the EFIS controller, the pilot can choose between various ND presentation modes. ND presentation features a graphical representation of the navigation data . Various presentation modes and display ranges can be selected via the EFIS controller.

All ND-modes present the following information/data:

1. The Flight Route as a **straight Continues line**.
2. Upper left: Ground Speed (GS) and True Air Speed (TAS).

3. Below the TAS: Wind Direction magnetic North (270°) and Wind Speed in knots (22). The Wind Direction is displayed in digital numbers and a graphical arrow.. On ground, the Wind Data are only displayed when the Airbus passes 100 knots.
4. Upper right: Airport/WPT-ID with course, distance as well as the ETA (Estimated Time of Arrival) at the WPT. In the picture, the course to the WPT-MEBEK is 082º, the distance 8.1 NM and the estimated time at the WPT is 18:44 UTC.
5. Bottom left: NAV 1. Mode of Navigation, ID/frequency, DME distance for VOR/ILS selection. *Note: These data are not shown on the real Airbus in PLAN mode.*
   Bottom right: NAV 2. Mode of Navigation, ID/frequency, DME distance for VOR/ILS selection. *Note: These data are not shown on the real Airbus in PLAN mode.*
6. Centre top: Approach Information (ILS). The information is displayed after the Airbus reached the CRZ-ALT (Cruising Altitude) and the remaining distance to the destination Airport is less than 200 NM. The information is again shown in all modes, except PLAN.

The ARC-Mode

The ARC-Mode is a forward-looking cut-out of the compass rose, comparable to the view of the pilot out of the cockpit windows. The circular ARC extends from the middle to left and right, each segment covering half of the compass rose cut-out. Therefore, the range selection of 40 NM represents an area of 80 NM.

This Mode illustrates the Flight Plan with the best accuracy and is usually the preferred choice by the pilot flying (PF).

The Rose-Mode

The Rose-Mode shows the complete compass rose with 360º and the Aircraft in the centre of the ND display. With the Rose-Mode the pilot is able to display a Flight Plan or part of it, even though it contains a 180º turn.

Another advantage of the Rose-Mode is, that the FS-pilot is able to read the reciprocal course directly from the ND without the need for mental calculation.

Furthermore, the Rose-Mode is the best suited ND representation in case of a TCAS warning (Traffic Alert and Avoidance System). Through the 360º view on the ND, Intruder Aircrafts can be seen with their correct position to one's own Aircraft. Newer A320 versions automatically change to Rose-Mode in case of an TCAS event.

The Rose-Mode consists of:

NAV-Mode

The NAV-Modus provides a 360º representation of the Aircraft position with regards to NavAids and the Flight Path, similar to the HSI Instrument (Horizontal Situation Indicator) in a conventional Cockpit. As already mentioned, this mode gives the pilot a complete picture of the actual Aircraft position in space.

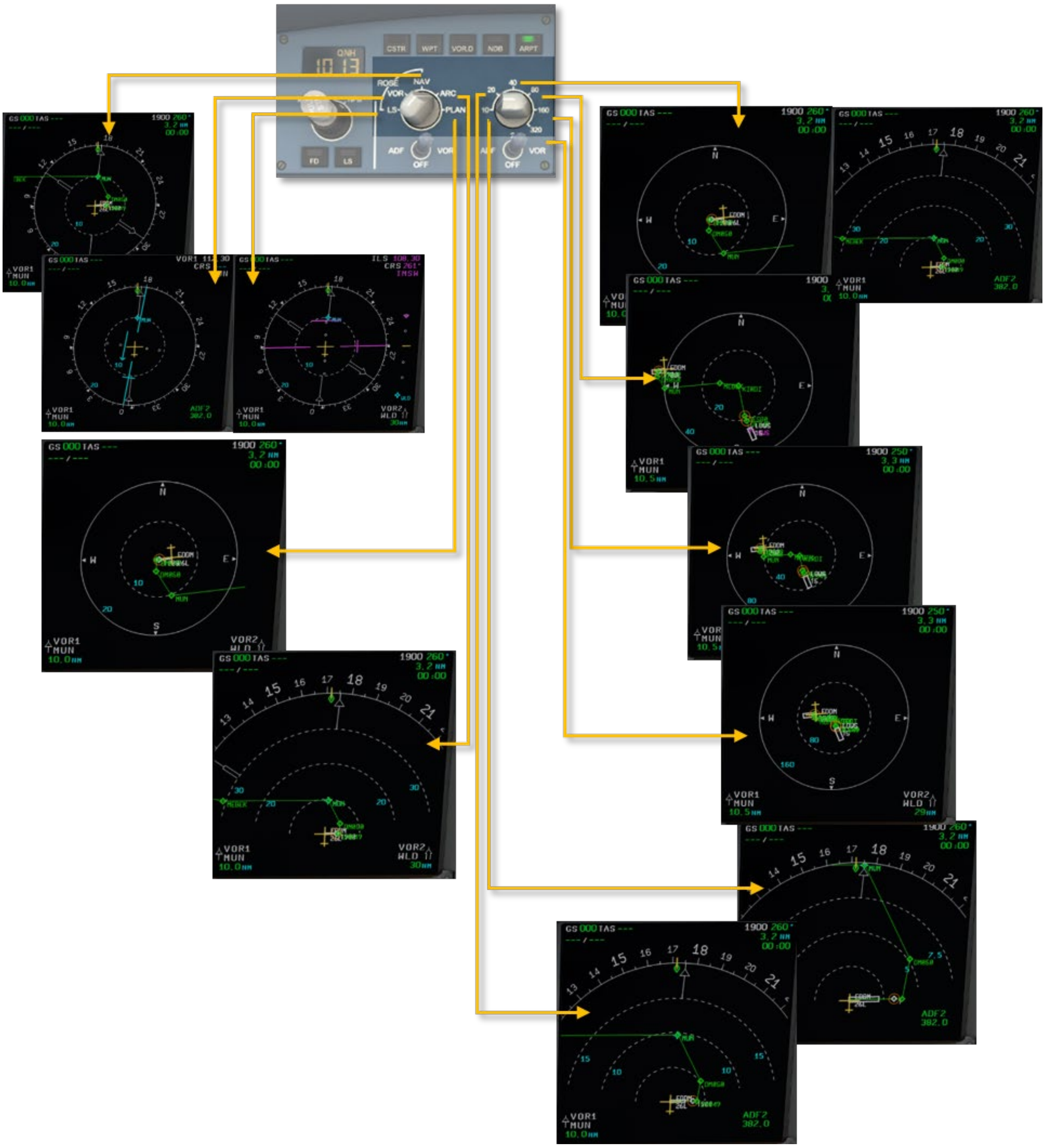
VOR-Mode

The VOR-Mode shows the selected Radial with a **Blue Line**. A deviation from the Radial is indicated by means of a **Blue Arrow** like in conventional VOR flight instruments. The **Blue Arrow Head** tells the pilot the direction to the VOR station.

LS-Mode

The LS-Mode (Landing System) provides a classical representation of the ILS indication for Localizer (LOC) and Glideslope (G/S). The Localizer is displayed like the VOR-Radial but with the **Line** and **Arrow** in **Magenta**. The Glideslope is displayed in form of a **Magenta Rhomb** (diamond) similar to the PFD.

The following picture gives an overview of the ND-Modes.



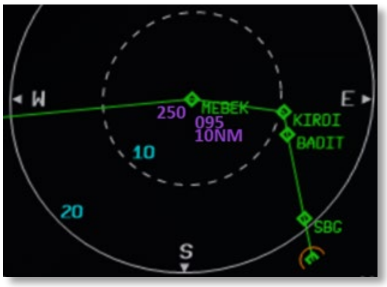
The left part shows the representation for, ARC, NAV, VOR, LS and PLAN.

The right part shows the available range selections covering from 10 NM to 320 NM with varying ND display modes.

The Plan-Mode

The pilot uses the PLAN-Mode predominantly for the preparation and check of the Flight Plan. The ND presentation follows the input sequence of the pilot by placing the actual TO-WPT in the centre of the ND. The display in PLAN-Mode is always arranged towards magnetic North.

Additionally, the PLAN-Mode always shows the distance (NM) and Bearing (course) between the WPT in the centre of the ND and the next WPT in the direction of the flight.



If the pilot selects CSTR on the EFIS controller, then the ND displays CSTR information (altitude and/or speed restrictions) additonally to distance and course. WPT MEBEK includes a speed constraint of 250 knots.

The VOR- / LS- /- NDB Mode

In order to display the Navigations information correctly on the ND, the corresponding NavAids must be selected through the RadNav page and the EFIS controller.

The A320 uses the RadNav page for the selection of all Navigation systems. There are no NAV-panels with rotary knobs like in conventional cockpits.

The manual selection of NavAids is also called Hard-Tuning, which has priority over the FMS selection.

NDB: ID-Code or frequency - LSK5L for ADF-1 and LSK5R for ADF-2. NDB is the NAV-ground equipment and ADF the corresponding on-board NAV-instrument. NDB-s usually contain an Identification Code (ID), which simplifies the input. The ID can also be acoustically checked by the pilot. In rare cases, the NDB does not provide a Morse code which is than artificially provided using a BFO (Beat Frequency Oscillator), LSK6l and LSK6R.

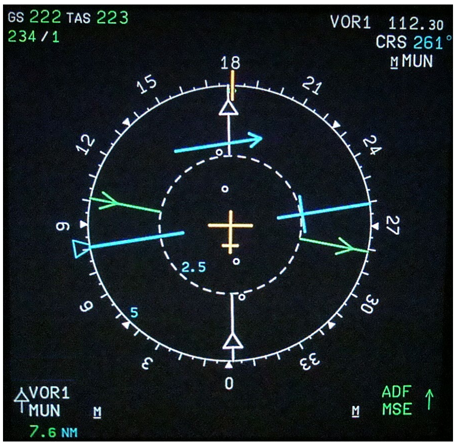
VOR: ID-Code or frequency - LSK1L for VOR-1 and LSK1R for VOR-2. In order to show the Radial on the ND, the course for VOR-1 is inserted via LSK2L (Captain ND) and LSK2R for VOR-2 (F/O ND). The VOR-1 MUN is shown in large letters (not to mistake with capital letters) because it has been manually selected by the pilot (hard tuned). This selection stays, until the Pilot cancels it by means of the CLR-key. In the meantime, automatic scanning cannot be used for this NAV-Position. The VOR-WLD is displayed with small letters that means, this VOR has been automatically scanned and tuned by the FMS.

ILS: ID-Code or frequency - LSK3L. The ID always includes the ILS-frequency and the Runway course. If the frequency is manually inserted, ID and Runway course also need to be entered via LSK4L. The ILS-ID has also been manually inserted (large letters).

In the example, the ILS RWY 15 at LOWS and VOR-MUN are part of the active Flight Plan. Therefore, **ILS15** is shown in the centre of the ND and MUN as the TO-WPT.

VOR-MUN has also been manually selected and the corresponding arrow points to the VOR station, which is ahead of the Airbus. The M next to the ID-MUN confirms the manual tuning.

The double-line arrow for VOR-2 WLD points back to the VOR station which is located next to EDDM. Because the ARC-Mode looks forward, the arrowhead cannot be seen.

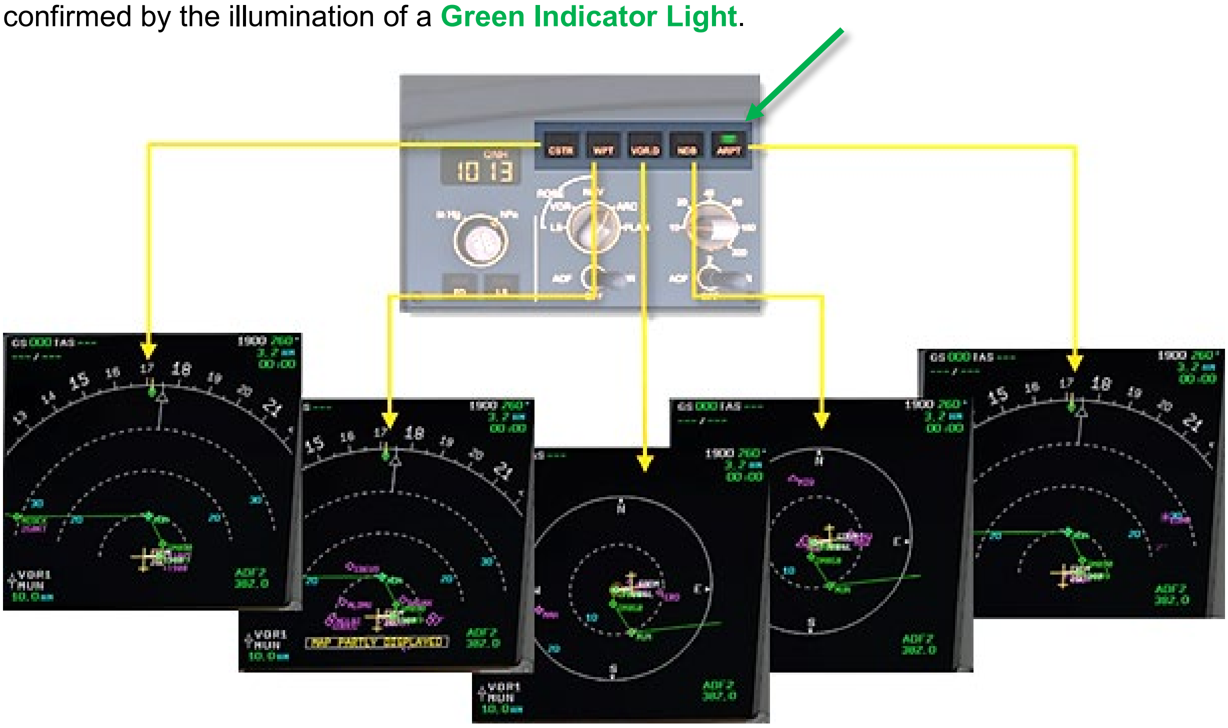


In the right picture, the Captain has selected MUN as the VOR1 with a course of 261°. The F/O selected ADF MSE as ADF2, which is the MM (middle marker) of EDDM Runway 26R.

The VOR MUN is ahead and to the right (arrow head) of the A320.

6.1.2 The ND-Display Variants

Above the rotary knobs for ND-Mode and Range selection, five illuminated buttons are placed for the selection of specific information. Only one selection can be made at a time, which is confirmed by the illumination of a **Green Indicator Light**.



6.1.3 The Constraints Symbolic

In Managed Mode, the FMGS considers all Pseudo-WPTs as well as Constraints (CSTR) included in the Flight Plan.

Constraints are always part of an active Waypoint and can be monitored/managed via the MCD-F-PLN-VERT REV-page. In the right picture the pilot entered SPD and ALT constraints at WPT **XXXXX**.

The CSTR values (**250** / **5000**) are shown on the ND, if CSTR has been selected on the EFIS controller.

The Constraint Symbols

ND	***F-PLN***	***CSTR-Conditions***
	*	CSTR will be met
	*	CSTR will be missed
	*	CSTR is not considered

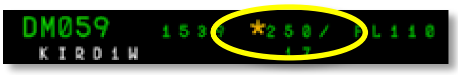
With regards to SPD-constraints, two additional symbols are in place, which are:

	*	SPD change takes place at the position, SPD-LIM or SPD-Constraint
	*	DECEL (Deceleration Point)

SPD-LIM always concerns the speed change to/from 250 knots at FL100.

SPD-CSTR which are considered and met according to the actual flight progress, are shown with a **Magenta Star*** on the F-PLN-page.

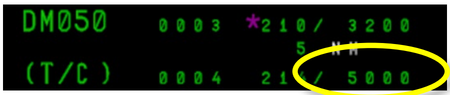
SPD-CSTR which are not met, are shown with a **Yellow Star*** on the F-PLN-page.



When the selected FCU altitude of e.g. FL70 is lower than FL100, then SPD-LIM is not indicated on the ND. However, in the F-PLN-page SPD-LIM is shown if a FL greater than 100 has been entered into the INIT-A-page as the CRZ-ALT.

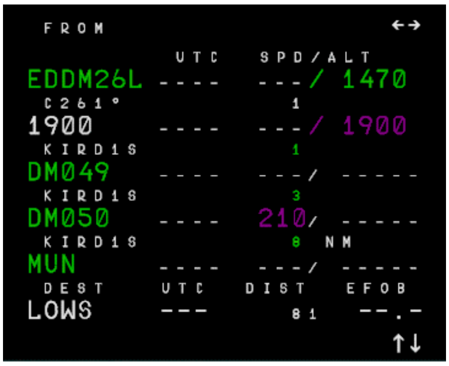
When the pilot selects 11.000 feet (FL110) on the FCU, SPD-LIM is displayed on the ND with a **Magenta Point ●**. SPD-LIM point is not part of a WPT and its location depends on the FL100 position.

If the pilot enters a cruise altitude lower than FL100 into the INIT-A page, e.g. 5000 feet (right picture Line 5-T/C), then the SPD-LIM point is not calculated by the FMGS and not displayed on either F-PLN page and ND.

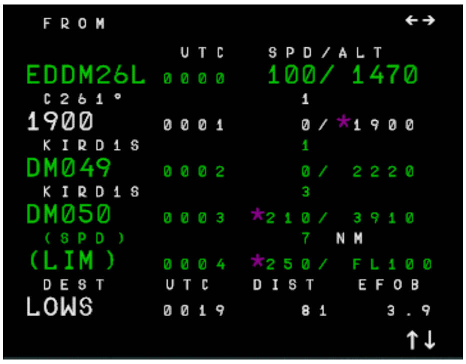


Contrary to SPD-CSTR, ALT-CSTR are always displayed on the F-PLN page and ND, irrespectively if CSTR has been selected on the EFIS controller. In case the pilot selects CSTR on the EFIS controller, the CSTR **value** (e.g. 5000) is displayed next to the Circle symbol.

F-PLN-A before the input of weight data. CSTR are in **Magenta (Letter)**.



F-PLN-A after input of weight data. CSTR are in **Magenta (*)**. Prediction are in **Green**.



When CSTR is selected on the EFIS controller, the values for both SPD and ALT constraints are displayed on the ND.

The value next to the Star * is the FMGS Prediction- and not the CSTR-value.

If the pilot wants to check the CSTR values, he/she may do so on the ND (EFIS-controller CSTR selection) or the MCDU on the F-PLN-VERT-REV page.

6.2 The FMGS Principle

The Airbus „Flight Management and Guidance System“ (FMGS) consist of the sub-domains „Flight Management System“ (FMS) and „Flight Guidance“ (FG).

The Flight Management System - FMS is responsible for:

- Provision of Flight Information
- Flight Route Planning
- Auto Scanning (Tuning) of NavAids (VOR, NDB, ILS, DME, RA-Radio Altitude)

The Flight Guidance System - FMGS is responsible for:

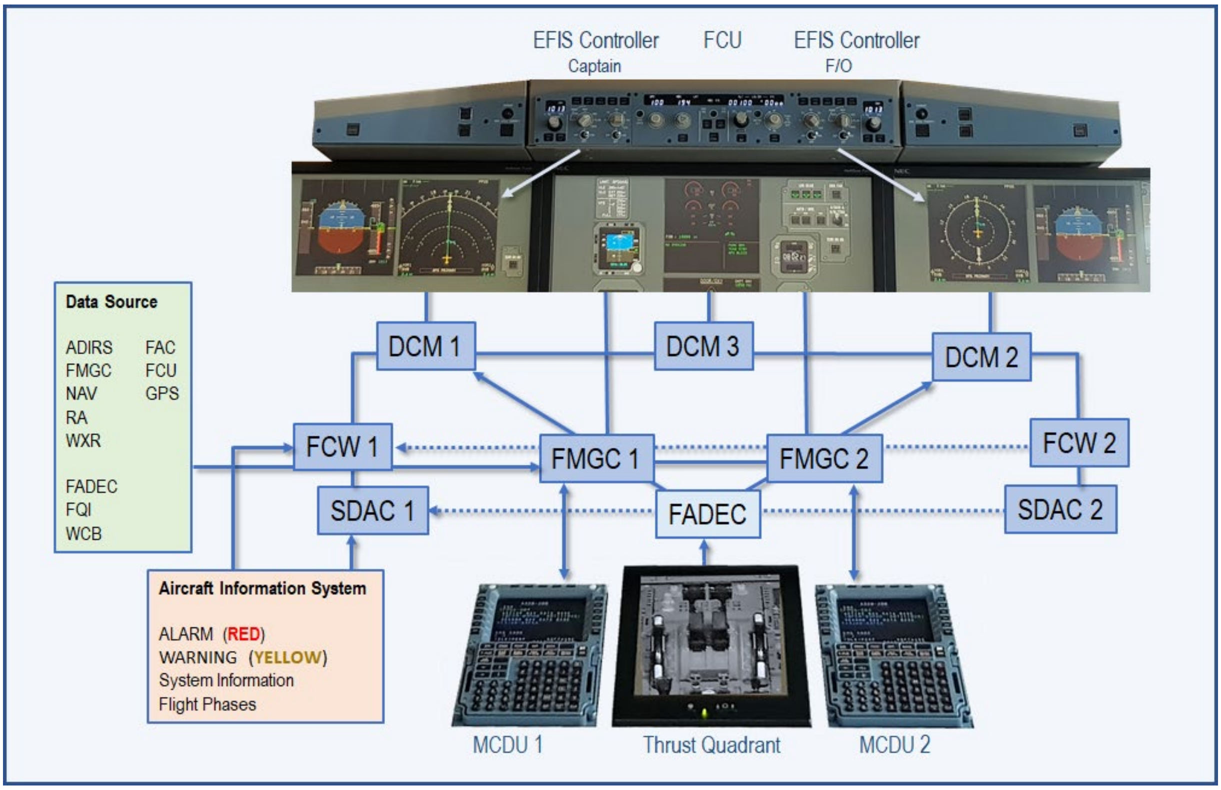
- Flight Director (FD)
- Auto Pilot (AP)
- Auto Thrust (A/THR)

- Flight Plan Predictions (e.g. Profile)
- Adherence to Constraints (CSTR)

6.2.1 The FMGS Configuration

The FMGS is based on three in principle independent systems, which are integrated by the FMGS functionality. Therefore, the FMGS consist of:

1. FMS - Flight Management System
2. AP - Auto Pilot
3. A/THR – Automatic Thrust (AutoThrust)



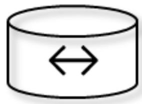
FCU, MCDU and the Thrust Levers are the man-machine-interfaces between the Pilot and the Flight Management and Guidance System (FMGS). The two (2) Flight Management and Guidance Computers (FMGC) are the main units of the FMGS where the complete processing of Flight Data takes place.

Before Flight Data can be displayed on the Flight-Instruments (PFD, ND und ECAM), they must be acquired and processed. After processing by the FMGCs, the data are distributed via the DMC (Display Management Computer) and displayed on the respective Flight-Instruments.

The Flight information data are complemented by Alarm- and Caution-Messages on the ECAM Display and acoustic warning sounds. This part is provided by the FWCs (Flight Warning Computer). The FWCs receive the necessary data via the SDACs (System Data Acquisition Concentrator).

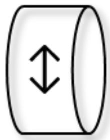
6.2.2 The MCDU Control Unit

The Menu pages are the main information source, which are selected via Page-Keys and may include several levels. The selection of other levels or sub-pages is done by means of Slew-Keys.



The Keys for page selection →← are working like a horizontal spool.

The keys for turning pages ↑↓ are working like a vertical spool.



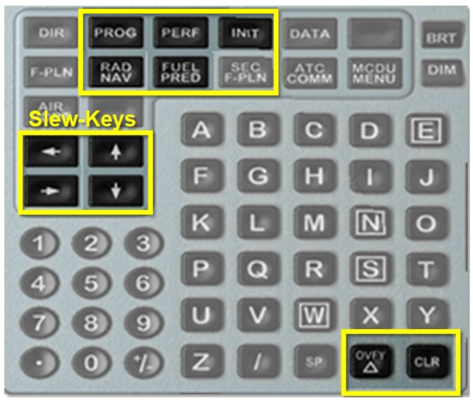
Whenever a function covers more than one menu page, soft keys are shown on the upper right corner of the page. With key ← the pilot can turn to the next menu page. Returning back to the previous page is done with the → key.

Whenever the F-PLN requires more than one display page, soft keys are shown on the lower right corner of the page. With the slew- keys ↑ ↓ the pilot can scroll the display lines up and down.

The graphical (soft) keys are only a notification of the availability of the function. For the selection, the pilot must use the corresponding slew keys (buttons) of the MCDU keyboard.

For this chapter, the following MCDU function keys are of interest:

- INIT-A, INIT-B is selected from the INIT-A page using Slew-key ←
- FUEL-PRED
- PROG
- PERF
- RAD-NAV
- CLR



Inadvertent and/or erroneous inputs by the pilot can be cleared or deleted using the CLR-key. Each pressure on the CTR-key clears the last letter input on the Scratchpad. That means after entering EDDM, pressing the CLR-key will delete the last letter M. The subsequent pressure will delete letter D and so on.

If the Scratchpad shows a message, e.g. „ **INSERT DEST DATA**", then pressing the CLR-key will delete the whole message.

6.3 The FMGS Functions

The FMGS uses Flight Plan Data to calculate the most economical Flight Profile (vertical and lateral) over the entire Flight. These data include, Cost-Index, Meteorological Data such as Wind and Temperature, Aircraft Data including Weight (Pax and Cargo) and Fuel.

6.3.1 The Flight Phases

The FMGS guides the flight along the vertical and lateral F-PLN and complies with all constraints and limitations concerning Speed, Altitude, Time and Fuel.

In order to meet this requirement, Airbus defined typical Flight Profiles and classified them into Flight Phases. In chapter 4, the Flight Phases have been discussed with regards to the functions of the Flight Management System (FMS)and are also valid for the FMGS. The following table provides an overview of the Flight Phases and their characteristics.

The FMGS Flight Phases

Flight Phase	Reference-Speed	Transition Conditions	Next Phase
PRE-FLIGHT 1	N/A	SRS Mode active and N1 > 85% or Ground Speed > 90 knots	TAKE-OFF
TAKEOFF 2	V2 + 10	Passing ACC ALT SRS Mode is replaced by another vertical mode, e.g. OP CLB.	CLIMB
CLIMB 3	ECON Climb Speed	Level-off at Cruise Altitude	CRUISE
CRUISE 4	ECON Cruise Speed	Initiation of the DES. The actual FL must be equal or above the INIT FL and the distance to the destination Airport <200 NM.	DESCENT
DESCENT 5	ECON Descent Speed	Crossing the DECEL WPT or Manual Activation	APPROACH
APPROACH 6	V APP	Go-Around Initiation	GO-AROUND
GO-AROUND 7	V APP or Actual Speed	Manual Activation of the APPR-Page or Selection of CLB-, OP-CLB-Mode	APPROACH CLIMB
DONE 8		30 seconds after Landing	PREFLIGHT

6.3.2 Guidance Modes

The FMGS AutoFlight System also differentiates between „Managed“ and „Selected“ Modes of Operation.

A typical Flight in Managed Mode is carried-out with an active Flight Plan. These Data are entered via the MCDU and permanently monitored by the FMGS. Divergent instructions by the ATC (Air Traffic Control - ATC) due to traffic volume and weather conditions are selected on the FCU causing a change to Selected Modes.

The AutoFlight-Modes (AFS) and their application are explained in chapter 4. Following is a brief repetition of the main functions.

- **Managed Mode**

When in Managed Mode, the FMGS completely operates the Flight automatically using AP and A/THR.

The Data provided by the Flight Plan are the basis for the flight guidance, complimented by specific pilot inputs (via the MCDU) if required. Out of this data, the FMGS calculates and flies the optimum flight profile.

The **Dot ●** in the FCU windows confirms, which AutoFlight function operates in Managed Mode, either active or armed. This principle is valid for Speed (SPD), Heading (HDG), Altitude (ALT) and Vertical Speed (V/S – climb or descent).

In order to activate the Managed Modes, the pilot pushes the corresponding rotary knob. In the example, the pilot changes from HDG- to NAV-Mode (Flight Plan) by pushing the HDG knob.

- **Selected Mode**

When in Selected Mode, the FMGS receives the necessary information directly from the pilot, via the FCU. In accordance with this data, the FMGS flies the selected flight path.

In order to activate Selected Modes, the pilot inserts the desired value and pulls the corresponding rotary knob.

In the example, the pilot changes from NAV-Mode (Flight Plan) to the HDG-Mode by pulling the HDG knob.

- **AutoThrust Mode (A/THR)**

Similar procedures apply for the AutoThrust Modes (A/THR).

The Aircraft Speed is either controlled via the FCU SPD window in Selected A/THR Mode. Or the Speed information is controlled by the FMGS and the A/THR-Mode is in Managed Mode. The A/THR controls the Speed either with fixed Thrust (THRUST-Mode) or flexible Thrust (SPEED-Mode).

6.3.4 Performance and Progress Monitoring

In order to monitor the flight progress, the FMGS offers several Menu-Pages on the MCDU, which are activated by the FMS according to the Flight Phase:

- **The Performance Pages**

  The Performance Pages (PERF-Page) allow the input of Aircraft, as well as specific flight guidance data, e.g. weather information at the destination Airport. There is a Performance Page for each Flight Phase from Take-off to Landing. Excluded are the Flight Phases 1 (Pre-flight) and 8 (Done).

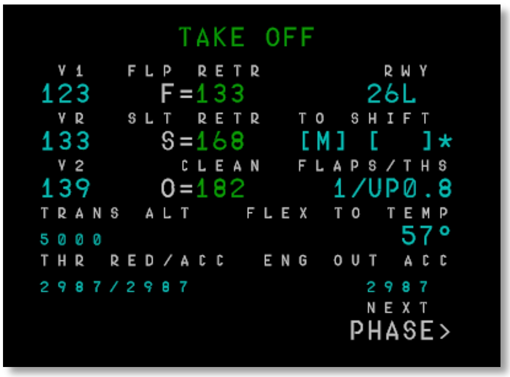
- **The Progress Pages**

  The Progress-Pages (PROG-Page) allow the pilot to monitor the Flight Progress and to call-up important flight information. There is a PROG-Page for each Flight Phase similar to the PERF-page scheme. The Progress-Pages includes a page for Phase 1 (Pre-flight) but also no page for Phase 8 (Done).

6.4 The Performance Pages

The performance pages are the main source for the pilot to manage and monitor the performance of the Airbus. The page IDs correspond with the active Flight Phase. Actually, switching between the pages is referred as next/previous Phase and <u>not</u> Page.

6.4.1 The Take-off-Page (TAKE OFF)



In the Take-off-Page the pilot enters the V-Speeds **V_1, V_R, V_2** for the Take-off. These Speeds are not calculated by the FMGS but by the pilot using an external program.

The FMGS calculates:

F – Speed

S – Speed

GD – **Greed Dot (o)** Speed

Additional information to be entered into the Take-off-Page are:

TO SHIFT		TO-Shift is inserted in meters and determines the actual TORA (<u>T</u>ake-<u>O</u>ff <u>R</u>unway <u>A</u>vailable) which is RWY length minus TO-Shift. The TO-Shift value depends on the taxi-way entry.
TO FLAPS	**1**	The flap position 1 corresponds to a take-off flap setting of 1+F. This input is not necessary for the FMGS functions. However, the information is used as a check-item for the Before-Take-off Check.
THS (Trim)	**0,8**	For the take-off, the trim value for the A320 family is usually within 1 DN to 1 UP. The **Green** THS zone covers the setting from -2,5 DN to +2,5 UP. The pilot may choose, to set the trim more top-heavy or

tail-heavy. Also, this information is only a check-item. For the take-off, the manual trim-wheel position defines the setting.

TRANS ALT 5.000 The Transition-Altitude in Europa is not homogeneous, in Germany it is 5.000 feet and in the Netherland 7.000 feet. In the USA the transition altitude is as high as 18.000 feet. The TRANS-ALT (TA) is taken from the FMS data-base and automatically inserted.
During the approach the Transition Level (TL) is used instead of a defined altitude. The actual TL is defined by the ATC (function of the transition altitude and the QNH) and broadcasted via ATIS (Automated Terminal Information Service).

THR RED / ACC The Thrust-Reduction (THR-RED) and the Acceleration-Altitude (ACC-ALT) usually have the same reference altitude. However, e.g. for noise abatement procedures the altitudes may differ.
The THR-RED, ACC-ALT and TRANS-ALT are indicated in feet MSL (Mean Sea Level).

ENG OUT ACC The Engine Out Acceleration-Altitude is normally the same as the ACC-ALT.

The switch from the Take-off to the Climb-Page takes place, when the A320 passes the ACC-ALT. If different altitudes are inserted for THR-RED and ACC-ALT, the ACC-ALT is the trigger.

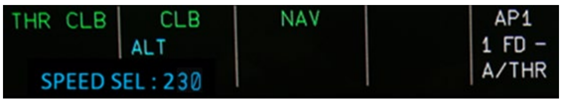
6.4.2 The Climb Page (CLB)

The CLB Page contains information with regards to the climb phase, which are:

- Current Aircraft Mode – Managed or Selected
- CI – Cost Index
- Managed/Selected Speed
- Pre-selected (PRESEL) speed for climb if applicable

Additional information include Time (UTC), FOB (Estimated Fuel on Board) and the Distance (DIST) to reach the Cruise-Flight-Level (CRZ-FL).

If a Climb speed has been pre-selected (PRESEL), e.g. 230 knots as in the example above, the Airbus will accelerate to 230 knots instead of 250 knots when passing the ACC-ALT. The pre-selected speed is also shown on the PFD, column 1 and 2 of the FMA.



The switch from the CLB to the CRZ-Page takes place, when the Airbus levels-off at the FL which has been inserted into the INIT-Page, e.g. FL110. If no CRZ-FL has been inserted into the INIT-Page, then the FCU-ALT at take-off power setting is the initial CRZ-ALT.

6.4.3 The Cruise Page (CRZ)

The CRZ Page contains widely the same data/information as the CLB-Page.

Like the CLB-Page the pilot can also pre-select a cruise speed (PRESEL) in the CRZ-Page. In the example, no specific cruise speed is inserted. The indicated/managed cruise speed has been calculated by the FMGS.

In the CRZ-Page, the distance to the Top of Descent (T/D) is indicated. This information is essential to the pilot in order to call ATC in good time for the clearance to descent.

The pre-set standard descent cabin rate (Packs) is shown in the lower right part of the page. Before starting the descent, the rate can be modified by the pilot.

The switch from the CRZ to the DES-Page happens with the descent initiation by the pilot. Prerequisite is, that **ALT-CRZ** is the active mode shown on the PFD-FMA. Furthermore, the distance to the destination must be less than 200 NM. If the actual distance is more than 200 NM, then the FMGS regards the new altitude selection as a FL-Change and not a descent. No switch to the DES-Page occurs and the CRZ-Page remains active.

Generally, any change in altitude, regardless in which Mode and at which Altitude must be initiated by the pilot. The Airbus will not automatically start to descent at the T/D, even the pilot has selected a lower altitude on the FCU.

The switch to the DES phase only takes place, if the Airbus flies at the CRZ altitude as entered on the INIT page. If not, then the CRZ altitude must be altered manually, see later under PROG-CRZ page,

6.4.4 The Descent Page (DES)

The DES-Page offers descent related information, like the actual descent speed (DES-Speed) either for Manged or Selected Mode.

In the example the Airbus descents in Managed Mode. If the pilot changes to Selected Mode the ACT MODE field will change to **SELECTED**.

The EFOB (Estimated Fuel on Board) data on the upper right corner is very important for the approach planning.

In case the FOB value is shown in **Orange**, then the fuel is critical and requires action by the pilot. One possibility is to ask ATC for a direct (DIR TO) clearance to shorten the flight leg. Or he/she need to ask for landing priority which is a more severe issue usually leading to an investigation by the ATC.

There are two ways to switch from the DES to the APPR-phase:

- Automatically by the FMGS when the Airbus crosses the Deceleration Point (DECEL)
- Manually by the pilot. The pilot can manually activate the APPR-Page/Phase from any Page except the Take-off-Page.

If no active F-Plan is used, then no DECEL-WPT is available. In this case, the pilot should manually activate the APPR-Page latest at the IAF (Initial Approach Fix). Only then, specific functions such as Managed Speed reduction via the Flap selection are available to the pilot.

6.4.5 The Approach Page (APPR)

The APPR-Page shows all necessary information for a safe and stabilized approach.

Out of these data, the FMGS calculates the following approach speeds:

F – Speed.

S – Speed

0 – **o Greed Dot (GD)** Speed

VLS – Lowest Selectable Speed. The VLS is always 5 knots less than the V**APP**.

VAPP – for Flap Configuration Full or 3. In order to precisely calculate the V**APP**, the FMGS requires the wind data. Otherwise, the calculation is based on calm wind conditions.

Flaps full is the default configuration for the **VAPP** calculation. With LSK4R the pilot can select a Flap 3 landing. The APPR-Speeds for F3 are slightly higher.

Additional Information shall be entered by the pilot:

QNH – Barometric air pressure referred to MSL, e.g. QNH 1020.

TEMP – Airport field temperature.

MAG WIND – Airport field wind data (direction and speed) transmitted by the ATC.

TRANS ALT – Transition-Altitude, if applicable.

BARO/RADIO – Baro and Radio are altitude gates to alert to pilot for the impending approach decision altitude/height. At 100 feet before reaching the inserted altitude the alert call-out „100 ABOVE“ sounds.

- *MDA* is the minimum altitude for NPA approaches – Minimum Descent Altitude and refers to MSL (Mean Sea Level).
- *MDH* is the minimum height for NPA approaches – Minimum Descent Height and refers to AGL (Above Ground Level).
- *DA* is the decision altitude for ILS approaches – Decision Altitude (MSL).
- *DH* is the decision height for ILS approaches – Decision Height (AGL).

The pilot enters either the MDH/MDA (Baro) or DH/DA (Radio) in feet.

LDG CONF – Selection of the landing configuration (LDG CONF) Flaps 3 or Full with display of the corresponding landing speeds VAPP and VLS.

FINAL – Is the Information of the actual runway and the approach method. In the example: ILS15 is an ILS-Approach to runway 15 at LOWS.

The switch from the APPR to the Take-off-phase takes place after landing, when the Airbus is at least 30 seconds on ground. In case of a GA, the switch to the GA-phase occurs by setting the thrust levers into the TOGA detent and activating the GA-Mode.

6.4.6 The Go-Around Page

The GA-Page provides vital information about the actual **GD** – **S** – **F** Speed, which are important for the second approach preparation.

Via LSK6L ← **APPR PHASE** the pilot can switch back to the APPR-phase, if an immediate second approach is planned. The FMGS calculates the APPR speeds new and displays them on the page. Due to the GA procedure, the missed-approach flight route and eventually a holding, the additional fuel consumption has changed the landing weight.

The target speed after the ACC-ALT or GA-ACC-ALT is the **GD**-Speed and not 250 knots as for a normal take-off. The **GD**-speed is also the target speed to select flap 1 for the approach.

In the event, that no second approach is planned (e.g. weather conditions), the flight will continue to the Alternate Airport. In this case, a mode-change to OP-CLB-Mode with an accompanying switch to the CLB-phase must be initiated by the pilot.

In order to initiate the GA, at least one thrust lever must be set into the TOGA detent, as the GA can also be flown with one engine. If the thrust levers are inadvertently set into MCT detent, the GA-phase will not be activated and no switch to the GA-phase occurs. That means, the GA-Modes **SRS** and **GA TRK** or **NAV** are not available to the pilot.

6.4.7 The Active PERF-Page

The pilot can open each Performance Pages manually at his/her discretion to monitor the flight and/or to enter new data. To do so, the pilot presses the LSK next to the prompt Next Phase> in the active PERF-page. The pilot returns to the previous or the active page using the <Prev Phase key.

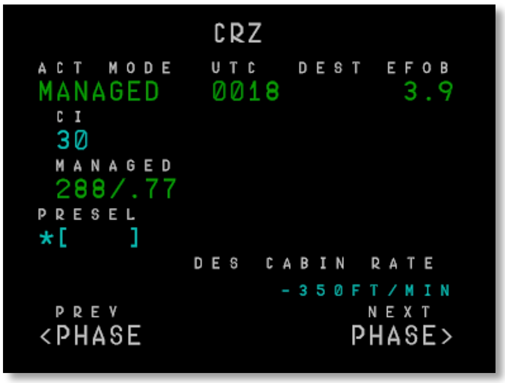
In order to provide an easy reference, the header (page-designation) of the active Page/Phase is shown in **Green**. The headers of all other pages are in White, as shown below.

By pressing LSK6L the APPR-phase can manually be activated, except in the Take-off-Page. The prompt changes from **Cyan** to **Orange**.

The switch to the APPR-phase must be confirmed by a subsequent second touch on LSK6L.

With LSK6R (Next PHASE>), the pilot can switch to the next Page, or activate the APPR-phase with LSK6L

On the non-active PERF-Page, LSK6L provides a return function (Prev <PHASE) instead of the APPR-phase activation.



6.5 The Progress Pages

The systematics of the Progress Pages is similar to the performance Pages. They contain primarily dynamic information with regards to the flight progress.

Progress Pages do not provide a Next-phase function, meaning the pages cannot be opened independently. The pages are automatically opened according to the Flight Phases and Inputs can only be made into the active PROG-page. The Page Designator (header) is therefore always in **Green**. The page-switching conditions are equal to the PERF-pages.

All PROG-pages, except the GA-page, show the actual GPS-Accuracy in accordance with the active Flight Phase. **GPS PRIMARY** must be shown, otherwise RNAV-Navigation is not permitted, for Departures, Airways and Approaches.

As already mentioned, the Progress-Pages also do not include a Done-page but comprise a Pre-flight-page. *Note: the Pre-flight-Page is not available with the Aerosoft Airbus Add-on.*

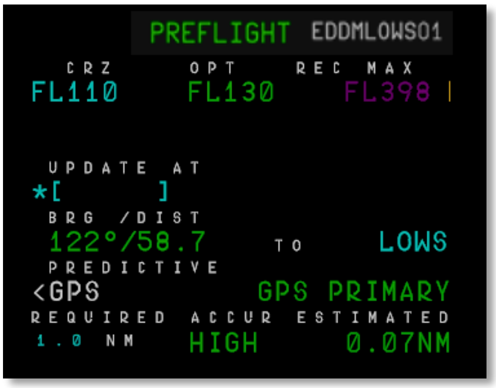
6.5.1 The Pre-flight Page

The **PREFLIGHT** -Page allows the pilot to check the Flight Plan with regards to the Flight Distance and Bearing. For this purpose, the pilot enters the destination Airport into the TO field, in the example LOWS. The active Flight Plan who follows the published Navigation Routes, will show slightly different data.

The active Flight Plan EDDMLOWS01 is shown in the upper right corner of the **PREFLIGHT**-Page.

As with every Progress-page, the GPS accuracy can be checked in line 5. The required GPS-Accuracy of 1NM, is met (HIGH with 0.07NM).

The **PREFLIGHT**-page switches to the Take-off-Page when the aircraft speed exceeds 80Kts. This is the only difference to the PERF-switching conditions.



6.5.2 The Take-off-Page (TAKE OFF)

The **TAKE OFF**-page contains more or less the same information as the **PREFLIGHT**-Page.

The GPS-Accuracy (GPS PRIMARY) is important to fly RNAV-SIDs.

The page further shows the CRZ-FL (INIT), the OPT-FL (optimal, most economical FL) and the REC MAX-FL (recommended maximum FL, not to exceed).

6.5.3 The Climb Page (CLB)

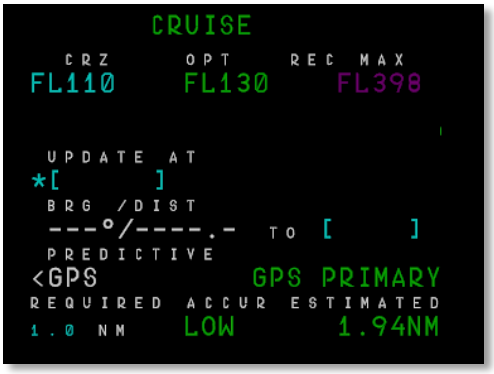
Again, the Climb-page contains similar information as the **PREFLIGHT**- and the **TAKE OFF**-pages.

If, as in the example, the FMGS calculated optimum FL 130 (OPT) is above the planned CRZ FL 110, the pilot may contact ATC for a FL change. As higher the Airbus flies, as thinner the air density and as lower the fuel consumption is.

6.5.4 The Cruise Page (CRZ)

The Cruise-Page again provides quite similar information and functions as the other PROG-pages, including the GPS accuracy. In the example, the GPS-accuracy is LOW preventing the pilot from using RNAV Routes.

Consequently, the pilot must inform ATC accordingly and may need to alter the Flight Plan routing.



The Cruise Page allows to alter the planned FL 110 (INIT-Page) with a new, or the actually flown FL,, for example FL130.

If the new FL is higher than the planned FL, e.g. 130 instead of 110, the INIT page will be modified automatically.

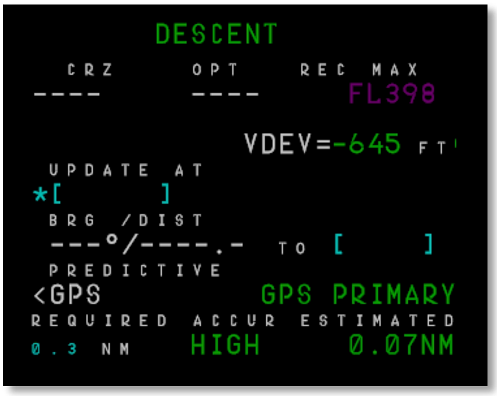
If the new FL is lower than the planned FL, e.g. 090 instead of 110, then the switch from the CRZ-Page to the DES-Page will not occur.

Hence, the INIT ALT must be synchronized with the FCU-ALT. For this purpose, the pilot writes the new ALT (FL110) into the Scratchpad and confirms with LSK1L.

This procedure can be simplified by typing the number 1 into the Scratchpad and pressing the LSK1L. The FMGS writes the actual FCU-ALT into the CRZ field, which becomes the new CRZ-ALT.

6.5.4 The Descent Page (DES)

The Descent-Page covers additional information in addition to the very same data as in the previous pages. These added information concern primarily the descent profile, the VDEV. VDEV stands for Vertical Deviation and informs the pilot about the actual deviation from the FMGS calculated descent profile.



A Plus-Information (+) means, the Airbus is above the Profile and the Sink Rate must be increased.

A Minus-Information (–) means, the Airbus is below the Profile and the Sink Rate must be reduced.

In the example, the Airbus flies below the Sink Profile. This may be the result of the descent initiated before the T/D. The Airbus descents between 500 and 1000 ft/min instead of the usual 2000 ft/min until the calculated profile is intercepted.

6.5.5 The Approach Page (APPR)

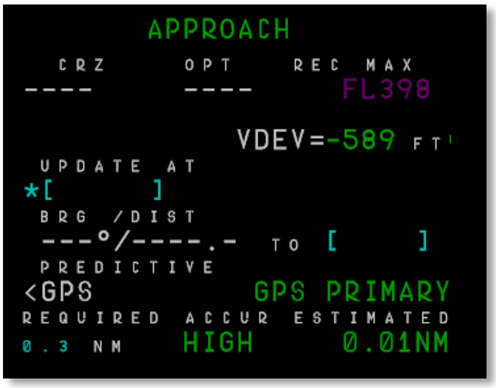
The APPR-page again shows the GPS-Accuracy, which is very important for any approach method. Managed RNAV-Approaches are only possible (authorized) when GPS-Primary is displayed in Line 5.

The required accuracy for the approach is 0.3 NM compared to 1.0 NM for Take-off and 5.0 NM for the en-route segment.

Like the **DESCENT**-page the **APPR**-page displays the vertical deviation from the calculated Sink-Profile.

This Information is particularly important for NPA-approaches to fly the published Flight Path Angle (FPA).

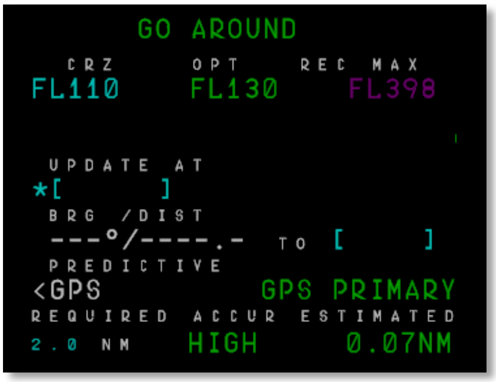
The pilot insert any desired WPT or the destination airport into the TO-field and the predictive bearing and distance is provided by the FMGS.



6.5.6 The Go-Around Page

The Go-Around-Page (GA), like all the other PROG-Pages provides the same dynamic information with no additional data.

The required GSP-Accuracy for a GA is 2.0 NM which is met in the example.



Generally, only narrow differences exist between the various PROG-Pages. This may be the reason, why the content of the PROG-pages has been merged with the PERF-pages on the A350.

6.6 The Flight Guidance

The control devices for the FMGS are located on the Glare shield in the centre of the cockpit, which are:

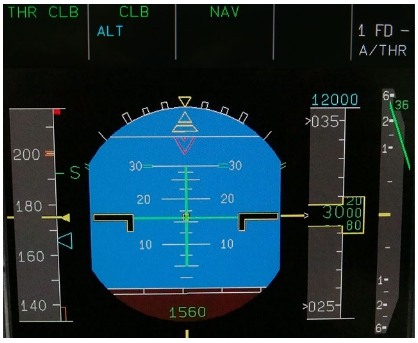
1. FD - Flight Director
2. AP - Auto Pilot
3. A/THR – Automatic Thrust (AutoThrust)

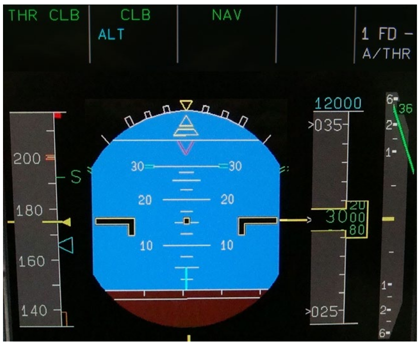
The example in the picture above shows a Flight in Managed-Mode with both FD and AP2 in operation. AP2 asserts, that the F/O is the pilot flying (PF). The QNH is 1013 hPa.

6.6.1 The FD – Flight Director

In real Line Operation, the flight is conducted from Take-off to Landing by means of the FD. The Take-off without at least one Flight Director is not permitted by international Airlines.

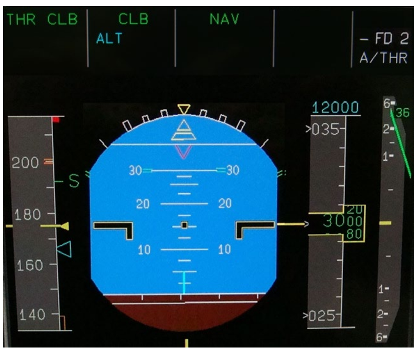
The FD can be independently activated/de-activated by the Captain and the F/O. It provides accurate flight guidance information (vertical and lateral) even for manual Aircraft control and the use of Raw-Data (HDG – V/S). The following FD-variations are possible:

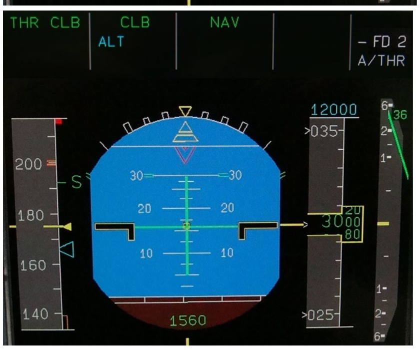




The Captain FD is switched-on, the F/O - FD is switched-off.

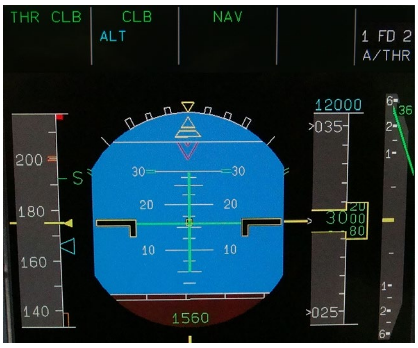
The AFS-Modes are displayed on both PFD, the FMGS is active.

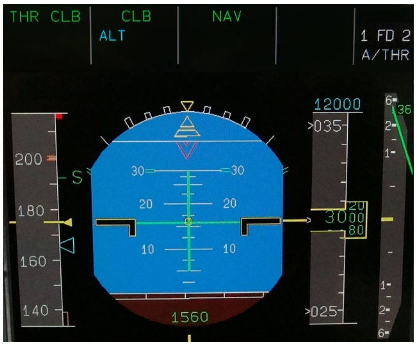




The Captain FD is switched-off, the F/O – FD is switched-on.

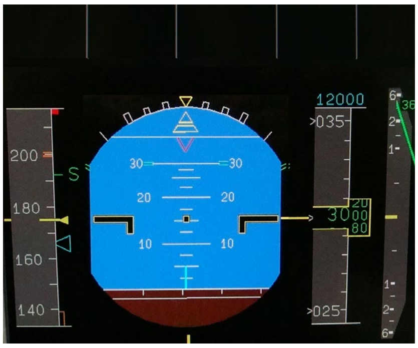
The AFS-Modes are displayed on both PFD, the FMGS is active.

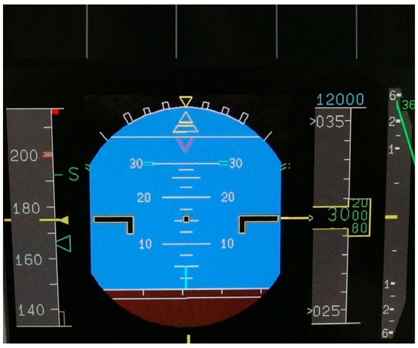




The Captain and F/O FD are both switched-on.

The AFS-Modes are displayed on both PFD, the FMGS is active.





The Captain and F/O FD are both switched-off.

The AFS-Modes are not displayed on both PFD, the FMGS is not active.

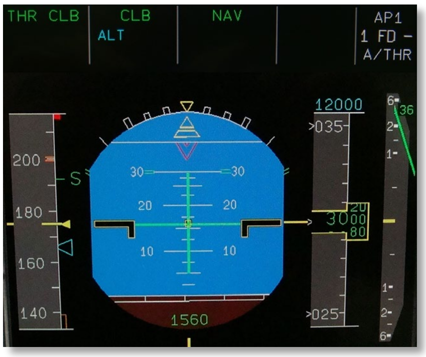
AFS-Modes are also shown on the PFDs when both FDs are switched-off but one AP is active. If the pilot decides to fly purely Raw-Data, both FDs and the AP need to be switched-off. In this case the A/THR, if active, will switch to the **SPEED**-mode.

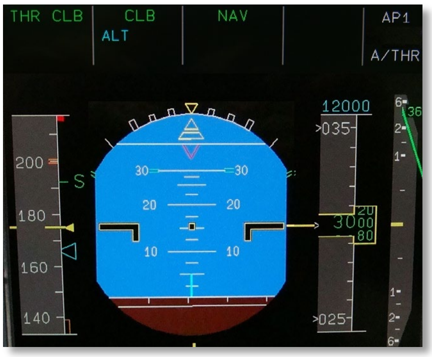
6.6.2 The AP – Autopilot

The AutoPilot is engaged by means of specific buttons, located in the centre of the FCU. There are two buttons, one for AP1 and one for AP2. Standard procedure is, that AP1 is active when the Captain is the pilot flying (PF) and AP2 when the FO is PF. This procedure also ensures, that both APs are alternatively in operation and malfunctions can be detected.

The AP can be engaged as early as 100 feet or 5 seconds after take-off-rotation until landing. If the airbus is flown outside its defined Flight Envelope (e.g. Pitch too high), then the AP cannot be engaged until the Airbus is again within the envelop.

Either AP (1,2) may be operated with or without an active FD. However, it is recommended to engage the FD first, before the AP is switched ON.





In the left picture the Captain FD and AP1 are engaged.

In the right picture, AP1 is engaged but not the FD. Nonetheless, the AFS-Modes are displayed.

The AP system provide the following additional functions:

- Automatic landing (Autoland) including Rollout
- NPA-Approaches down to the MDA
- Engine-out Operation
- Abnormal Aircraft Operation (e.g. flaps asymmetry), down to the decision height

In order to dis-engage the AP, the pilot shall always use the **Red** button on the Sidestick, called the Instinctive Disconnect Button. Only than knows the system, that the AP was dis-engaged by the pilot and not by a system malfunction.

In the upper ECAM (Inactive Systeme Section) a corresponding **Red** AP Message is displayed for 8 seconds.

If the AP is dis-connected via the FCU-AP buttons, then a **Red** warning message is displayed on the ECAM (section malfunctions) accompanied with a repeated acustic warning tone. Additionally, the Master-Warning-button is illuminated and must be manually disabled by pressing the button. Also, the ECAM message must be manually cancelled by the pilot using the CLR-button on the ECAM-controller.

Furthermore, either AP can be dis-engaged, if the Sidestick is moved with force in either direction. This procedure is for emergency situations only.

Same procedure applies to the use of the rudder pedals, if the pilot pushes either pedal with force. A typical example is the rollout after an Autoland with the AP still engaged. The pilot may push the Rudder to turn to the runway exit, but forgot to dis-engaging the AP.

The pilot must avoid pushing the rudder to the limit, that can lead to heavy load to and damage of the aircraft's tail fin.

6.6.3 The AutoThrust System

The AutoThrust (A/THR) is engaged via a specific button on the FCU. Pre-requisite for the activation are three pilot actions:

1. The correct speed value must be dialled into the SPD window, e.g. 210 knots.
2. Pressing the A/THR button.
3. Setting the Thrust levers into the CL detent.

Especially item 1 must be considered, because the default value for the selected speed is 100. In case the pilot activates the A/THR overlooking the 100, the A/THR commands IDLE thrust to reduce the speed accordingly. Then, the Speed will decrease fast until the Low-Speed Warning sounds and subsequently Alpha-Floor-Protection is activated.

The A/THR can be operated independently from FD and AP, but only in **SPEED**-Mode. Without AFS-Modes, no other THRUST-Mode is available.

The left picture shows the approach without an active FD. The A/THR-Mode is engaged (**white** indication in column 5) and in **SPEED**-Mode (column 1).

The selected speed is 132 knots (V_{APP}) and displayed as a **Blue Triangle** on the Speed-Tape as well as value in the FCU SPD window.

SPD	HDG	ALT	LVL/CH	V/S
132	152	8000		- - - -

The selected GA altitude of 8.000 feet is displayed on the PFD (above the altitude tape) and in the FCU ALT window.

Similar to the AP, the A/THR shall be dis-engaged using the **Red** instinctive disconnect button on either side of the thrust levers. Like for the AP, only then knows the system, that the pilot disconnected the A/THR.

In the upper ECAM (Inactive Systeme Section) a corresponding **Orange** A/THR Message is displayed for 8 seconds.

If the A/THR is disconnected via the FCU button, then an **Orange** caution message is displayed on the ECAM (section malfunctions) accompanied with a single acustic warning tone. Additionally, the Master-Caution-button is illuminated and must be manually disabled by the pilot by pressing the button. Also, the ECAM message must be manually cancelled by the pilot using the CLR-button on the ECAM-controller

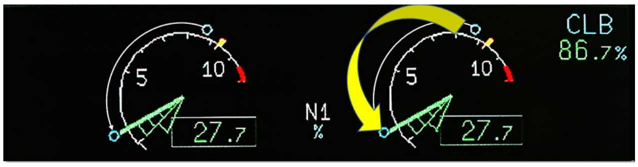
Activating Manual Thrust

If the pilot wishes to switch from A/THR to manual thrust setting, he/she must observe the following condition:

- The Airbus thrust levers do not move and are fixed in the CL detent.
- Therefore, the thrust levers must be brought in line with the actual thrust setting before disengagement. Otherwise, the engines will immediately produce unwanted climb power.

Airbus supports the pilot with the TLP (Thrust Lever Position) indicator. The TLP is a **Blue Circle**, also called the Donut defining the current thrust-lever position, which have to be synchronized with the actual power setting, represented by the **Green Line**.

The picture below shows the thrust lever in the CL detent (**Blue Circle**) at the 83% N1 Position and the actual thrust closed to IDLE at 27,7% N1.



Before the A/THRs de-activation, the thrust levers, followed by the **Blue** TLP must be moved, so the TLP is in line with the **Green** power indicator.

Now, the A/THR can be disconnected without unwanted power changes.

If the pilot wants to re-activate the A/THR, he/she simply moves the thrust levers back into the CL-detent and presses the A/THR button the FCU. As part of the disengagement process, the A/THR button on the FCU has been disabled. Therefore, the **Green** indication in the A/THR button estiguished.

The pilot is further able, to limit the A/THR range temporarely by moving the thrust levers out of the CL detent. On the ECAM, the Master Caution Message "**THRUST LEVER LIMITED**" appears, accompanied by a single-Chime acustic warning. The acustic warning is repeated every 5 seconds until the levers are back in the CL detent.

On the PFD-FMA (column 1) **THR LVR** replaces the actual A/THR mode. The warning reminds the pilot of the A/THR status and the corrective action, if the thrust lever movement was done inadvertently.

6.6.4 The Integration of FD - AP - A/THR

The AutoThrust (A/THR) system supports all operation methods such as: Managed- and Selected AFS-Modes as well as Manual Flight without Modes. The following table provides an overview of the interdependence of AFS- and A/THR-Modes.

Vertical Modes	A/THR Modes
ALT, ALT CSTR, ALT CSTR* ALT*, G/S, G/S*, FINAL	SPEED / MACH
FD/AP OFF	
CLB / DES OP CLB / OP DES SRS	THRUST (CLB THRUST OR IDLE)
FLARE	RETARD (IDLE)
NO AFS MODES /Manual	SPEED

In case of a malfunction of the active A/THR, the Thrust Lock-function- **THR LK** is activated. The system activity is displayed on the PFD in column 1 and the last actual power setting is frozen, regardless of the thrust lever position.

THR LK	OP CLB	NAV		1AP 1FD2 A/THR

In this event, the pilot can continue the flight without difficulties and evaluate the problem.

6.7 The Flight-Plan Logic

Operational Flight Plans can either be prepared by the pilot, using the MCDU F-PLN pages, or downloaded into the MCDU by means of the ACARS Datalink, see chapter 5.

There are three versions of Flight Plans:

1. The active Flight Plan (F-PLN), which is used for the flight execution containing the PRIMARY and the ALTERNATE Flight Plan. The Alternate F-PLN serves as back-up, if a landing at the Destination Airport is not possible, e.g. local weather conditions.
2. The TEMPORARY F-PLN. For each modification of the active F-PLN the FMS provides a TMPY-F-PLN for checking and confirmation by the pilot.
3. The SECONDARY F-PLN. The SEC-F-PLN allows the pilot to prepare a second version of the original F-PLN. After copying the F-PLN the pilot may modify the plan according to new or changing conditions, e.g. change of the destination Runway.
   The SEC-P-PLN may also serve as a back-up of the original plan to be activated as needed.
   If activated, the SEC becomes the active F-PLN.

6.7.3 The Predictions

The FMGS constantly monitors the flight progress and calculates Predictions, precondition of the insertion of the Aircraft weights before take-off. The FMGS uses these data to calculate and display the following Predictions:

F-PLN A-Page:

- Estimated Time of Arrrival (ETA based on UTC) at WPT
- Estimated Speed (SPD) at WPT
- Estimated Altitude (ALT) at WPT

F-PLN B-Page:

- EFOB – Estimated Fuel on Board at WPT
- Wind – Estimated wind at WPT. T stands for True-Wind (actual wind).

6.7.4 Flight Plan Sequencing

When the active mode is NAV, then the F-PLN-Sequencing is done by the FMGS. Among other things, sequencing is important for the provision of correct Navigation data.

The Flight Plan sequencing follows a specific and complex logic and is very important to enable the FMGS to calculate Predictions.. Moreover, the logic ensures that all flight plan segments are properly string together without a break (SID-Cruise-STAR-Approach), and in line with the ATC clearance.

In the example, the Airbus flies between FROM-WPT **DM049** and TO-WPT **DM050**.

In the F-PLN-Page WPT DM049 is shown in Line 1 and DM050 in Line 2.

On the ND the TO-WPT-DM050 is indicated on the upper right corner in White, together with course, distance and ETA predictions.

After passing **DM050** this WPT becomes the FROM WPT and MUN the next or TO-WPT.

However, the TO-WPT **MUN** is shown on the F-PLN-page in Line 3, because the SPD-LIM point is in between **DM050** and **MUN** in Line 2. For that reason, SPD-LIM is displayed in White on the F-PLN-page but on the ND MUN is correctly shown in White.

This WPT presentation has, like the SBG WPTs, the potential to confuse the pilot, if not thoroughly trained

On the ND, the TO-WPT MUN is shown in White in the upper right corner. The course and distance to and the estimated time at the WPT are complimenting the information.

This procedure is repeated until the last WPT, normally being the Destination Airport.

6.7.7 Cleaning up the Flight Plan

Frequently, the flight is guided by the ATC by means of Vectors and the pilot uses the **HDG/TRK**-Mode for the Flight Guidance. When the **HDG/TRK**-Mode is active, the F-PLN sequencing is only provided by the FMGS, if the Airbus flies close to the **Green** F-PLN line.

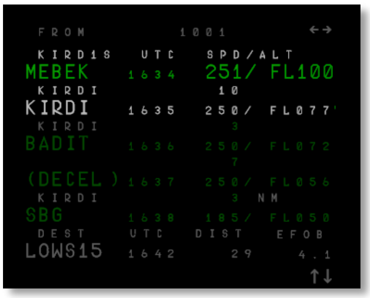
If the position of the of the Airbus is 1 NM or less to the F-PLN course line, than the change from **HDG** to **NAV**-Mode (pushing the HDG-knob on the FCU) occurs immediately. If the Airbus flies more than 1 NM, from the F-PLN course line, then other conditions prevail and must be considered.

The automatic sequencing is ensured up to 5 NM to the F-PLN course. In the example, the Airbus is beyond WPT-**MEBEK** and on its way to WPT-KIRDI. Therefore, **MEBEK** is the FROM-WPT and KIRDI the TO-WPT, displayed on the upper right ND corner in White.

As long as the Airbus stays within 5NM, KIRDI remains the TO-WPT.

In the F-PLN-Page, **MEBEK** is displayed in Line 1 and KIRDI in Line 2.

In this example, no SPD-LIM point separates the two WPTs.



If the Airbus flies outside 5 NM range, then the F-PLN is no longer sequenced automatically. The last WPT-**MEBEK**, has been passed by the flight, but remains as the TO-WPT. On the ND, MEBEK is shown in White on the upper right corner, instead of KIRDI.

In the F-PLN-Page the WPT-**MUN** (the last passed WPT) is displayed in Line 1 (FROM) and **MEBEK**, being still the TO-WPT in Line 3.

Again, a Pseudo-WPT is displayed in Line 2 between two active WPTs, in this case the T/D (Top of Descent) point.

In this example, the F-PLN sequencing, which means stringing the F-PLN into the correct order, must be done by the pilot. To do so, the pilot has several options on hand:

- DIR-TO: this function is frequently used and provides a direct and straight course to the selected WPT and is the pilot's preferred choice. With other words, it is a shortcut of the flight route. The DIR-TO function eliminates the 5 NM-Rule and the F-PLN is immediately sequence.

  One disadvantage of the DIR-TO is, that the Airbus intercepts the F-PLN course directly at the new TO- WPT. The FMGS defines the **T/P** (turning point) as the new FROM-WPT and the selected DIR-TO-WPT becomes the TO-WPT. The leg between the T/P and the new WPT is a straight course with a **Green** course line.

  In case the ATC advises the pilot to intercept the F-PLN course before the new WPT, then the HDG procedure must be applied by the pilot.

- HDG and INTERCEPT: if the Airbus is more than 1 NM from the F-PLN course, the NAV-Mode is not armed. Consequently, the Airbus will not immediately intercept the F-PLN course. The pilot must change the heading (**HDG**) so the actual heading (**continues Green Line**) crosses the F-PLN course (**dotted Green Line**) to intercept and fly the F-PLN course.

  However, the Airbus must be within 5 NM to make the F-PLN sequencing happen. Otherwise, if outside the 5 NM range, the Airbus will not intercept the F-PLN course and the message "**NO NAV INTERCEPT**" will be shown on the MCDU-F-PLN-page.

- The pilot may manually delete all relevant WPTs (F-PLN-page) one by one, until the required WPT is the new FROM-WPT and displayed in Line 1 on the F-PLN-Page. Depending on the extend of the F-PLN modification, this can be a lengthy procedure.

- Collapsing-WPTs: collapsing can be interpreted as deleting several WPTs at once. After deleting the first WPT, the TMPY-F-PLN is not immediately confirmed with the **INSERT *** key – LSK6R.

Subsequently, all intended WPTs are deleted one after the other, each changing the TMPY-F-PLN accordingly. When all intended WPTs are deleted, the last TMPY-F-PLN is confirmed by selecting the **INSERT *** key (LSK6R) producing the new and modified F-PLN.

With the provision of the TMPY-F-PLN, the FMS provides the pilot with a tool to allow multiple inputs and also correct inadvertently or false data inputs. However, as for all system-related activities failures cannot be ruled out.

This is one of the reasons, why a copy (back-up) of the active F-PLN in form of the SEC-F-PLN should be done before taking-off. This SEC-F-PLN can be used to overwrite the active F-PLN in case of need.

Chapter 7

Content

7 The Flight Management and Guidance System (FMGS) – Part 2

Even though the Flight Plan used for the exercises very much looks like a tutorial flight plan, it has been prepared to solely support the scope of the book. The intention is to make the reader understand the Airbus flight technique and procedures and not to provide another Flight Simulator (FS) tutorial.

Therefore, FS-operation procedures are only included to a limited extend, whenever appropriate to support the topic. Such procedures should sufficiently be covered by the Add-on documentation.

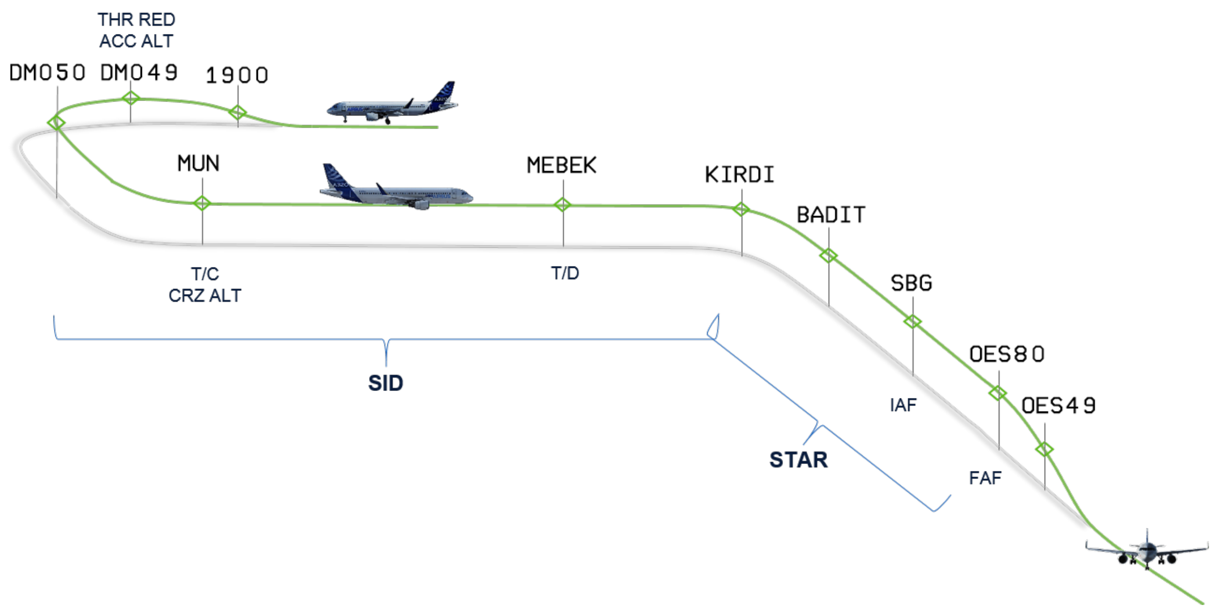
As for the previous chapters, the training flight from EDDM (Munich) to LOWS (Salzburg) provides the platform for the practical exercise. This flight is long enough to train all important procedures but short enough to do it within a manageable time frame.

It is presumed, that the FS-pilot is familiar with the functions of the Flight Management and Guidance system (FMGS), as well as the used terminology.

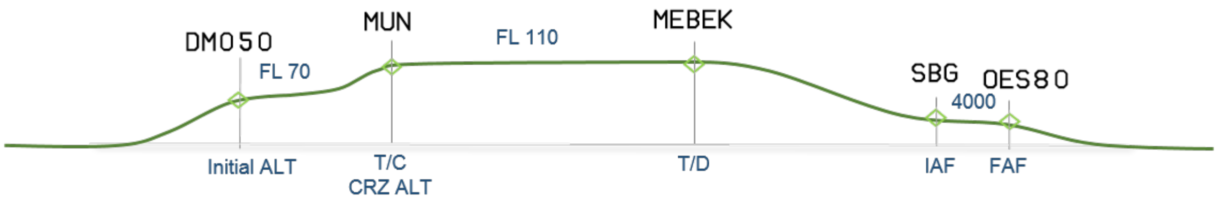
7.1 The Flight Preparation

7.1.1 The Flight Route

The Flight Plan used has been prepared in chapter 5 with a direct link between the EDDM-SID and the LOWS-STAR. The route is clearly laid-out and include all necessary elements for the exercises.



The vertical profile (altitudes) looks as follows:



7.1.2 The Cockpit Check

The pilot has received the taxi-clearance and the Airbus starts taxi from its gate position at EDDM to Runway 26L. In accordance with the SOP, the NAV-Lights have been switched-on before the APU was started. The NAV-lights will alert the ramp agent to observe, that the APU is started and the Airbus set under electric power.

A Check of the Overhead-Panels ensures, that no system button (White) is illuminated (Dark-Cockpit-procedure).

During Push-back the engines are started and the Beacon is switched on. This is also a sign to the outside world, that at least one engine is running. As already mention in chapter 3, the right engine number 2 is started first to charge the Brake-ACCU as well.

After the Push-back-Truck has been dis-connected and the Marshall clears the flight, the crew performs the following ac-tions:

- Flight-Control-Checks on both sides (Captain und F/O). For the rudder check, the NWS must be uncoupled by means of the button on the Tiller, see also chapter 3.
- THS-position check. Trim-wheel-position and PERF-TO-Page data must be in agreement. Correction via Trim-wheel may be necessary.

When the Airbus begins the Taxi to Runway 26L, the PNF set the flaps lever to position 1 (1+F). Depending on the daytime and visibility, the taxi and RWY lights are switched-on. The Strobe- and the landing lights are only switched-on when the Airbus lines-up with the Runway.

For the take-off, the PF selects the ARC-Mode with 10 NM range on the ND. The PNF selects a different setting, e.g. NAV-Mode with 20 NM on the ND. This setting allows him/her to check the traffic within the terminal area.

Regarding the MCDU-Page setup, the Captain may select the PERF-Page (speed checks) and the F/O the F-PLN-Page (route checks*). Remember: The Aerosoft Airbus uses MCDU-2 for Add-on specific features.*

7.2 The Flight Operation

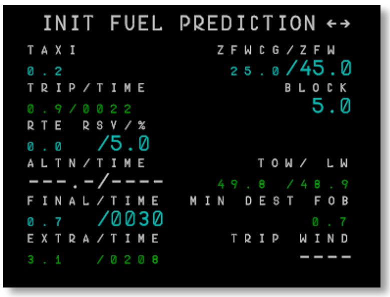
In real flight operation, pilots are encouraged to fly the Airbus manually during the first part of the Take-off and the approach.

However, the FS-pilot must keep in mind, that the short training flight has a very dynamic course of action and the Flight Phases are switching fast. One of the advantages of a Flight Simulator (FFS and Home Simulator alike) is, that the flight can be frozen at any position to give the pilot time for consideration and/or action.

The aircraft for the training flight is an A320-214 with the following weights:

- Zero Fuel Weight (ZFW) 45 tons
- Fuel on Board (FOB) 5 tons
- Take-off Weight (TOW) 50 tons

The following data are for CFM-56 engines, they are slightly different for IAE engines.



The FUEL-PRED includes all relevant weight data and the fuel quantity (Block Fuel).

Reserves and extra fuel are not considered because of the short flight distance. The Airbus consumes about 1 tonne for the short flight, that means, 5 tons is the five-fold quantity as required. The relatively high fuel quantity has also been chosen for weight and CG (THS) reasons.

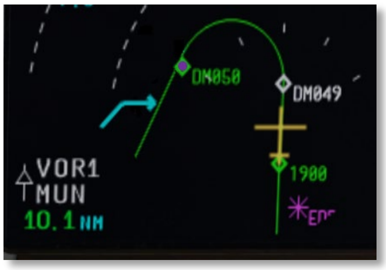
The training flight is stored in the FMS under CO-RTE-EDDMLOWS03, and transferred into the INIT-page. The CO-RTE is a personal development, because the Aerosoft Airbus data-base does not contain pre-arranged CO-RTEs.

The cruising altitude (CRZ-ALT) is FL130.

No Alternate Airport has been chosen for the training flight. The distance so short, that the Airbus can always easily return to EDDM in case of an emergency.

Before the TO-power is set, the SID may be displayed rectangular on the ND.

With the Take-off in progress, the flight route is properly shown on the ND. Now, also the T/C, according to the first initial altitude is displayed.



The TCAS is set to ABV (Above), which displays the traffic 2700 feet below and 9000 feet above the Airbus track.

During taxi, the pilot can perform another short and meaningful cross-check. If the PFD-FMA indicates **ALT** in column 2, then the FCU-ALT-selection is not correct. The FMA must display **CLB** as the armed mode.

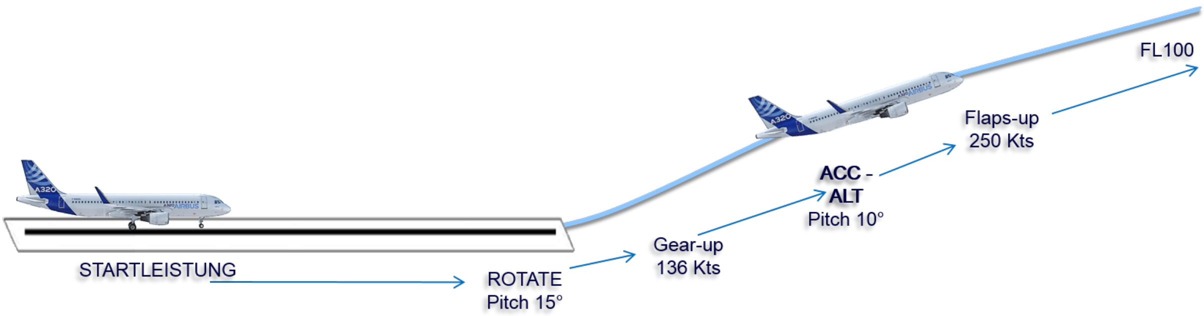
This check ensures, that the FCU-ALT confirms with the ATC clearance. Furthermore, it prevents the Airbus from levelling-off at a low ALT.

7.2.1 The Take-off

The Take-off is, like in real operation, done in Managed Mode with an Initial Altitude of 7000 feet. The FCU looks as follows.

- Initial ALT 7000 feet

- SPD, HDG and V/S show the Managed Dot as a confirmation for the Managed Mode
- Both FD are switched-on
- ND-ARC is selected for the Captain and NAV for F/O. *Note: The Aerosoft only provides same presentation on both NDs*



The following performance-data have been calculated and manually inserted into the TO-PERF-Page:

- Take-off (TO) Speeds
  V_1 122 knots, V_R 122 knots, V_2 124 knots
- Flex-Temperature 64°
- Flap Configuration 1+F
- THS-Position 1.0 UP

The Runway length (TORA) of EDDM26L is 4.000 meters (13.123 feet) and it is normal, that V_1 und V_R have the same values.

The Take-off is performed with reduced take-off power and Flex-Temperature 64°. The calculated take-off distance is approximately 800 meters with a Stop-Margin (buffer) of more than 2.000 meters.

Setting take-off-power will trigger the following events:

- The PERF-Page shows **V_1, V_R** und **V_2** in **Green**, no further input is possible.
- The PROG-Page switches from PREFLIGHT to TAKEOFF.
- The lower ECAM-page changes from WHEEL to ENGINE. Before the take-off the brake conditions (temperature) need to be checked on the Wheel page. For the take-off run, the engine parameters are essential.
- The ND displays the first SPD-CSTR and the first T/C (FCU selection).
- The **A/THR** is armed.
- The AFS-Modes **SRS**/**RWY** are activated and the next Modes **CLB**/**NAV** armed.

When the Airbus passes through 100 knots, the ND displays the actual wind data. The data are supplied by the ADIRS.

Furthermore, the time indication in the F-PLN-A-Page changes from 00.00 to the actual time, e.g. 16.25. UTC (Universal Time Coordinated). On the ND the correct ETA is shown on the WTP instead of the flight time to the WPT.

FMA and FCU show the following information:

MAN	SRS	RWY		1FD2
FLX 70	CLB	NAV		A/THR

SPD	HDG	ALT	LVL/CH	V/S
--- ●	--- ●	7000	●	----

Shortly before the ACC-ALT), AP1 may be engaged. The Airbus passes through the ACC-ALT (1.500 feet AGL) between RWY-WPT-1900 and WPT-**DM049**.

The FCU indication remains unchanged, the FMA changes with the ACC-ALT as follows:

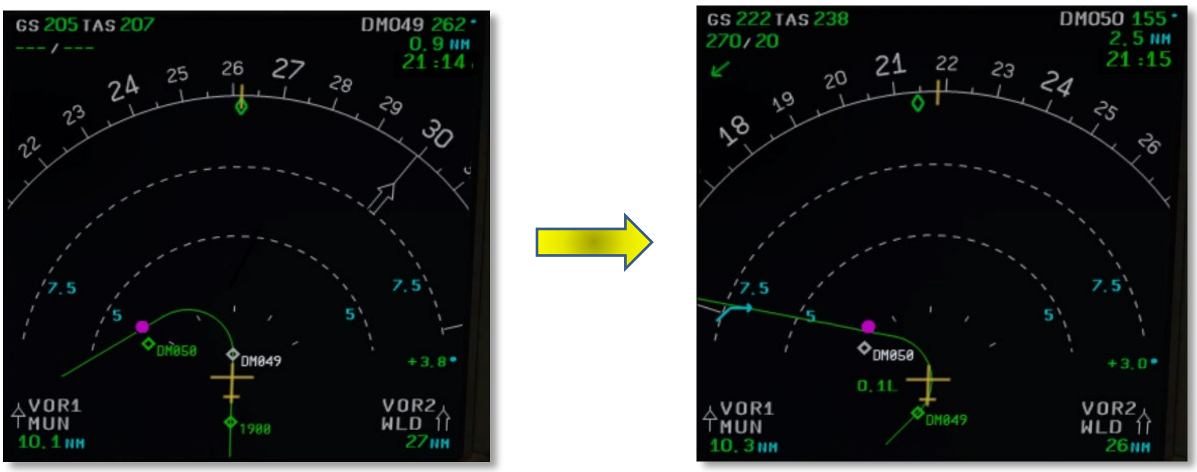
THR CLB	CLB	NAV		AP 1
	ALT			1FD2
				A/THR

In the F-PLN-Page all constraints related to the SID-KIRDI1S are shown. The SID KIRD1S is indicated in White in Label-Lines 1 and 2.

The first constraint is a SPD-CSTR of 210 knots at WPT-**DM050**. The SPD-CSTR will be met and therefore, a **Magenta *** is indicated.

The SPD-LIM of 250 knots until FL100 is irrelevant for the time being, because the FCU-ALT is FL70.

On the ND, the SPD-CSTR is displayed with a **Magenta Point** and the T/C for the initial altitude of FL70 is indicated by a **Blue Kinked Arrow**.



Performance-Data for Climb until ACC-ALT

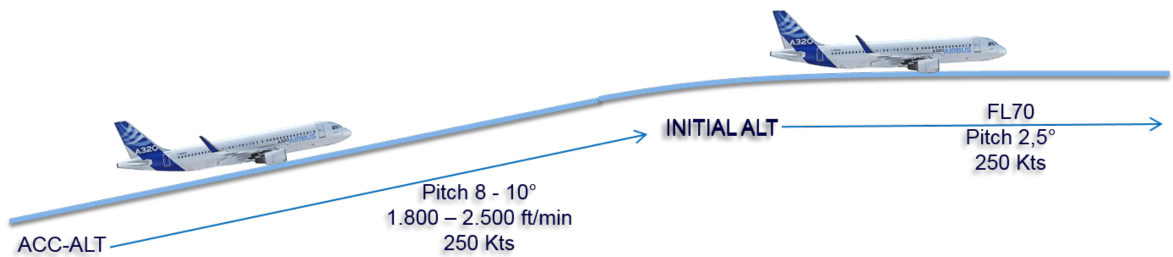
Speed	136 knots (V_2+10)
Climb Rate	3600 – 4100 ft/min
Pitch	15 – 17,5°
Thrust	98% (TOGA) 86% (FLX)
Fuel-Flow	4.000 kg/h
EGT	780°

7.2.2 The Climb

The climb phase starts when the Airbus has passed the ACC-ALT, accelerating first to 210 knots and after WPT-DM050 to the initial climb speed of 250 knots. The flaps have been retracted after the ACC-ALT as per schedule.

First Initial cruising altitude is FL70 and will be reached between WPT-**DM050** and MUN. WPT-**MUN** is defined by the **VOR-MUN** which has been automatically scanned by the FMS. The exact geographic point of the ALT intercept depends on the climb rate and moves accordingly.

Passing 5.000 feet, the QNH annunciation on the PFD flashes, alerting the pilot to switch from airport- to standard QNH. If the pilot pulls the QNH knob, then STD is automatically changed on the PFD and the ALT indication changes from **7000** to **FL70**.



Before intercepting FL70, ATC instructes to climb to the planned cruise altitude (CRZ-ALT) of FL110. All FMA-FCU Information remain unchanged only the FCU ALT window indicates the selected new ALT.

THR CLB	CLB ALT	NAV		AP 1 1FD2 A/THR

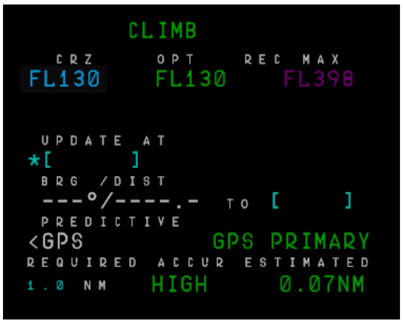
SPD	HDG	ALT	LVL/CH	V/S
--- ●	--- ●	11000	●	----

Now, the slected ALT is < FL100 and SPD-LIM is shown by a **Magenta Point**.

The **Blue Kinked Arrow** indicating the T/C has moved on the ND and shows the geographic point where the CRZ-ALT will be reached.

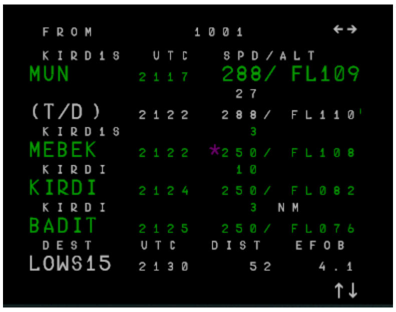
The new T/C for FL110 still lies between WPT-**DM050** and the WPT-MUN.

The PERF- and PROG-Pages show the following information during Climb:



The planned and optimum cruise altitude (CRZ-ALT) in the PROG-CLIMB page are both FL130. In line 5, GPS PRIMARY is displayed, that means no restrictions concerning the use of RNAV-methods are to be observed.

The Airbus now flies on FL110 between WPT-MUN WPT-MEBEK, but the planned CRZ-ALT is still FL130.



Shortly before intercepting the FCU-ALT-FL110 the AFS-Modes change. A/THR from **THR CLB** to **SPEED**-Mode and the vertical Mode from **CLB** to **ALT*** (Capture-Mode), followed by **ALT**-Mode.

The FMA sill displays **ALT**, because the actual FCU-ALT of FL110 is lower than the planned FL130, which has been inserted into the INIT-Page.

SPEED	ALT*	NAV		AP 1 1FD2 A/THR
SPEED	ALT	NAV		AP 1 1FD2 A/THR

The White rectangle is an attention-getter indicating that the Mode change is in progress.

Performance-Data for Climb until CRZ-ALT

Speed	288 knots
Climb Rate	1800 – 2500 ft/min
Pitch	5 - 10°
Thrust	83 - 86%
Fuel-Flow	3.600 kg/h
EGT	740°

7.2.3 The Cruise Flight

After reaching the final CRZ-ALT, as instructed by ATC, the PROG-Page must be modified to comply with the new CRZ-ALT. After modification, the PROG-CRUISE-page show FL110 as the new CRZ-ALT.

The FMA finally shows **CRZ ALT**, the final cruising ALT.

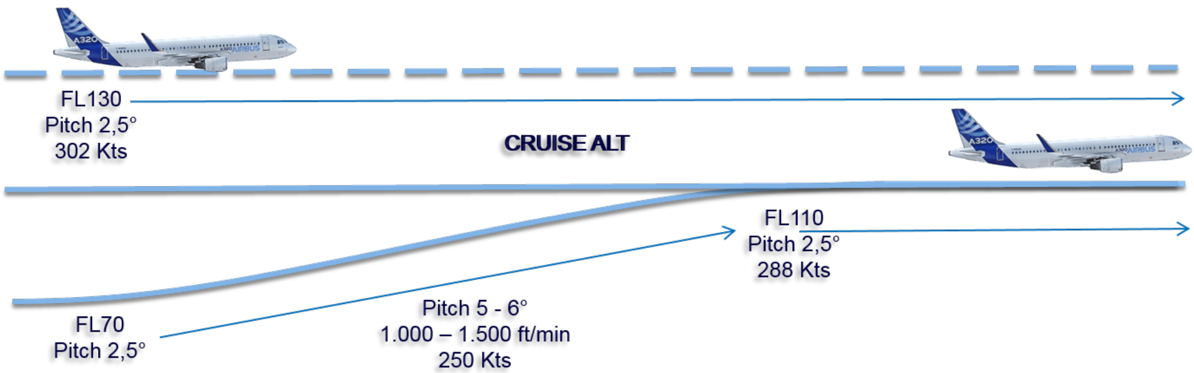
SPEED	CRZ ALT	NAV		AP 1 1FD2 A/THR

The FCU-ALT and the INIT/ CRZ-FL are now synchronized. Hence, the subsequent switch-over to DES-page/phase is assured.

If the PROG-CRUISE-page is not modified and the FMA shows **ALT**, then the DES-page will not be activation when the pilot starts descending. The FMGS considers the descending flight as a Level-Change and not a Descent.

Together with the CRZ-ALT the FMGS activates the ALT-Soft-Mode. That means, the FMGS allows ALT fluctuations of +/- 50 feet, without permanently adjusting the thrust.

The short training flight continous on FL110 and not, as previously planned, on FL130 and consequently with a slightly lower than usual cruise speed (FMGS calculation) of 302 knots.



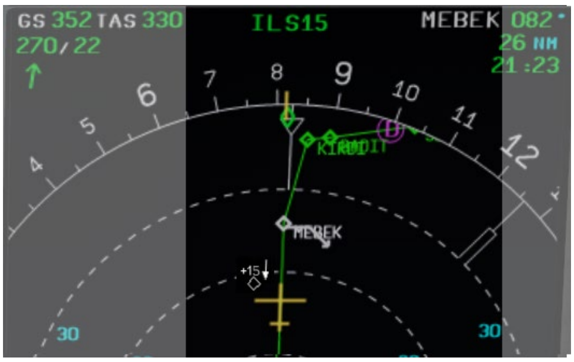
During the en-route section the TCAS-System has been set to N (normal). All aircrafts between +/- 2700 feet are displayed on the ND.

The en-route flight offes the time to cross-check the flight planning and predictions with the actual flight data. A short Approach Briefing shall include:

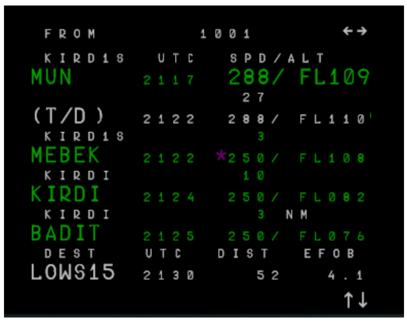
- Is the fuel consumtion in line with the planning/predictions?
- Is GPS PRIMARY displayed?
- Is the correct Approach ILS15 inserted into the MCDU and shown on the ND (in the top centre of the ND)?
- The PERF- and PROG-pages may also be included in the briefing to confirm GPS-PRIMARY.

The Airbus is now on FL110 beween WPT-**MUN** and WPT-MEBEK. The FMGS calculated T/D is located close to WPT-MEBEK (White Kinked arrow).

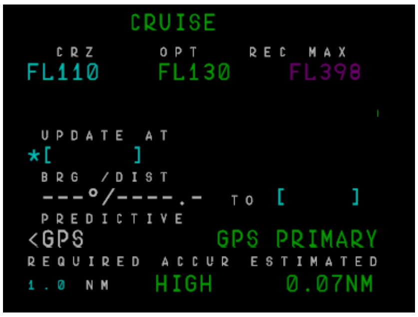
On the upper right part of the ND, the Deceleration-Point **(D)** can be seen between WPT-**BADIT** and **SBG**.



The distance to the T/D is 8 NM and can be taken from the PERF-CRZ-page. The F-PLN-page shows the ETA at the T/D in line 2. The destination Airport LOWS is displayed in the last line indicating the expected ILS approach to Runway 15.



The EFOB (Estimated Fuel on Board) at LOWS is shown in the PERF-CRZ- and F-PLN-page (last line LOWS). In case the indication is shown in **Orange**, then the EFOB is below the required minimum quantity.



Performance-Data for Level Flight

Speed	302 knots
Level Flight	0 ft/min
Pitch	2,0 – 2,5°
Thrust	63 - 65%
Fuel-Flow	2.800 kg/h
EGT	520°

Before the descent is initiated by the pilot, the approach data shall be inserted into the PERF-APPR-page. Otherwise the message „**ENTER DESTINATION DATA**" will appear on the MCU Scratchpad. During normal line operation, e.g. on FL310, the information „ **ENTER DESTINATION DATA**" is displayed on the MCDU Scratchpad, when the Airbus is 180 NM from the destination Airport.

In the PERF-APPR-page, QNH, Temperature and Wind at the destination must be inserted. They are used by the FMGS to calculate the exact approach speeds **0**, **S**, **F**, **VAPP** and **VLS**.

The approach speeds are depending on the actual landing weight, which should be around 48-49 tons. Up to now, the fuel consumption should be approximately 1 tonne.

The ILS approach to RWY15 is approved by ATC.

Even for an ILS-approaches the Decision Height (DH) must by entered, e.g. 200 feet AGL for CAT-I.

For such a short training flight, the APPR-data could be entered even before the Take-off. During the 15 minutes flight the changes are high, that the data remain current until landing.

7.2.4 The Descent

After Take-off and during Climb, ATC aims to guide the flight to cruising altitude as fast as possible. During the descent, altitude and speed must be reduced in order to reach a defined point (IAF-Initial Approach Fix) which takes much longer.

During climb, climb rates of 2.500 to 4.000 ft/min are normal and the T/C, e.g. for FL310, is reached after approximately 40 NM. In contrast, the Airbus requires for the descent to the IAF approximately 100 NM with a descent rat of usually 1.800 – 2.000 ft/min.

Therefore, several factors need to be taken into consideration. Even so, the descent for the training flight with a cruising altitude of just 11.000 feet (FL110) is relatively short, it must be properly planned.

Descent Preparation

When ATC clears the flight for descent at or shortly before the T/D, the Airbus will descent with a stable rate of approximately 2000 ft/min and thrust IDLE until the DECEL point.

Because of the low cruising altitude of FL110 the descent will be cleared straight to the IAF. WPT-**SBG** is the IAF for LOWS and the required altitude is 4000 feet. That means, 7000 feet must be lost which takes roughly 20 NM, starting at WPT-MEBEK.

The descent speed is not 270 knots as usual but 250 knots instead, due to the SPD-CSTR at WPT-MEBEK.

The following factors need to be considered for the descent planning:

1. The FMGS calculates the descent profile from the 1.000 feet point back to the T/D (Top of Descent) From DECEL the profile is calculated to reach V_{APP} at 1.000 feet above the Touch Down elevation (1000 feet AGL). All constraints are taken into consideration.

2. The FMGS considers all constraints and waypoints to calculate the descent profile

   The Standard descent is based on a 3° profile or 5% gradient. According to the 1:3 rule, the calculation is as: Altitude to be lost in feet /1000 x3. Example FL310: 31.000/1000 = 31 x 3 = 93 NM. Therefore, the descent must be initiated at least 93 NM before the destination Airport, if no constraints are to be observed.
   Example FL110: 11.000/1000 = 11 x 3 = 33 NM or roughly 30 NM.

3. If the descent is initiated before the T/D (Early Descent), then the Airbus descents with 1.000 ft/min or 500 ft/min respectively, until the FMGS calculated descent profile is intercepted. The A/THR-Mode is **SPEED** or **MACH**.

4. If the descent is initiated after the T/D (Late Descent), then the situation is more complex.

First, the Airbus tries to increase the sink rate by adjusting the pitch to return to the profile. However, the decent speed may increase from the usual 270 knots to the upper limit of the speed band, in this example maximum 290 knots.

When the speed tends to exceed the limit, the Airbus will adjust the pitch to keep the speed within the speed band. As the result, the speed will remain on the upper limit, but the Airbus will stay above the FMGS profile.

In order to return to the profile without exceeding the speed limit, the pilot deploys the spoiler. Hence, the sink rate will increase with the speed limit band.

The **Blue Crooked Arrow** on the ND indicates the position where the Airbus, under the actual conditions, will meet the FMGS profile.

If this procedure is also not successful, then the last resort is a Three-Sixty a 360° turn. Off-course this procedure requires the Ok (clearance) from the ATC.

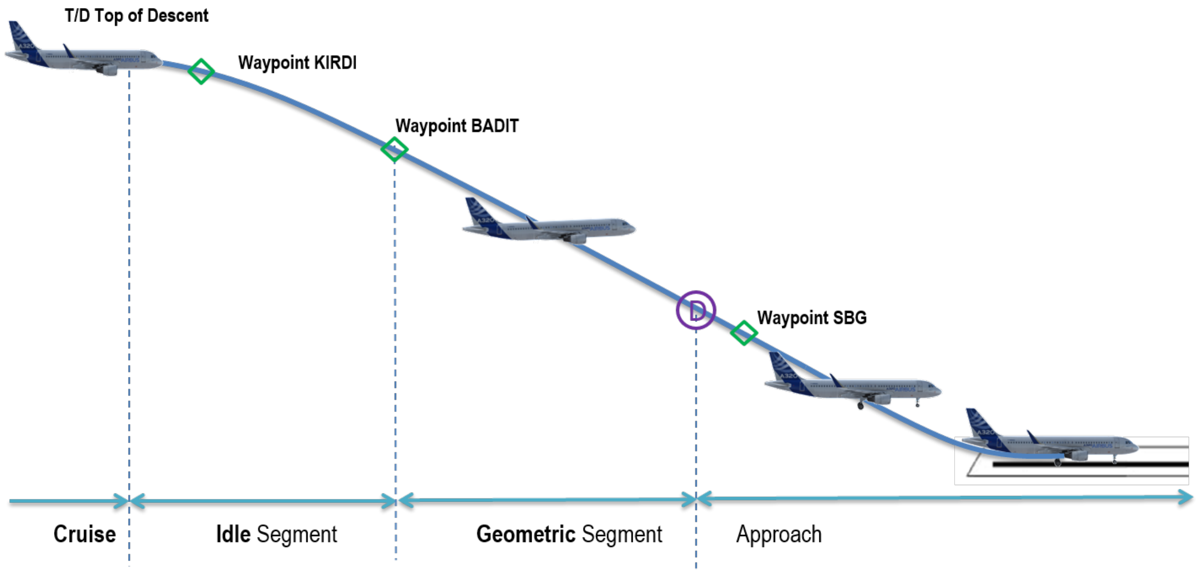
When the OP-DES-mode is active, the sink rate increases and the Airbus leaves the FMGS profile. Therefore, the V-DEV indication is no longer provided. SPD-Mode in **OP-DES**-Mode is always **THR-IDLE**.

5. The SPD-LIM is also shown on the ND in descent, again as a **Magenta Point**. The point is slightly before FL100 as some time is necessary to reduce the speed to 250 knots. The FMGS calculates the SPD-LIM in such a way, that 250 knots are met shortly after passing FL100. During normal operation reducing the speed from 288/302 knots to 250 knots takes about 4 NM.

The criteria for the switch from the CRZ- to the DES-page includes:

- The Airbus must fly at the CRZ-ALT with the active PERF-CRZ-phase. Otherwise, the FMGS considers the descent as a level change.
- Selection of a FCU ALT, which is lower as the actual altitude,
- The Airbus must be within 200 NM to the destination Airport. If not, the FMGS again considers the descent as a level change. Because of the short distance of the training flight, 200 NM are never exceeded.

The Descent is divided into IDLE- and GEOMETRIC segments.

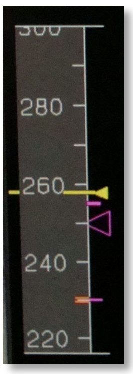


- An IDLE-Segment is those part of the descent, which is flown with IDLE thrust. The Idle-Segment of the training flight is very short, leading from T/D via WPT-**KIRDI** to WPT-**BADIT**. An Idle-Segment can be flown in either **DES**- or **OP-DES**-mode.
- A Geometric-Segment always begins with a WPT and finishes at the **DECEL**-Point. The geometric segment of the training flight starts at WPT-**BADIT** (end of the Idle segment) stretching to the **DECEL**-Point, which is located before WPT-**SBG**.
  The descent may include several geometric segments, including WPTs with SPD-ALT-CSTR Geometrical segments are only considered when the A320 is in **DES**-mode, because the **OP-DES**-mode does not consider SPD-ALT-CSTR.

Flying the Descent

Shortly before reaching the T/D (approx. 0,3 NM), the pilot dials-in the new FCU altitude of 4000 feet and initiates the descent by pushing the ALT knob (Managed Descent).

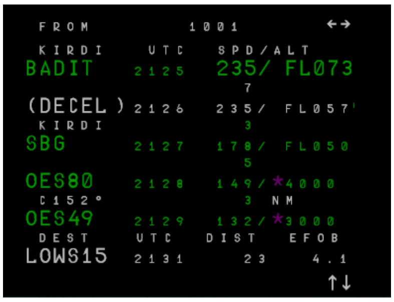
Because the descent is started at the T/D, the Airbus sinks at the FMGS calculated profile. The active Mode **DES** is shown on the FMA.



The target descent speed is 250 knots.

The ND displays a perfect descent or sink profile. The new initial altitude of 4000 feet will be reached exactly at the FAF, where the ILS approach starts.

The pilot can draw the required altitude and predicted speeds at the various WPTs along the ILS track from the F-PLN-A-Page. In case the FS-pilot is supported by a F/O (PNF), he/she may check the data against the approach chart.



The F-PLN-Page on the right indicates, that the speed will decrease from 235 to 149 knots on the way from WPT-BADIT to the FAF-OES80.

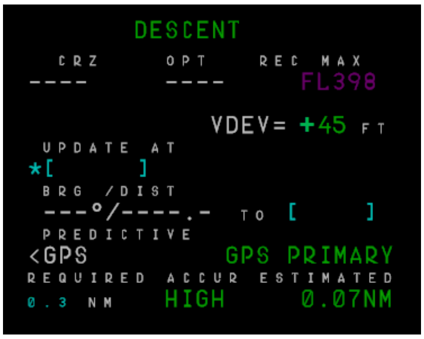
The FAF is also be referred to as FAP (Final Approach Point).

The FMA shows the following information before reaching WPT-**SBG**:

In the PROG-DESCENT-page, the VDEV (Vertical Deviation) indication informs the pilot of the actual deviation from the calculated profile. In the example, the Airbus is slightly (+45 feet) above the optimum profile. In the picture on the far right, the **Green Point** shown on the altitude-tape of the PFD indicates the **VDEV**. There is also an older PFD version with a **Magenta Point** instead.

The pilot uses the DESCENT-Page to monitor the descending flight and checks, if the GPS-Accuracy is sufficient for the planned approach procedure. However, the GPS-check is not absolutely necessary for the planned ILS approach, because it is a Precision Approach. Nevertheless, the ILS-approach may not be possible and alternatively a NPA (Non-Precision-Approach) must be performed. Then, the GPS-Accuracy becomes a vital information, if such an approach can be executed.

Luckily, the DESCENT-Page shows GPS-PRIMARY, no further considerations are necessary.



Performance-Data for Descent until DECEL-Point

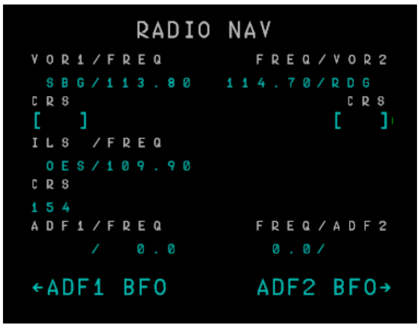
Speed	250 knots
Sink Rate	1800 – 2000 ft/min
Pitch	0 to -0,5°
Thrust	IDLE approximately 30%
Fuel-Flow	720 kg/h
EGT	460°

7.2.5 The Approach

The approach begins at the **DECEL**-Point with the activation of the PERF-APPR-page and the switch to the APPR-phase (Flight Phase 7), either manually or throught the FMGS.

Latest at this point, the APPR-button on the FCU must be pressed to arme the ILS approach. This is ok for the short training flight, but normally the APPR-button is pressed immediately after ATC confirms the approach.

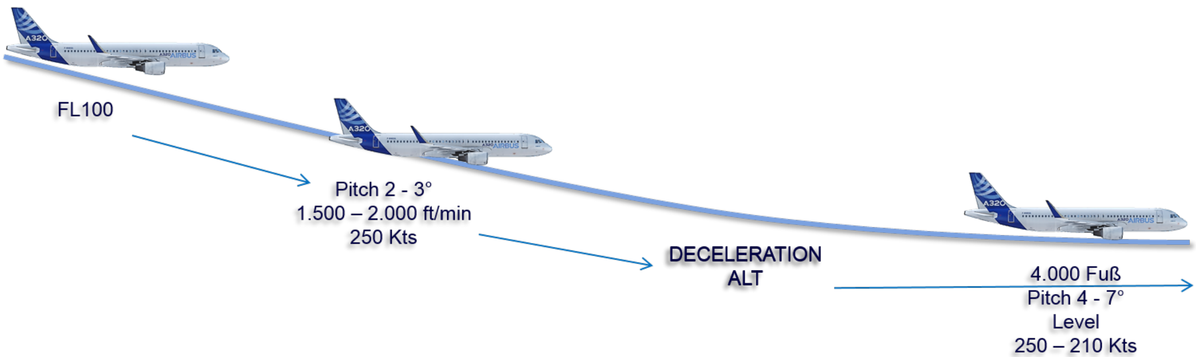
The TCAS-System should be set to BLW (Below). All Aircraft between 2700 feet above and 9000 feet below are displayed on the ND. As of 1300 feet, RAs (Resolution Advisories) are inhibited by the TCAS system.



Another useful action is a RadNav page check to ensure, the correct NavAids are scanned. If not, the pilot may select the NavAids via hard-tuning. In the example, the ILS OES and VOR SBG have been correctly auto-tuned by the FMGS.

VOR-RDG (Roding - Straubing Airport) has been auto-scanned for position alignment.

The picture below shows a standard descent from FL100 to the DECEL altitude.



The required altitude (ALT) at the FAF/FAP for the LOWS ILS15 approach is 4000 feet, which is selected in the FCU ALT-window.

Similar ND-Modes may be set for Approach as for the Take-off:

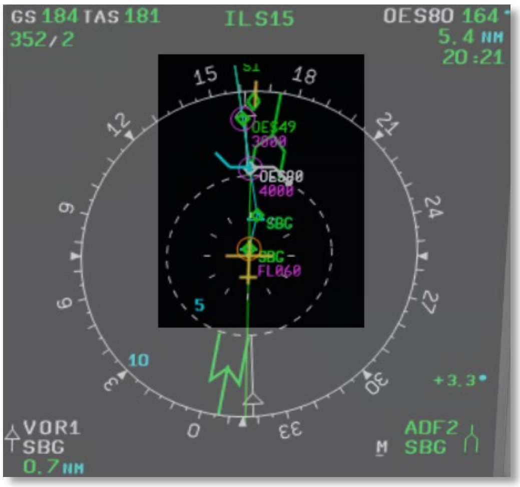
- ARC-Mode for the Captain ND with a range of 10 NM and CSTR indication. This is very usefull to cross-check required and actual altitude at certain WPTs. This procedure is a must for the NPA in order to exacly meet the required altitude gates.

- NAV-Mode for the F/O ND with a range of 20 NM and Airport (APT) indication. If a Go-Around with subsequent flight to an alternate-airport is necessary, its location may already been shown on the ND. If not, it can be made visible by changing the range.
- The PNF, if on hand, supports the PF complying with the ALT-CSTR, by calling-out the altitude at each gate. For a NPA the PNF takes the CSTR-Information from the F-PLN-Page and cross-checks with the ND and the approach chart.

The picture on the right shows the F/O ND. All ALT-CSTR are shown on the ND by **Magenta Numbers** and **Circle-Symbols**.

These indications make it easy for the PNF to support the PF by calling-out the ALT-CSTR information at WPT-SBG, OES80 and OES49. The PNF does not need to consult the F-PLN-Page or the approach chart. He/she can read it straight from the ND.

If no F/O is on hand, then complying with the NPA profile at LOWS is extremely challenging.



Via the RAD NAV-Page the VOR-SBG and NDB-SI shall be manually hard-tuned. To the South, LOWS is surrounded by high mountain ridges which make the GA a bit awkward. Especially the NDB can be useful as a counter-check for the tight GA track. The M before the NavAid IDs stands for Manual- or hard-tuned.

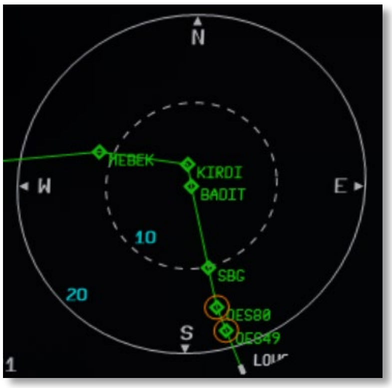
The right picture shows the ND with the TERR switched-on. It clearly proves the close and high mountainous terrain requiring a sharp left turn towards NDB-SI. The **Green Flight Track** has been superimposed.

Approach Preparation

The Approach is classifed by four segments, which are:

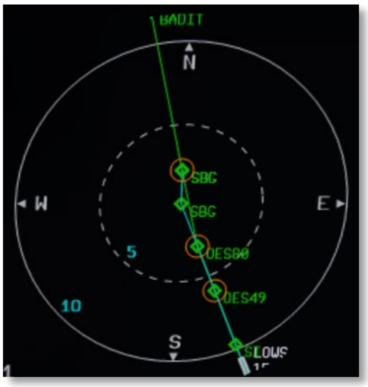
1. Approach segment – end of STAR
2. Initial Approach (Holding Area, published track or vetors to runway cours)
3. Intermediate Approach (intercepting the runway cours- ILS-Localicer)
4. Final Approach (FAF, FAP, intercepting the ILS-Glideslope)

Frequently, the Initial and Intermediate approach are defined by a common segment. Also the training flight does not include an Intermediate Section.



The Airbus FMS includes two WPTs with same ID-**SBG**. One WPT is defined by the **VOR-SBG** and the other by the **NDB-SBG**.

The picture on the left indicates, that the approach leads directly from WPT-**SBG** to FAP-**OES80**.



The picture on the right shows the Missed-Approach-Track (**Blue Continues Line**) incorporating both SBG WPTs.

- The STAR segment passes from WPT-**BADIT** to WPT-**SBG**.
- The Intermediate-Approach segment covers the area between the two SBG-WPTs.
- The Initial Approach Segment leads from WPT-**SBG** to FAP-**OES80**.
  Because only one WPT-**SBG** is considered, the Intermediat-Segment is omitted.
- The Final-Approach begins at FAF/FAP-**OES80** (8 NM from the runway threshold).

Whats the difference between FAF and FAP?

- The FAF is the Final Approach Fix for a Non-Precision Approach (NPA). It is a geographic WPT, where the Airbus starts the final descent, e.g. with a FPA (Flight Path Angle) of -3°. The FMA shows **FPA** as the vertical Mode.
- The FAP is the Final Approach Point for a Precision Approach (ILS). It is the point (not a geograhical WPT), where the Airbus intercepts the ILS Glideslope. The FMA shows **G/S** and **LOC**. The FAP is often marked on the approach charts with a Ⓟ symbol.

Below FL100 the following gates (steps) shall be considered:

- 9.000 feet AGL at 30 NM
- 3.000 feet AGL at 15 NM

These values are slightly less then calculated with the 1:3 Rule, which is welcomed. The lower altitude ensures, that the ILS Glideslope is intercepted from below.

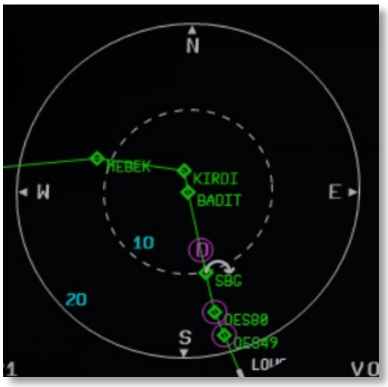
For the deceleration the following rules-of-thumb may be used:

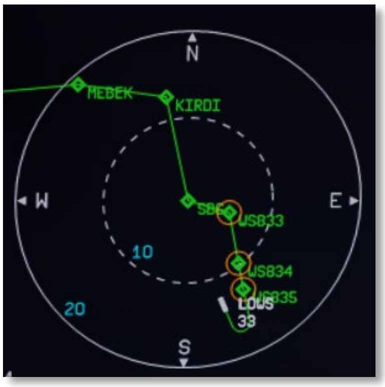
- Deceleration at Level Flight: 10 - 15 knots per 1 NM
- Deceleration on 3° G/S, Flaps Full and Gear Down: 10 -20 knots per 1 NM
- Deceleration during descent without flaps is not possible

With aLAW of 49 tonnes and a calculated VAPP of 122 knots, the approach speed at the Outermarker (6 NM before the Runway Threshold) shall not exceed 160 knots. According to the 1:3 Rule, from the OM at 6 NM to the 1.000 feet gate at 3 NM, the speed need to be reduced by 38 knots (13 knots/NM).

Below 3.200 feet/AGL, the A/THR is more reactive to power demands. This is particularly important for approaches in windy conditions, when speed changes may happen fast.

The **VOR-SBG** is the Holding-Fix as well as the IAF-Fix for both runways (15 and 33) RWYs.





The approach to RWY15, leads directly to the FAF or FAP-**OES80** (picture on the far left).

The approach to RWY33 is only available as a NPA or Visual and also starts at the VOR-SBG.

WPT-**WS833** is the FAF, WPT-**WS834** an ALT-CSTR and WPT-**WS835** the MA-point.

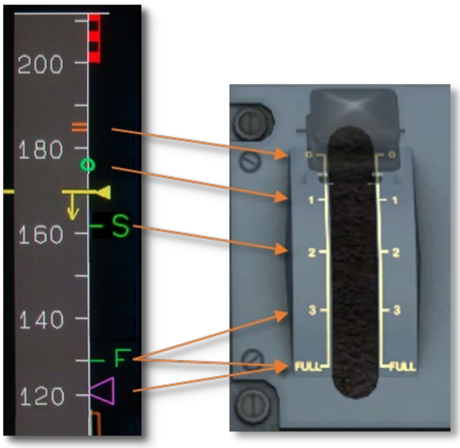
At WPT-**WS835** the final visual sement begins with a tight right turn towards RWY 33.

Deceleration to VAPP

An Airbus speciality is the flap-speed control. After passing the **DECEL**-Point (APPR-phase activation), the pilot can set the various flap speeds by simply selecting the corresponding flap position until VAPP. Pre-requisite is, that the A/THR is in Managed Mode.

The procedure for the speed reduction takes places as follows:

With the APPR-page/phase activation, the A/THR commands immediately **GD-Speed** (**o**).



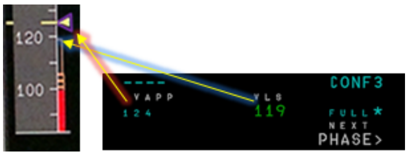
- When **GD**-Speed is reached the flaps are selected to F1 and the A/THR commands **S-Speed**.
- When **S**-Speed is reached the flaps are selected to F2 and the A/THR commands **F-Speed**. When the flaps are extended (check ECAM upper display), the Gear is lowered.
- When **F**-Speed is reached the flaps are selected to F3 and the A/THR keeps commanding **F-Speed**.
- Reaching 1.500 feet the flaps are selected to Full and the A/THR commands **VAPP.**

If the A/THR is in Selected Mode and the APPR-phase is activated, the message "**SET MANAGED SPEED**" is shown on the PFD.

However,, the pilot can, at any time, control the A/THR in Selected-Mode by dialling-in the desired approach speed into the FCU-SPD-window. Only for the first speed selection he/she must pull the SPD knob to activate the Selected Mode. All subsequent selections will directly command the A/THR.

If the pilot controls the A/THR manually (Selected Mode) then he/she must comply with the selected speed displayed on the PFD with the **Blue Triangle or SPD-Bug**.

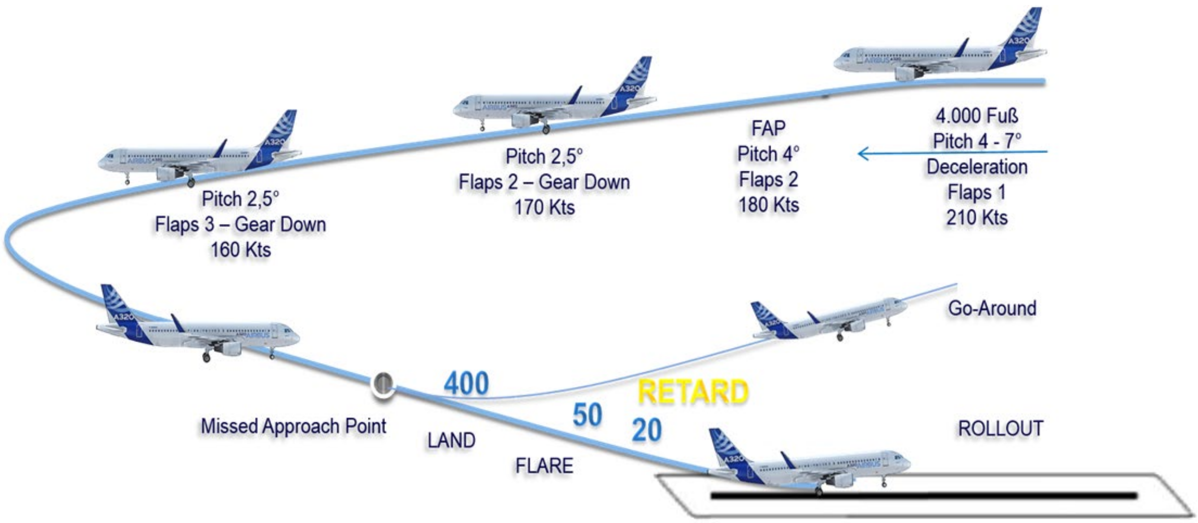
Before reaching the final approach speed **VAPP**, the pilot must cross-check the speed indications on the APPR-PERF-page with the PFD speed tape. Detailed information on this subject is provided under chapter 2.



Only if the FAC-calculated VLS on the PFD is higher than the FMGS-calculated VLS on the PERF-page, then the **VAPP** on the APPR-page must be altered by the same value.

7.2.6 The Landing

The Final Approach begins at the FAP / FAF and ends with the rollout on the Runway. The ILS approach is intended with flaps in configuration Full and a Decision Height (DH) of 200 feet (CAT-I).



The APPR-Page indicates all relevant approach speeds for Flap-configuration Full and 3. VAPP and VLS differ by 5 knots.

Today it is quite normal to land with Flaps in configuration 3 (noise-, fuel- and engine wear-reduction). By pressing LSK4R (**CONF 3***) the APPR-page changes the approach speeds accordingly.

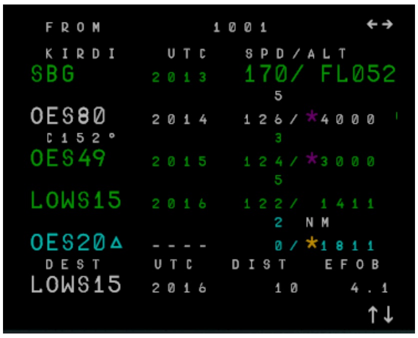
F, **S** und **0** (**GD**) are not changed, because they only depend on the actual Landing Weight (LAW).

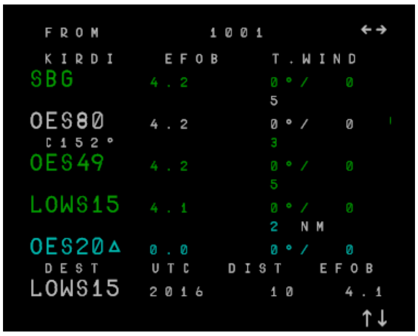
For an ILS-approach, the FMA shows the following modes during the Initial- / Intermediate-segment:

SPEED	DES	NAV		AP 1

	ALT G/S	LOC		1FD2 A/THR

The F-PLN-pages A and B provide approach information, from WPT-**SBG** to RWY15.





The picture on the far left shows the A-page with SPD-ALT values to be observed at each WPT.

The left picture shows the B-Page with the predicted Wind and Fuel data.

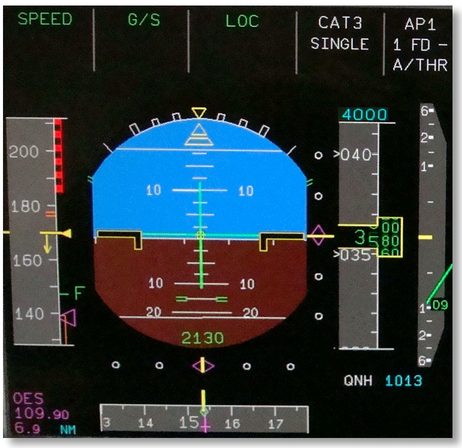
On the ND (in NAV-Mode), the Airbus has intercepted the ILS-localicer and flies within the inital-approach-segment. Now, only small control input should be made by the pilot, to avoid oversteering.

The ILS-course (F-PLN) is shown as a **Green Continues Line**, complimented by the **Blue** Missed-approach-course, which goes back to the **VOR-SBG**.Therefore, both courses overlap.

Once the Airbus is established on the ILS the FMA indication changes as follows:

SPEED	G/S	LOC	CAT II SINGLE	AP 1 1FD2 A/THR

The PFD picture on the right shows the Final Approach shortly after the Airbus is established on the ILS. The approach speed decreases towards **F**-Speed with the gear down and flaps cofiguration 3 (the **Red** bar at 185 knots indicates the flaps overspeed sector).



The FD and the **Magenta Rhombes** for localicer and gide-slope confirm, that the approach is flown correctly.

Due to the early state of the ILS interception, the sink rate of 900 ft/min (pitch 1.5°) is at the upper threshold and will shortly stabilize at 700 ft/min with a pitch of 2.5°.

By selecting NAV/LS on the EFIS-controller, the pilot can choose the ILS-Rose-Format presentation, just like a conventional HSI.

The thrust setting for a 700 ft/min stabilized approach is approximately LAW - 5 knots. In the example, the calculated landing weight (LAW) is 49 Tonnen, and the thrust setting 49 – 5 = 44% N1.

From 700 feet, the **LDG INHIBIT** function inhibits all non-critical Warnings to avoid pilot distraction. For example: a critical warning would be an engine-out condition or wind-shear.

At 700 feet the FMGS further freezes the FCU and no inputs are possible by the pilot. In case of FMGS malfunction, the pilot must take over and manually fly the Airbus.

Passing through 400 feet (up to 350 feet) on an ILS-approach, the AFS-modes change to the **LAND**-mode followed by the **FLARE**-mode in 50 feet. After touch-down the **ROLLOUT**-mode will be activated, which is especially important in case of an AutoLand.

SPEED	LAND FLARE ROLLOUT		AP 1 2 1FD2 A/THR

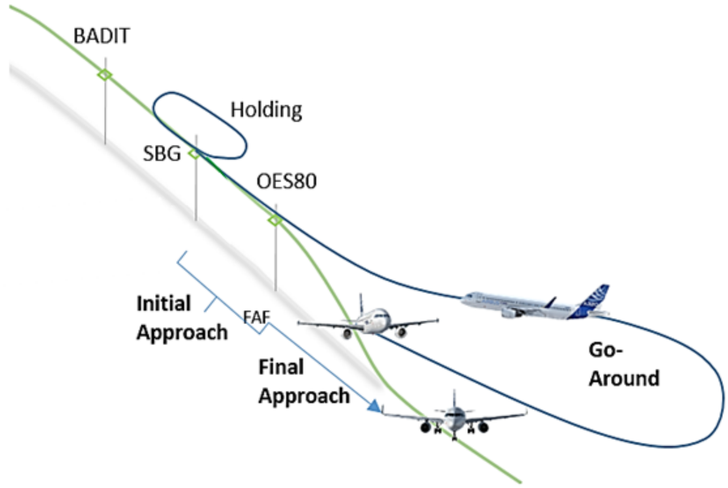
Performance-Data for an ILS-Approach

Speed	122knots (VAPP)
Sink Rate	-700 ft/min
Pitch	2,5°
Thrust	44%
Fuel-Flow	1.100 kg/h
EGT	500°

Within 30 seconds after touch-down, the FMGS clears the F-PLN and resets the FMS to Take-off- (Performance page) and Pre-flight (Progress page).

7.2.7 The Go-Around

The picture illustrates the Go-Around procedure (GA) in **Blue** with the Flight Route back to the Holding (**VOR-SBG**). The original approach course is still depicted in **Green**.



Due to changing weather conditions, the A320 may be forced to GA. The Missed-Approach course directs the flight back to the **VOR-SBG** with a subsequent Holding pattern.

A Go-Around (GA) or Missed Approach (MA) is a challenging, but still a standard procedure. The GA is not an Emergency.

Especially in LOWS, the pilot must execute the GA with care. Nevertheless, the high terrain my still trigger a short GWPS warning - **TERRAIN**.

A GWPS-Terrain-Warning automatically activates the Terrain presentation on the ND, including altitude indications in the lower right corner.

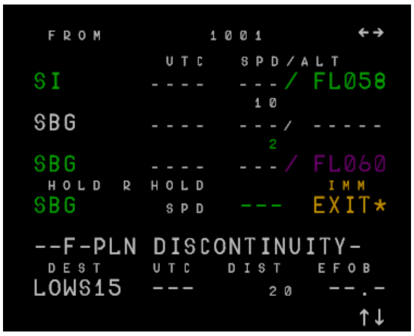
Very general, a **Yellow** indication means same height (max. +1.000 feet), **Red** an area above and **Green** below the actual altitude of the A320. However, depending on the terrain and the flight path, the **Green** area may not be below but slightly above the Aircraft (+100 feet).

After the GA initiation, the Missed Approach course (MA) is shown in the F-PLN-Page and on the ND in **Green** and no more in **Blue**. It became alive and is now the active F-PLN.

In the lower right corner of the ND, terrain indications are still displayed. They are all **Green** and shall be safe.

The Holding pattern at WPT-**SBG** is shown as a **White** half circle, because the A320 is still 12 NM from the holding fix.

The distance between the WPTs is shown in the Label Lines associated with the WPT.

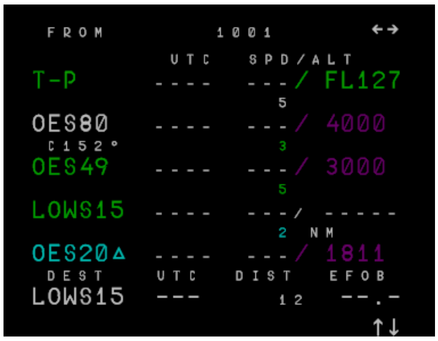


In the example, the distance between WPT-**SI** (present Aircraft position) and WPT-**SBG** is **10** NM. It is shown in the SI Label Line between LSK1L und LSK2L. The two **SBG**-WPTs are separated by **2** NM.

Shortly before WPT-**SBG** the complete Left-turn Holding Pattern is displayed on the ND, requiring a Teardrop-Entry. Thereby, the Holding procedure with Fix-**SBG** and the left rotation is the same for both flight routes, GA via **SBG** or Initial Approach from **BADIT**.

The pilot leaves the Holding pattern by pressing LSK3R – **IMM EXIT***.

Using the DIR TO-function the pilot directs the flight to WPT-**OES80** (the FAP of the ILS approach), which becomes the TO-WPT. The FMGS creates the **T/P** (present aircraft position) which is the new FROM-WPT as seen in the right picture.



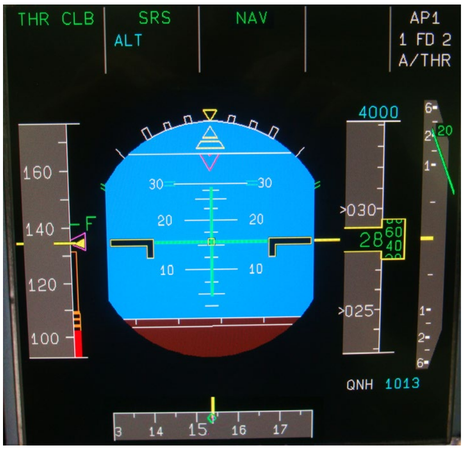
After **LOWS15** the WPT-**OES20** is again the first MA-WPT and displayed in **Blue**.

It has been mentioned, that high mountain ridges surround the LOWS Airport to the South, East and West.

That means, the terrain rises sharply within a few NM from the Airport (field) altitude of 1410 feet to 6000 – 7000 feet.

Therefore, it is recommended to switch the ND terrain presentation on, when approaching LOWS.

To do so, the pilot presses the - TERR ON ND - button, which is located next to the ECAM-Displays.



The PFD shows the correct Aircraft Attitude after the GA initiation with the pitch of 15° Pitch and the active **SRS**- and **NAV**-modes.

The combination of **SRS** and the A/THR-Mode **THR-CLB** is possible during the GA, to avoid a high pitch attitude.

The GA-Page is already active and the Airbus is shortly passing the ACC-ALT of 2.910 feet.

Until passing the ACC-ALT (or GA-ACC-ALT if defined in the PERF-Page) the FMGS takes VAPP- or actual speed at GA-initiation (the higher of the two) as the **SRS** target speed. Afterwards the A320 accelerates to and flies the **GD Speed**.

The pilot must dynamically retract the flaps to avoid an overspeed warning. However, if the A/THR is active the flap protection system would interfere, if necessary.

The GA-PERF-Page/Phase displays the relevant speed informationen as well as the ACC-ALT and the EO-ACC-ALT..

From the GA-Page the pilot may switch directly to the APPR-page for a new ILS approach. Flying at GD-speed allows an immediate aircraft configuration to F1.

A direct switch from the GA-Page to the CLB-Page is not possible. Either a new F-PLN (**NAV**) or a new altitude (**OP-CLB**) must be activated for the switch-over to happen.

Chapter 8

Content

8 The Flight Management and Guidance System (FMGS) – Part 3

Due to the dense European Airspace with a high traffic volume, changes to the approved Flight-Plan by the ATC are very common. That means, the ATC may instruct the pilot to deviate from the Flight-Plan, e.g. new heading or vectors, altitude and/or speed limitations, etc.

The Airbus FMGS offers a host of specific functions and operational options to enable the pilot to react very flexible to ATC instructions with a minimum of additional workload.

8.1 The Flight Plan Management

8.1.1 The Revision Pages

The Revision pages of the Flight Plan enable the pilot to manually cross-check, alter and/or modify the F-PLN at a specific WPT, e.g. WPT - KIRDI.

This activity is called Lateral or Vertical Revision (LAT REV / VERT REV). Revisions are done on the F-PLN page, which is called-up via the F-PLN key on the MCDU.

Revision pages are on the second menu level which are selected via the LSK keys of the concerned WPT.

In the example, Revision are considered for WP-**KIRDI**, located between WPT-**MEBEK**, and LOWS (Airport).

Left-LSK opens the lateral page.

Right-LSK opens the vertical page.

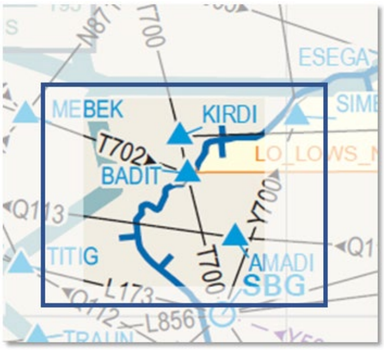
The pilot can open either LAT REV or VERT REV pages, but not both at the same time. In case alterations are planned for lateral and vertical data, then changes must be done one by one.

8.1.2 The Input of Airways

As already discussed, the FMS data-base is updated every 28 days. In the latest version the STAR **KIRDI** does not exist any longer and is replaced by STAR BAGSI. As a consequence, the direct connection of SID (EDDM) and STAR (LOWS) is no longer possible

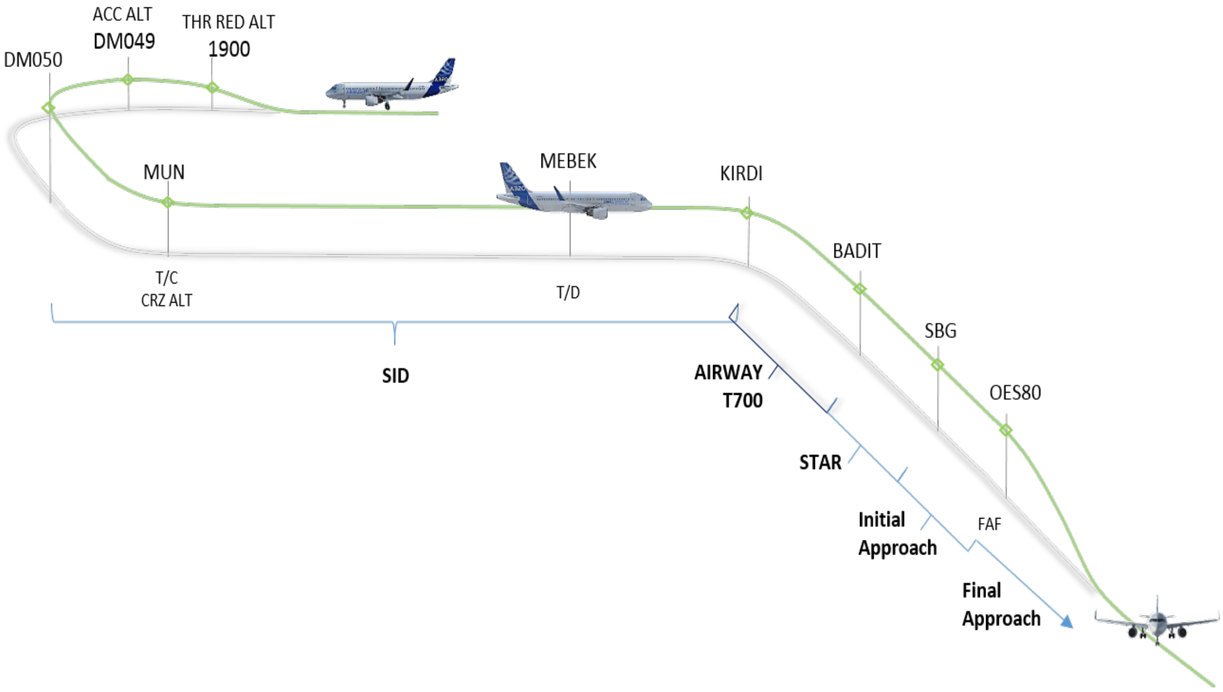
Therefore, the airway T700 must be inserted between WPT **KIRDI** and **BADIT**.

The former STAR-segment between **KIRDI** and **BADIT** is replaced with airway T700. As seen in the right picture, the airway is very short with only 2 NM.



As a second and simple alternative, this short distance could be bridged with a straight connection. In this case, the pilot only needs to clear (CLR) the Discontinuity between the two WPTs. However, for training reason, the airway T700 will be inserted.

The following picture shows the new flight route including airway T700 between **KIRDI** and **BADIT** and the new STAR BAGSI. The ILS approach to RWY15 is unchanged with the FAP OES80.

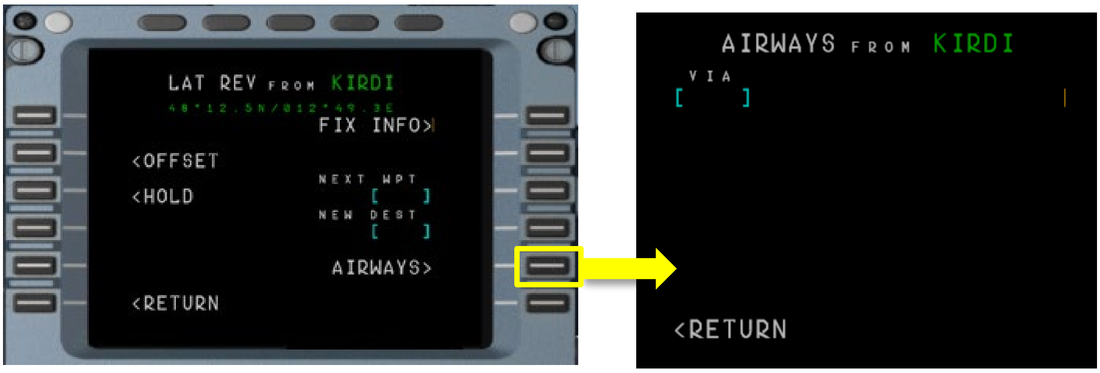


MCDU and ND show the following Information.

At first, the F-PLN shows a discontinuity. It is not necessary to manually clear the DISCON, it will automatically be deleted with the insertion of the airway.

By means of the LAT-REV function, the pilot extends the F-PLN with Airway T700, after prior check with the en-route charts.

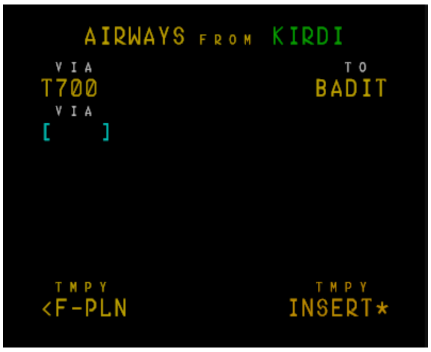
As the first step, the pilot opens the LAT-REV page for WPT-**KIRDI**, last WPT of the SID, via LSK2L (picture above) followed by the AIRWAYS-Page via LSK5R (picture below).

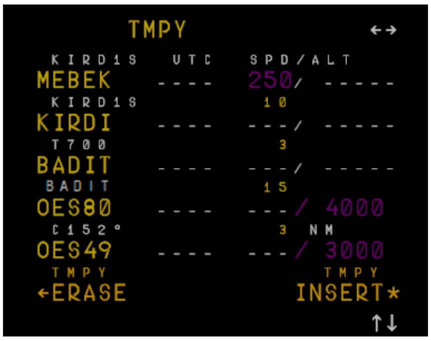


Entering the Airway data requires several steps with the following sequence:

The pilot writes T700 into the scratchpad and inserts the airway with LSK1L.

The input field TO is displayed. The TO-WPT-**BADIT** is written into the scratchpad and inserted with LSK1R.

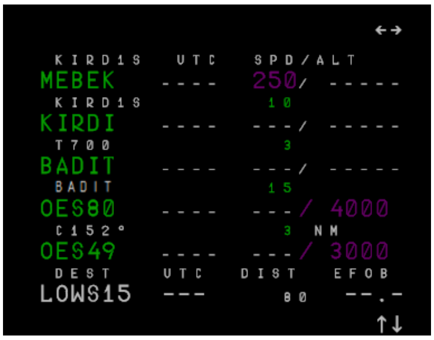




As the result, the TMPY F-PLN is generated and shown in **Yellow** on the MCU and the ND.

After each input, a new line for the subsequent Airway and TO-WPT is offered.

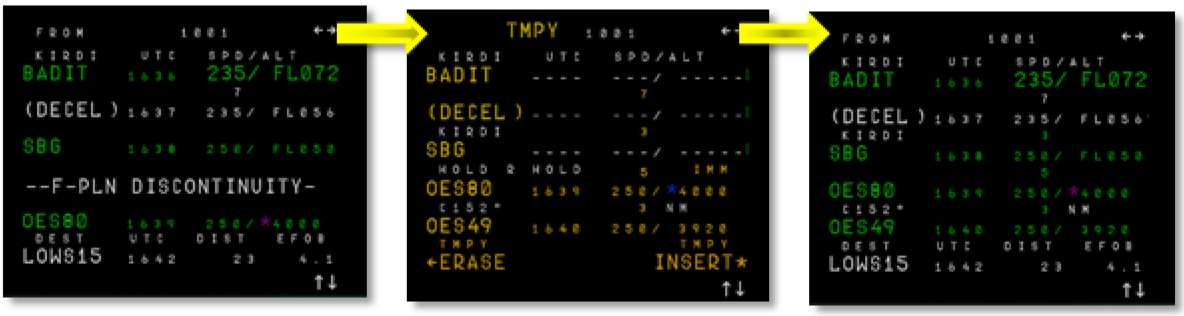
This procedure allows the pilot to enter the whole en-route F-PLN at once and accept the route with a single command.



After checking the TMPY F-PLN, the pilot accepts the entry by pressing LSK6R, **TMPY INSERT**.

8.2 The Temporary Flight Plan

The Temporary Flight-Plan (TMPY) is an important tool for the pilot with regards to F-PLN handling and a secure method for modifications. The Pilot can carry-out multiple-inputs or changes, check the entries and accept all in one step.



The Flight Route on the ND and the data on the F-PLN-Page are displayed in **Yellow**. Therefore, the TMPY-F-PLN distinguishes clearly from the active F-PLN, which is displayed in **Green**.

The pilot can monitor the several steps of the process on the ND.

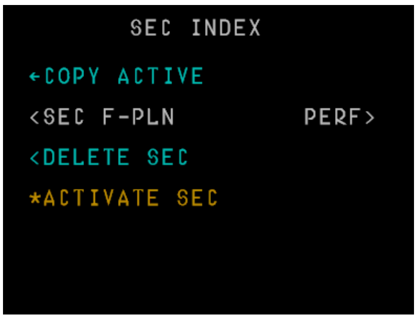
8.3 The Secondary Flight Plan

The Secondary Flight Plan (SEC-F-PLN) is a useful tool to support the following procedures:

- Back-up of the active F-PLN,
  If, for whatever reason, the pilot needs the F-PLN section behind the FROM-WPT, the only solution is to overwrite the F-PLN with the SEC.
- A good example is an engine-out situation after a LVTO Take-off (Low-Visibility-Take-off). As a precautionary measure, the pilot may create a SEC-F-PLN to a nearby located alternate airport, which can be used when required.

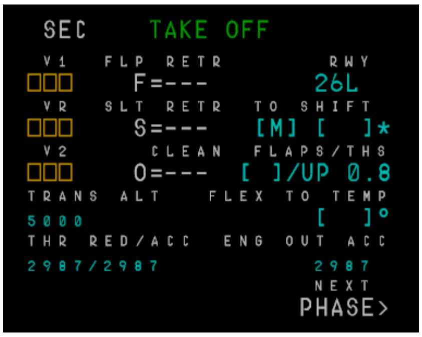
Via the SEC-F-PLN-key on the MCDU, the pilot calls-up the SEC-INDEX-Page which offers three selections:

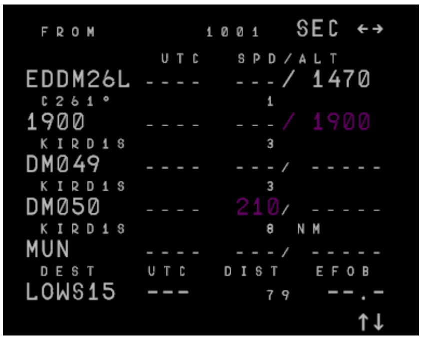
- To prepare a SEC-F-PLN via the SEC-INIT-page, LSK1R.
- To copy the active F-PLN as back-up, LSK1L.
- To open an existing SEC-F-PLN, LSK2L.



After copying the active F-PLN, the pilot calls-up the SEC Index again. This time more selections are offered:

- **←COPY ACTIVE**. Copy and storage of the active F-PLN for future use.
- <SEC-FPLN. Presentation of the SEC on the MCDU (F-PLN page) and the ND, independent form the active F-PLN.





- **<DELETE SEC**. Deleting the SEC-F-PLN.
- ***ACTIVATE SEC**. Activation of the SEC-F-PLN. The existing active F-PLN will be overwritten.
- PERF. Inserting specific SEC-PERF-Data.

The SEC-TO-Page allows the pilot to enter Aircraft Performance Data, which are only used together with the SEC-F-PLN.

Example: The take-off has been planned as a normal Flex-Take-off. However, the alternate runway may need a TOGA take-off, e.g. due to a reduced TORA. Hence, the original and the alternate runways need different performance settings.

The SEC-F-PLN-Page is similar to the active F-PLN-Page, only the waypoints and airports are all displayed in White and not **Green**.

A runway change at LOWS is advised by ATC, due to varying weather conditions. The ND displays the SEC-F-PLN in White, overlapping the **Green** F-PLN course.

As a pre-cautionary measure, the pilot prepares a SEC-F-PLN with an approach to runway 33. It would certainly be possible to change the runway within the active F-PLN.

In this example, just copying the corresponding SEC-F-PLN is the better and faster solution, compared to a runway change of the active F-PLN under time pressure. The procedure is similar to the preparation of a standard F-PLN.

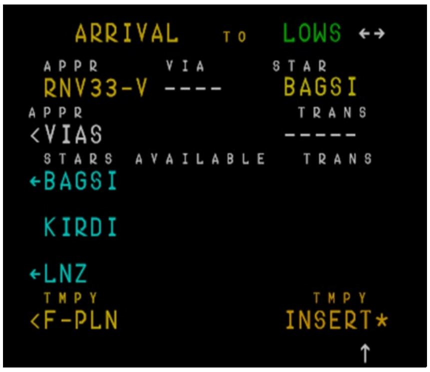
With Slew-Key ↑ the pilot scrolls the F-PLN-Page until the destination airport (LOWS15) is displayed. Pressing LSK6L opens the Arrival-Page.

The requested approach is not shown.

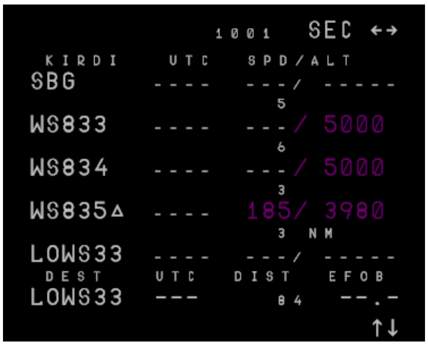
With Slew-Key ↑ the pilot scrolls the page until RNV33 (RNAV-Approach) is shown.

Pressing LSK4L selects the RNV33-V approach.

Afterward the STAR BAGSI is selected and confirmed with TMPY INSERT*.



The SEC-F-PLN is now prepared and ready to be used or modified, if the situation changes. F-PLN-page and ND display the approach to RWY33 in White.



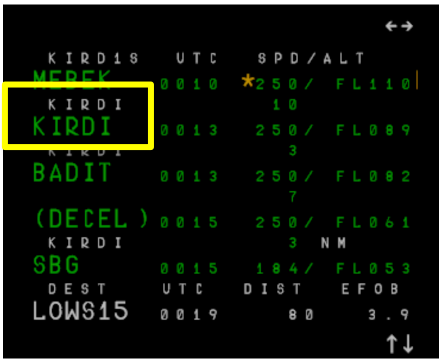
The SEC does not offer predictions, but constraints (CSTR) are displayed and considered as well.

The pilot can return to the active F-PLN by pressing the F-PLN function key on the MCDU.

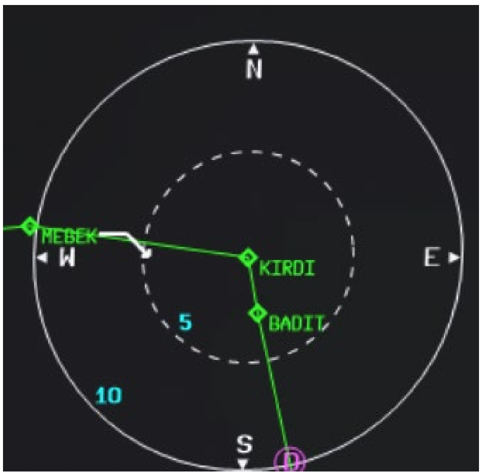
8.4 The Waypoint Management

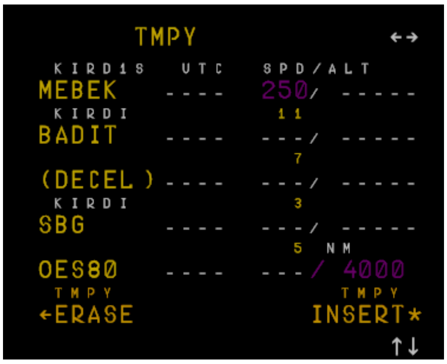
8.4.1 Inserting and Deleting a WPT

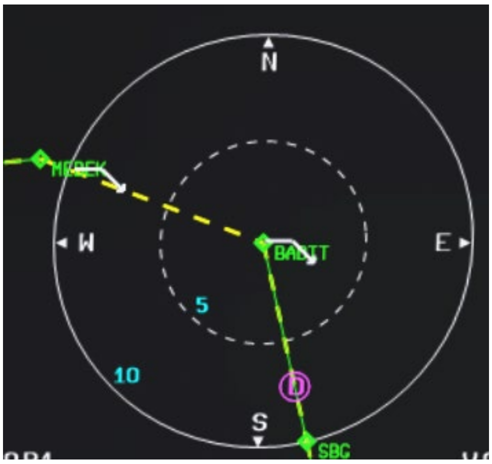
In the example, the WPT- KIRDI shall be deleted. The pilot scrolls the F-Plan Page until KIRDI is shown in Line 2 and in the ND centre.



The pilot presses the CLR followed by LSK2L to delete the WPT.

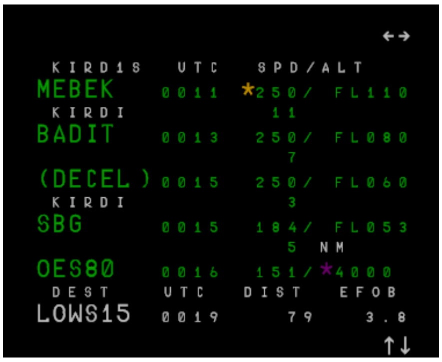


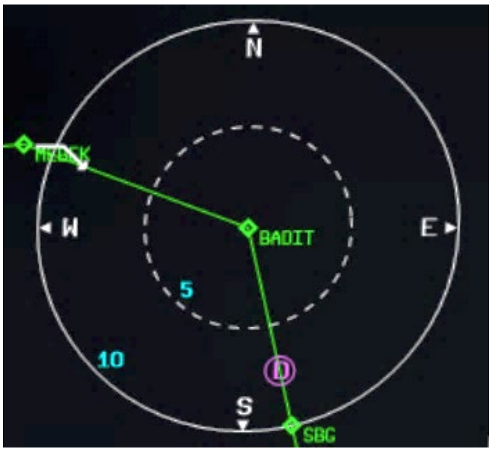




As always, a TMPY-F-PLN is created, which is accepted and activated via **TMPY INSERT***.

By selecting **TMPY ←ERASE**, the pilot can go back to the original F-PLN state and carry-out new modifications.

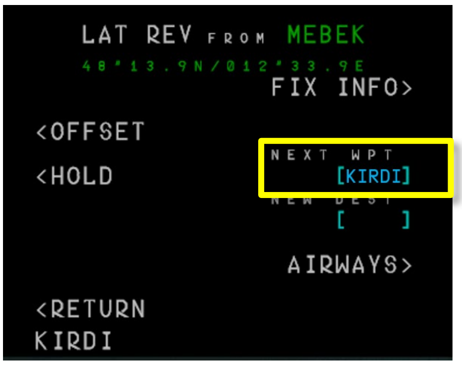




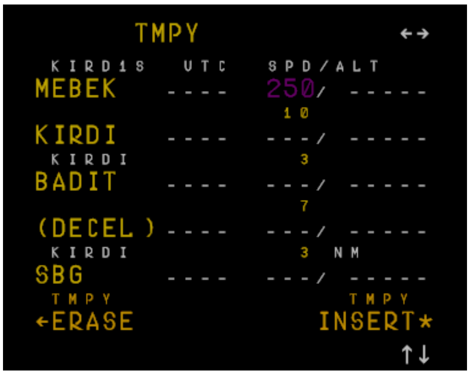
Immediately, the WPT is deleted and the F-PLN sequenced.

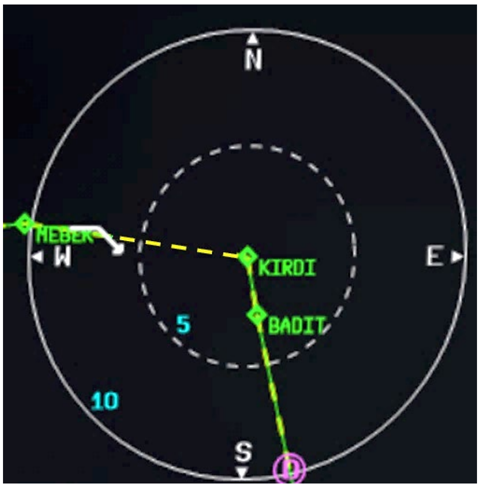
In this example WPT-**KIRDI** shall be inserted between **MEBEK** and **BADIT**. There are several methods available to the pilot, which are:

1. The LAT REV page for WPT-**MEBEK** is opened via LSK1L. **MEBEK** is the WPT, after which the new WPT-**KIRDI** shall be inserted.
   The pilot writes KIRDI into the Scratchpad and transfers the data into prompt NEXT WPT via LSK3R.

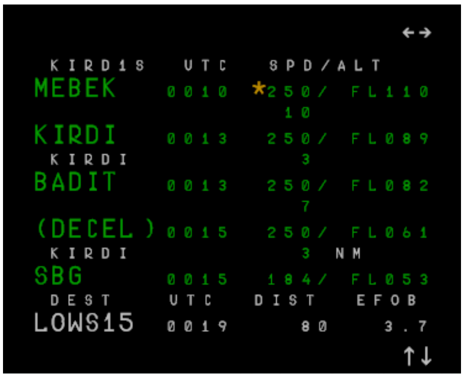


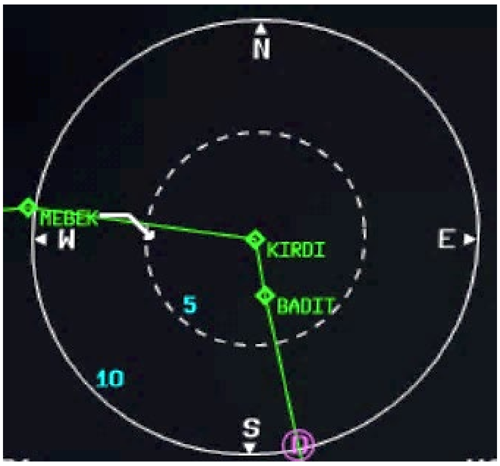
A TMPY-F-PLN including the new WPT-**KIRDI** is prepared and the ND shows the new F-PLN track with WPT-**KIRDI** between WPT-**MEBEK** and WPT-**BADIT.**



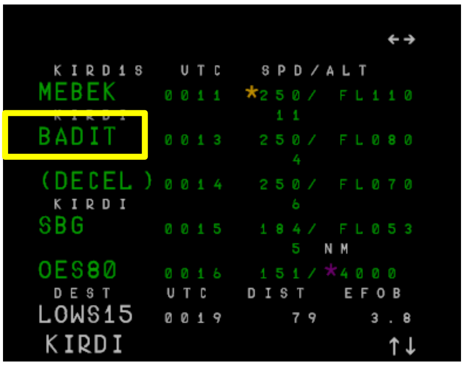


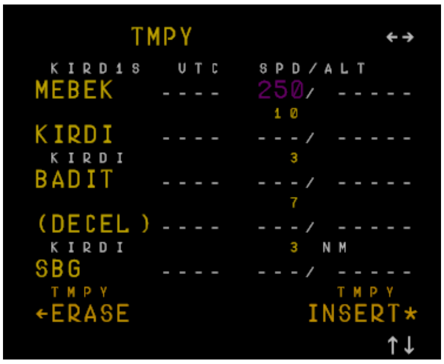
After acceptance of the change with LSK6R **TMPY INSERT***, the WPT-**KIRDI** becomes part of the active F-PLN-page and is shown in **Green**.



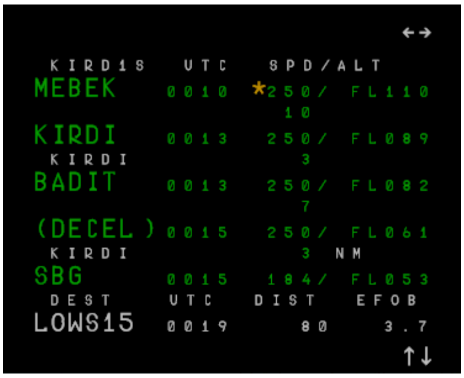


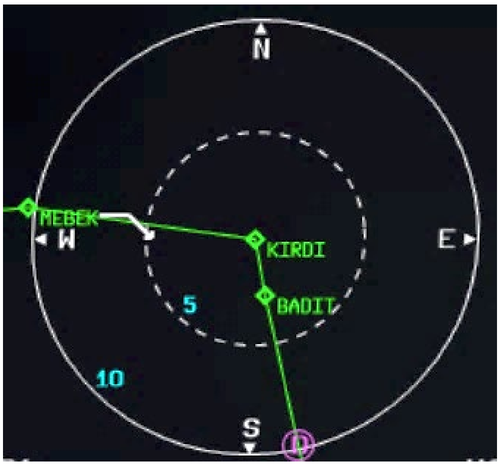
2. The pilot writes KIRDI into the Scratchpad and selects WPT-**BADIT**, the new WPT shall be inserted before **BADIT** and after **MEBEK**. This procedure is the opposite way to example 1, but with the same result.





The new WPT- **KIRDI** is immediately shown on the F-PLN page, without an intermediate step. Again a TMPY is prepared and accepted via LSK6R **TMPY INSERT***. Afterwards the new WPT is part of the F-PLN and shown in **Green** on theF-PLN-page and the ND as well.





8.4.2 The PBD Waypoints

In the examples before, the new WPT has been taken from the FMS data-base. However, if the pilot needs a temporary WPT, he/she can program WPTs independently from the FMS data-base.

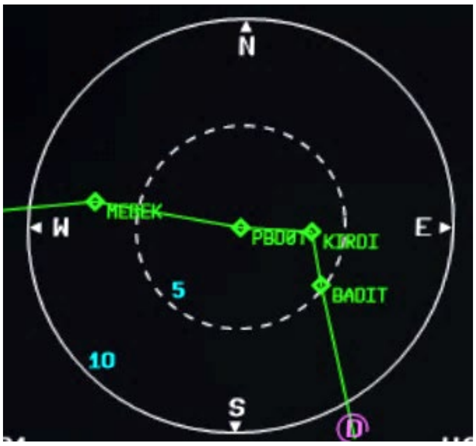
The programming is done according to the PBD-criteria:

- **P**lace, which is an existing/reference WPT/RWY of the F-PLN or from the data-base
- **B**earing, which is the course from/to this WPT
- **D**istance, which is the distance from/to this WPT

This procedure is known under the term PBD-Waypoint. An artificial ID of the new WPT is automatically prepared by the FMS.

PBD Waypoints

PBD means Place-Bearing-Distance and defines the location of the new WPT. Starting point is the reference F-PLN-WPT, of which the course and distance is derived from. Example: **MEBEK**/100/7. That means, the new WPT is located 7NM at 100º from WPT **MEBEK**.

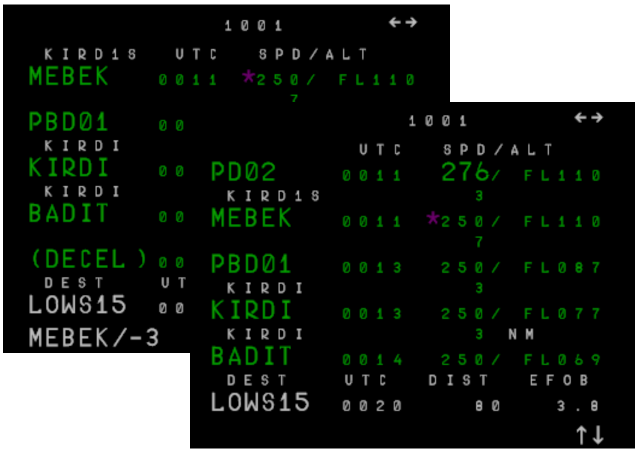


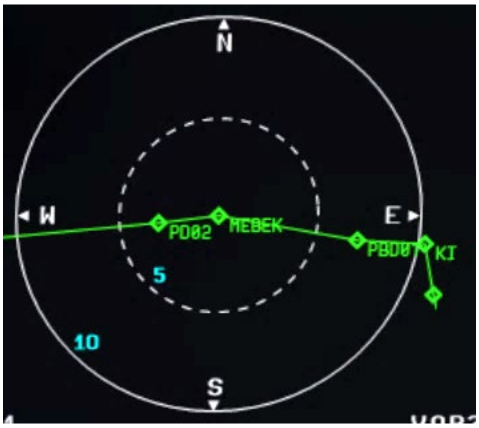
The FMS defines the name of the new WPT as PBD001 (PositionBearingDistance001, 001 being a running number).

PD Waypoints

PD (Place-Distance) is a new WPT which is only defined be the distance form the reference WPT along the F-PLN track. Example: **MEBEK**/-3 The new WPT is located - 3NM before WPT-**MEBEK**.

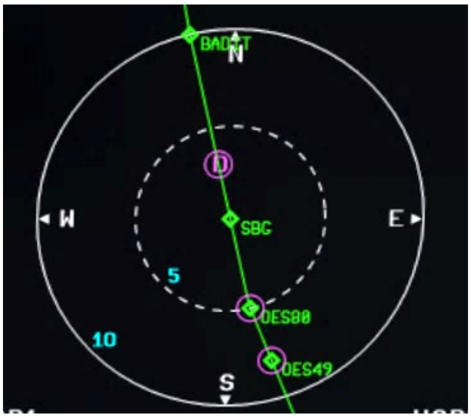
A minus (-) in front of NM means, that the new WPT is inserted before the reference WPT-**MEBEK**. Consequently, a plus (+) or no prefix means after the reference WPT-**MEBEK**.





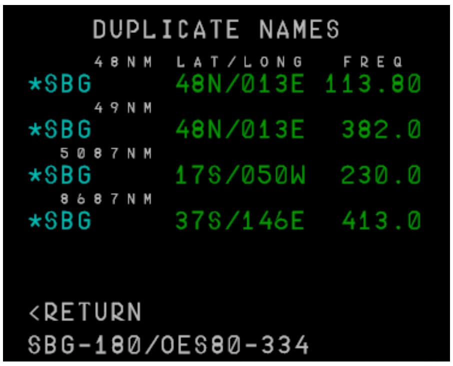
PB-PB Waypoints

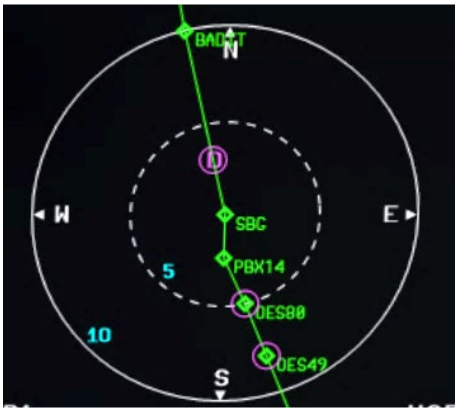
PB-PB (Place-Bearing/Place-Bearing) is a function to program a WPT with crossing courses (cross-bearing). In the example, the function is used to create and simulate the second **SBG**-WPT.



First, the LAT-REV-Page of WPT-**SBG** is opened, both coordinates - SBG-180/OES-334 - are written into the Scratchpad and transferred into the next WPT prompt via LSK3R.

Because several WPT exist with the name **SBG**, a Duplicate Names page is opened and the pilot must select the correct WPT (usually line LSK1L)





The new Waypoint **PBX14** is created and shown on the F-PLN-Page and on the ND. PBX means Position Bearing X-cross.

The running number is carried-forward for all PBD-WPTs prepared during the flight. In case one PBD WPT is deleted, this number is not used again for the active F-PLN.

The WPT-Coordinates can also be written into the Scratchpad and directly entered into the F-PLN without going via the LAT-REV-Page, whatever is more convenient. The later method is faster, but not so intuitive as the LAT-REV procedure.

8.4.3 Waypoint Overfly

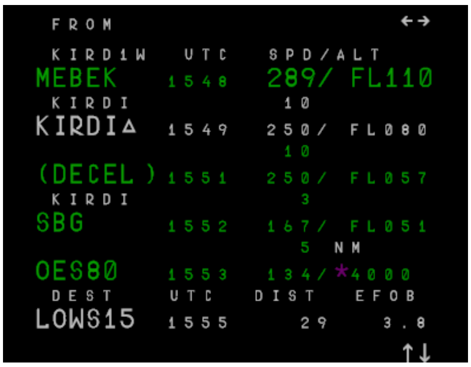
The FMGS always looks for the most economic and comfortable way to fly from one WPT to another. Consequently, not all WPTs are overflown directly but slightly sideward avoiding tight turns.

Nevertheless, in some cases, e.g. SID and/or STAR routes, a waypoint must compulsory be overflown.

The setting is straight forward. The pilot presses the OVFY function key on the MCDU keyboard and the OVFY-Symbol (an upturned faced triangle Δ) is inserted into the Scratchpad.

Subsequently, the pilot selects LSK2L (KIRDI). KIRDI is now marked with the upturned faced triangle (Δ) and will be directly overflown.

The new F-PLN track is shown on the right ND cut-out.



If the pilot selects the LSK2L again, the overfly command for KIRDI will be deleted and the normal conditions apply. However, for the second selection the OVFY-Symbol (Δ) must still be in the Scratchpad if not, the OVFY key must be pressed again.

8.4.4 The Pseudo - Waypoint

Pseudo-Waypoints (WPT) are inserted automatically by the FMGS to define important gates for the calculation of the flight profile. They are not part of the operational F-PLN but shown on the ND as well as the MCDU F-PLN-pages.

Pseudo-WPTs are:

- Top of Climb (T/C), **Blue Arrow**
- Top of Descent (T/D), **White Arrow**
- DECEL **(D)**
- SPD-LIM ●

8.4.5 The Runway-Waypoint

The first WPT of any F-PLN is the so-called Runway-Waypoint (RWY-WPT), which is directly linked to the chosen take-off RWY. The location and altitude of the RWY-WPT depends on the airport and the intended flight route.

In case of an operational F-PLN the RWY-WPT 800 is close to the RWY, at 800 feet (approximately 500 feet AGL at EDDF). This is the height, where no turn should be made before.

If only the RWY is defined on the F-PLN, the RWY-WPT 1864 is further out at 1864 feet (1500 feet AGL). This is the usual altitude for a traffic pattern at EDDF.

8.4.6 Discontinuity

Normally, the F-PLN segments or legs are automatically sequenced by the FMS. However, due to lack of data, a continuous sequencing my not be possible and a DISCONTINUITY is inserted into the Flight Plan.

A DISCONTINUITY represents an open/missing part of the F-PLN. The cause can be a route modification by the pilot.

To delete a DISCONTINUITY the pilot presses the CLR-key which is written into the Scratch-pad. Subsequently, the deletion is executed by pressing the corresponding LSKxL and a TPY F-PLN is generated. By pressing **TMPY INSERT*** on the TPY-F-PLN page, the DISCONTINU-ITY will finally be deleted.

8.5 The Constraint Management

Constraints (limits) are an integral part of the operational F-PLN. They are used to organize (guide) the traffic in the departure (SID) an arrival (STAR) section of the F-PLN. Two versions of constraints are used:

- Altitude constraints (ALT-CSTR), which require the pilot to either cross a WPT above, at or below a certain altitude.
- Speed constraints (SPD-CSTR), which require the pilot to cross a WPT at or below a defined speed (IAS).

The SPD-LIM, 250 knots below FL100 is not a constraint but a speed restriction.

Detailed information on this subject is provided under chapter 6 (FMS) and chapter 7 (FMGS).

8.6 The DIR TO-Functions

The Direct-To function allows the pilot to direct the Airbus to a specific point of the F-PLN usually a WPT, from the Present Position (**PPOS**).

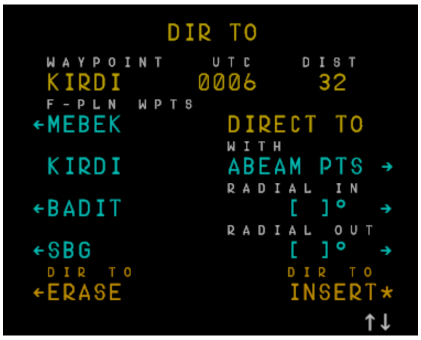
The following procedures are often executed by the pilot:

- DIR TO is the preferred method to sequence the F-PLN. Activating the DIR TO function changes the lateral AFS-Mode immediately to **NAV**. The present position becomes the Turning Point-**T/P** (from WPT) and all previous WPTs are deleted.
- If a NPA-approach is intended, the DIR TO-function is the favoured way to steer the Airbus to the final approach course.
- If the approach includes a MANUAL leg, the Discontinuity cannot be deleted. Then, DIR TO may be used to fly towards the FAF/FAP or another WPT within the approach segment and the Discontinuity will automatically be deleted.
- The ATC accepts a DIR TO request by the pilot to shorten the flight route, e.g. when the flight is delayed.

In order to use the DIR TO function, the pilot presses the DIR-key on the MCDU to open the DIR TO page.

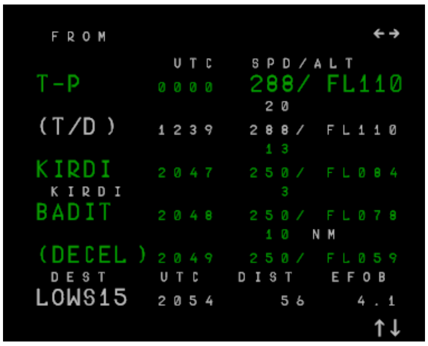
The page lists the next WPTs in direction of the flight. If the desired WPT is not listed, then the pilot enters the ID into the scratchpad and transfers the data with LSK1L. Or he/she can scroll the page (↑↓) until the desired WPT appears.

Example: With LSK3L, WPT-**KIRDI** is transferred into the DIR TO prompt.



As usual, a TMPY-F-PLN is prepared and shown in **Yellow** on the DIR TO page and on the ND as well.

With LSK6R **DIR TO INSERT***, the pilot accepts and activates DIR-TO and all WPTs are shown in **Green**. The **T/P** (Turning Point) is now the new FROM-WPT (line 1 in the F-PLN-Page).



The F-PLN-Page initially shows the T/D (Top of Descent) as the new TO-WPT.

The ND shows the T/D graphically as a White Kinked Arrow und KIRDI as the new TO-WPT in the upper right corner.

A disadvantage of the DIR TO method is, that the pilot dos not know where he/she is actually flying with regards to the original F-PLN track. This uncertainty causes no problem for the short training flight. However, in line operation with a possible long DIR TO track, it is important to always know the exact position of the Aircraft.

Airbus offers a solution for this challenge, called the ABEAM-WPT-Function.

8.6.1 The ABEAM Function

Abeam means the new DIR-TO-F-PLN track follows the original WPTs aside (aloof), which sounds a bit complicated, but isn't.

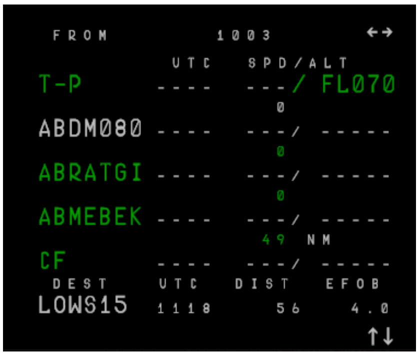
Via the DIR function key, the pilot again opens the DIR TO-page. The pilot selects LSK4L and WPT CF will be transferred into the WAYPOINT prompt. Before the WPT is activated, one more step is required. The pilot selects the ABEAM PTS function by pressing LSK3R.

Now, the DIR TO-page displays the Menu prompt **ABEAM PTS** in **Amber** as a confirmation of the selection. See picture on the left.

The original names (ID) of the WPTs do not change yet.

As always, a TMPY-F-PLN is generated. With LSK6R **DIR TO INSERT*** the TMPY-F-PLN is accepted and replaces the original F-PLN.

The original WPTs along the new F-PLN track to WPT-**CF** are mirrored. These ABEAM-WPTs are displayed with the prefix AB in front of the original name, e.g. ABMEBEK.



On the ND-Page the ABEAM-Points are shown on the DIR TO track in **Green**.

Now, the pilot knows the Aircraft's position with regards to the original F-PLN. This is a vital information for the calculation of flight time and fuel consumption.

8.6.2 The RADIAL IN/OUT

Non-Precision-Approaches (NPA) require to intercept the FAF-WPT (Final Approach Fix) on a specific Radial. Again, the DIR TO-Function is the solution for this procedure.

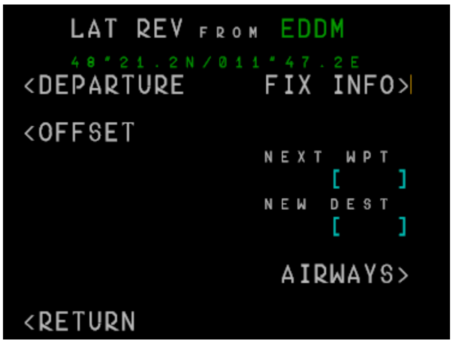
In the example, the NPA requires an In-Bound Radial to the FAF. The In-Bound Radial 332° is selected via LSK4R (RADIAL IN).

With LSK6R **DIR TO INSERT***, the Radial is activated with the **INTERCEPT**-Point as the new FROM-WPT and SBG the new TO-WPT. The pilot can monitor the course of action on the ND.

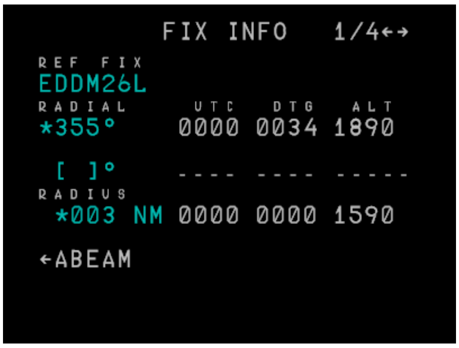
8.6.3 FIX - INFO

The FIX-INFO function is very useful for NPA and/or visual approaches, but can also be used for traffic pattern training. For example: the pilot can program Fixes, to provide him/her with specific approach reference points.

To do so, the pilot opens the LAT-REV page of any WPT (except Discontinuity) of the F-PLN and selects the FIX-INFO page.



The FIX-INFO page is displayed and the pilot can enter the reference Fix (REF FIX), e.g. **EDDM26L**. He/she confirms the choice with LSK1L.



The FIX-INFO page takes over the Fix information **EDDM26L** and offers additional selections.

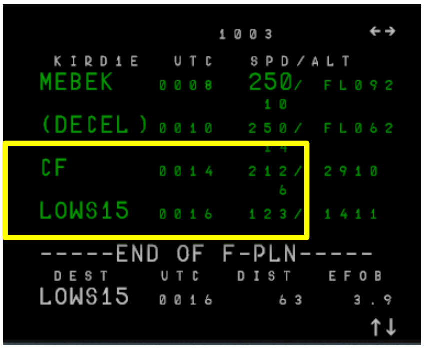
For a traffic pattern, as an example, the pattern radius of **3 NM** and a radial of **355º** is entered. Only one radial is possible per page. A second radial would require a second FIX-INFO page. Up to 4 Fix-Info pages can be defined. The ND displays radius and radial in **Blue**.

The pictures below illustrate a possible FIX-INFO setting for a traffic pattern at EDDM. The **Blue Dotted Radial Line** from threshold **EDDM26L** crosses the **3 NM Radius**, which is the point where the pilot starts timing, e.g. 45 seconds for 1500 feet AGL.

8.6.4 Course to FIX

The **CF**-WPT (Course to Fix) is the starting point and the FAF for a visual approach to LOWS RWY15, if the visual approach is part of an active F-PLN.

The **CF**-WPT is 6 NM from the Runway threshold usually the OM (Outer Marker) position.



8.6 HOLDING and OFFSET

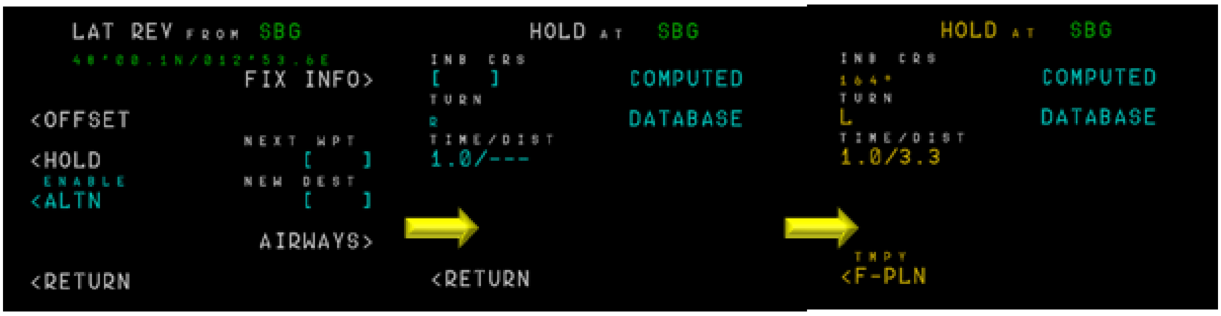
The Holding Pattern

A Holding is a standard procedure and still used by the ATC to manage the traffic volume. Holdings are defined by the Authorities and published on the approach charts. In case of LOWS, WPT-**SBG** (**VOR-SBG**) is the FAF for the approach and also the holding Fix for the missed approach procedure.

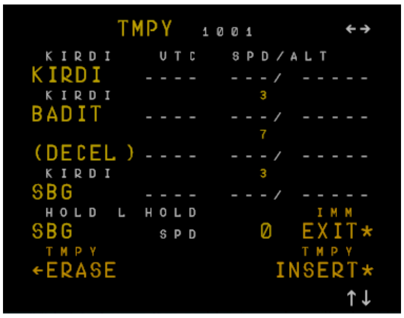
Therefore, the F-PLN does not include a Holding at WPT-**SBG** for the approach but for the missed approach. If advised by the ATC to hold over SBG, the pilot must enter the Holding manually. To do so, the pilot opens the LAT-REV page at WPT-**SBG**, followed by the selection of LSK3L <HOLD.

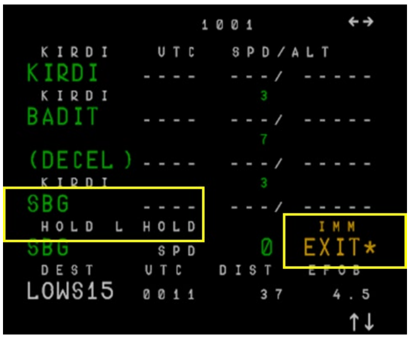
The HOLD page allows offers two choices:

1. **COMPUTED**: The FMS offers the standard Holding pattern, which is stored in the FMS data-base.
2. **DATABASE**: The Pilot prepares an individual Holding and enters inbound-course as well as rotation (L-left or R-right).



The flight time of the holding leg is usually 1 minute. If necessary, the pilot can modify the leg via LSK3L, e.g. for a leg of 1 ½ minutes.





After entering the Holding data, a TMPY-F-PLN is prepared by pressing LSK6L (**TMPY <F-PLN**) and subsequently activated via LSK6R (**TMPY INSERT***).

Now, the F-PLN page and the ND show the Holding as part of the F-PLN (HOLD L). By pressing LSK5R **IMM EXIT*** (immediate exit), the A320 will leave the Holding at the most appropriate position and continue the flight to WPT-**SBG**.

The option **IMM EXIT*** changes to **RESUME HOLD***, meaning the Holding can be continued, as long as the Airbus flies within the Holding area.

Another method to leave the Holding is the proven DIR TO function. In this case, the pilot calls-up the DIR-TO page and selects the desired WPT. This procedure enables the pilot to leave the Holding in any direction, e.g. direct to FAP-WPT-**OES80**.

The OFFSET Track

OFFSET means, the Airbus flies parallel of the F-PLN track by a certain distance.

This special procedure is common on long distance flights, to assist ATC in the traffic separation within dense areas. The procedure is called Strategic-Lateral-Offset-Procedure (SLOP) and allows a deviation from the F-PLN track up to 2 NM. But it is also quite usual, that the pilot flies an OFFSET track in remote areas to secure proper traffic separation.

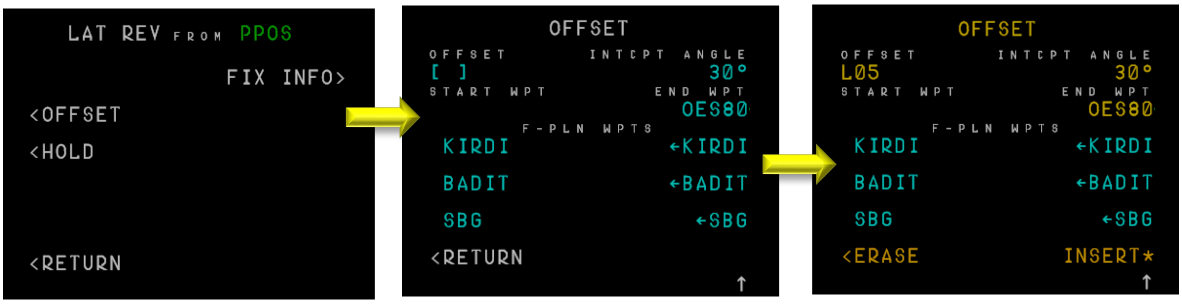
During short-to-medium flights, the OFFSET function is normally used to circumnavigate adverse weather.

The OFFSET function can only be initiated on the LAT-REV page of the FROM-WPT. Once OFFSET is active, the LAT-REV page shows **PPOS** (Present-Position) as the new FROM-WPT.

With LSK2L the pilot selects <OFFSET and the page offers several functions:

1. Starting the OFFESET at the **PPOS.**
2. Defining an OFFSET route from WPT to WPT, e.g. von **KIRDI** to **BADIT**.
3. Defining the OFFSET distance, intercept angle and the turn-out direction **L**eft or **R**ight.

In the example, the pilot enters an OFFSET track of 5 NM to the left of the F-PLN course (**L05**). The OFFSET begins at the **PPOS** and ends at the last WPT before the destination airport, usually the FAF/FAP.



The intercept angle to the OFFSET track is 30° by default, but can be modified. Again, a TMPY-F-PLN is prepared and activated via LSK6R **INSERT*.**

In the right picture, the OFFSET-track is displayed as a **Green Continues Line** and the original F-PLN with a **Green Dotted Line**.

The 5 NM Rule is not valid for the OFFSET function. That means, the F-PLN is sequenced even though the Airbus flies more than 5 NM from the F-PLN track.

After confirmation of the OFFSET entries, the page shows the deviation **L05** (5 NM) with the intercept angle of **30°**. On the ND, the OFFSET is confirmed on the lower left corner with an **OFST L5** indication.

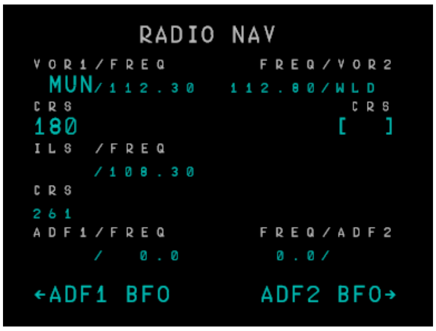
The pilot returns to the F-PLN-Page by pressing RETURN (LSK6L) or selecting the F-PLN function key on the MCDU.

In order to cancel the OFFSET function, the pilot has two possibilities on hand:

- Opening the OFFSET-Page and deleting the OFFSET with LSK6R, OFFSET *DELETE. The Airbus intercepts immediately the original F-PLN track.
- With the DIR-TO function a selected WPT along the F-PLN is tracked.

8.7 The VOR-Indication

In the following example, the Airbus on its way to LOWS flies towards **VOR-MUN**.

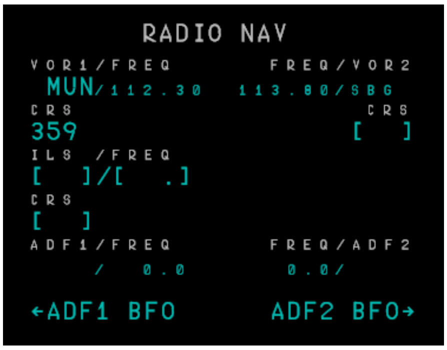


The **Blue Deviation Arrow** and the VOR1-pointer indicate the **VOR** location. It is right in the front of the Airbus.

The **VOR** is further depicted by the **VOR-WPT-MUN**.

The pilot has entered Radial **180° which is** indicated as the **TO**-course by the **Blue Line** and the **Blue Crossbar** on the 2,5 NM circle towards 18 on the compass rose.

If a **VOR**-**FROM** Radial is required, than the pilot enters the reciprocal course of **360°** or **0°**. The **Blue Crossbar** on the 2,5 NM circle changes in the opposite direction towards 0 on the compass rose.



The ND shows, that the Airbus has passed the **VOR-MUN** and the **Blue Deviation Arrow** points back. The **VOR-WPT-MUN** is now directly behind the Airbus.

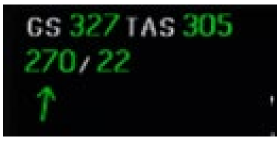
8.8 Inserting the WIND-Data

The Airbus FMGS needs wind data to calculate predictions. The wind data are either entered manually into the respective MCDU page or downloaded via the ACARS data link.

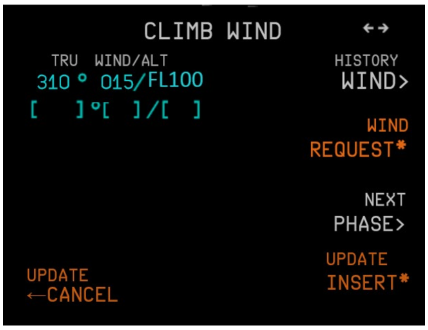
The Wind pages can be called-up via the INIT or Data page. In the example, the wind data entries are explained using the INIT page scenario.

The pilot opens the first WIND page with the Climb-Wind via the INIT-Page, LSK5R WIND>.

Actual Wind data are shown on the ND in the upper left corner with digital values and a wind direction arrow, as shown on the ND cut-out.



When the CLIMB-WIND page is open, the first input fields (prompts) are offered and the climb wind for **FL 100**, **310º 015** (Direction in degrees, Wind Speed in knots) shall be entered.



The procedure is straight forward, typing the data into the scratchpad (310015FL100) and transferring them with LSK1L. If the Ground wind is entered, then the pilot types GRND instead of FL.

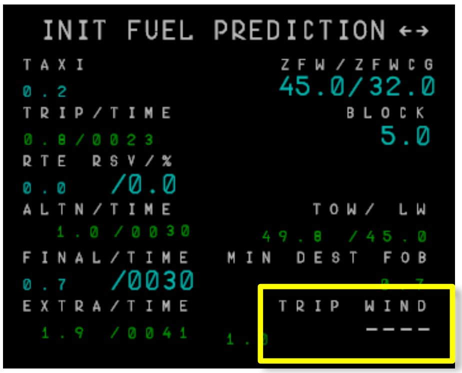
After input, the MCDU automatically offers the next line to enter the wind data for the next climb level, e.g. FL180. This sequence is repeated up to 6 times, that means for a maximum of 6 climb level winds.

Once all wind data for the particular page are entered, they are transferred to the FMGS with LSK6R, **UPDATE INSERT***. By pressing LSK5R, NEXT PHASE>, the wind page for the next phase CRUISE is opened. After cruise follows descent both with the same entry procedures.

The approach wind is always manually entered into the APPR-PERF page according to the information received from the ATC.

If no wind data are available, then the pilot may enter an average Trip-Wind into the INIT-B or FUEL-PRED page. Such a calculation is good enough for the short training flight EDDM-LOWS.

The FMGS takes this data combined with a specific algorithm to calculate F-PLN predictions, e.g. time, and fuel consumption.



As mentioned before, wind data can be downloaded via the ACARS datalink and transferred into the WIND pages. For each Wind-Page, a corresponding function button is provided – **WIND REQUEST***, LSK3R.

The FMS records the wind data of the preceding flight, which can be called-up by the pilot with LSK1R HISTORY WIND. The data are automatically transferred into the corresponding WIND page.

The second DATA-Index page of the real Airbus FMS provides an additional access to the Wind-pages.

- <WINDS LSK6L, opens the WIND pages where specific wind data per WPT can be entered instead of FL.

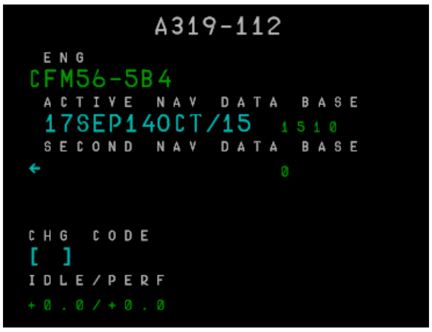
  In this case, the wind page header is, for example; CRUISE WIND AT **MEBEK** and not CRUISE WIND.

8.9 The DATA Pages

The DATA pages offer the pilot a host of additional functions, like storage of data (e.g. specific Waypoints), or NAV-Accuracy check. The Aerosoft Airbus add-on does not include all of the DATA pages. Following some useful data pages are explained.

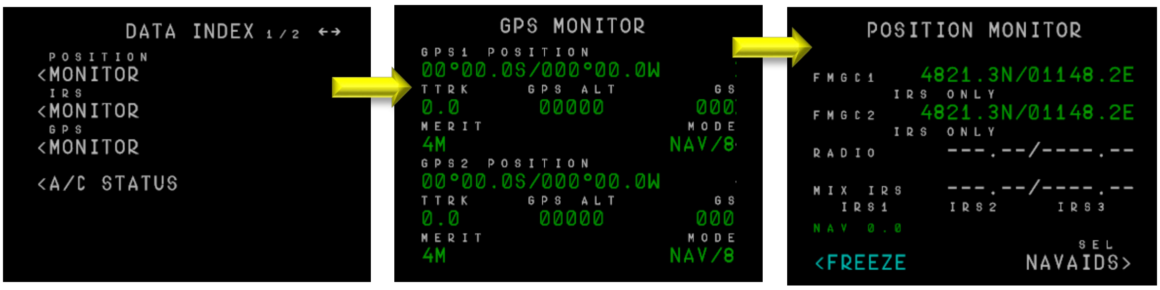
Whenever the A320 is set under power (real aircraft, FFS or Aerosoft add-on) the (A/C)-data-page is displayed on the MCDU.

The first page informs the pilot about the aircraft type (A319-112) and the actual version of the NAV database. In this example, the data base is hopelessly out of date and must be updated.



The real Airbus includes a second data-base (SECOND NAV DATA BASE), which can be activated in case of problems with the active base. Such a switch-over should not be done with care, because all FMS data are set back to square one and must be entered all over again.

On the first DATA-INDEX page the pilot can check GPS Position and Accuracy by selecting the GPS Monitor with LSK3L. It has already been mentioned, that a GPS check is not necessary if GPS PRIMARY is indicated on the PROG page and the ND.

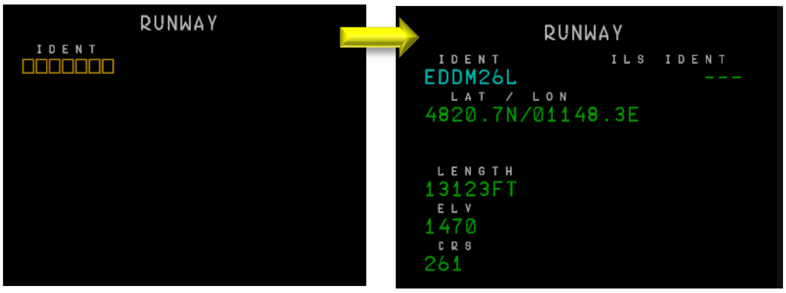


On the second DATA-INDEX page (access via slew-key), FMS data can be checked or newly progammed, like Waypoints, Navaids und Runways.

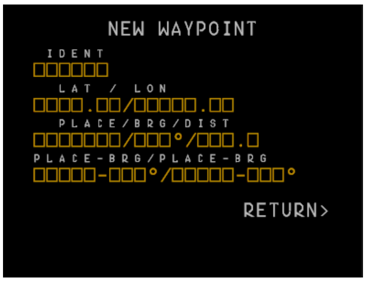
The FMS of the real Airbus even allows the programming of new airports.

With the LSK1-2-3L, the pilot opens the pages that allow the checking of NAV data.

For example: Runway-data can be checked by presssing LSK3L and entering, e.g. EDDM26L.



With the LSK1-2-3R, the pilot opens the pages that allow programming of new NAV data.



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Chapter 9

Content

9.1 The Automatic Flight (AutoFlight)

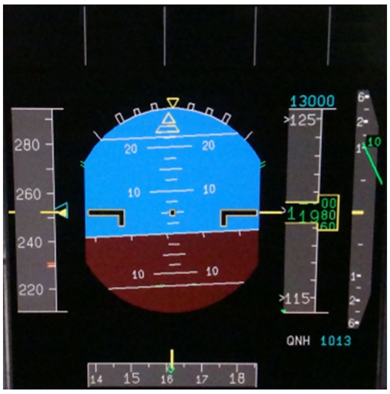
Within the A320 AutoFlight system, the Autopilot (AP) is an integrated part of the FMGS. However, the AP can also be used as an independent system at the pilot's discretion.

9.1.1 Sequence of AP Activation

The AP can be activated above 100 feet. The standard procedure for the AP activation/de-activation during a manual flight with raw-data is as follows.

When the pilot engages the AP the FMGS activates the corresponding AFS-Modes. The A/THR is usually engaged before the AP, but this is not a premise.

In this example, the initial climb is manually flown when A/THR and AP are engaged. The FD is normally engaged before the AP but is intentionally left OFF for training purpose.



Manual flying

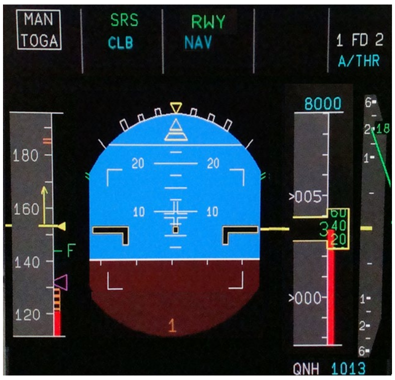
A/THR activated

AP activated

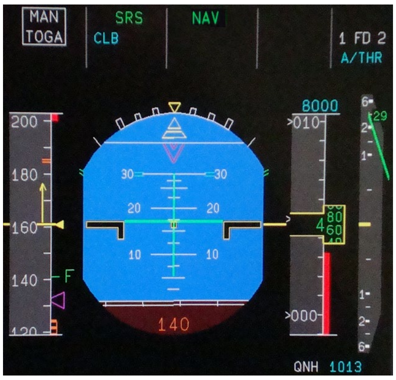
- At first the A/THR is activated and takes over the selected FCU speed. The **Blue** triangle on the speed scale confirms the selection and the speed value of 250 knots. The three activation conditions apply: SPD selection (SPD window), A/THR button **ON** (FCU) and thrust levers in CL detent. See chapter 4 for more detailed information.
- Subsequently, the AP is selected by pressing either the AP1 or AP2 button on the FCU. The AP becomes active in the basic modes **HDG-V/S** with the **ALT** mode armed. The actual values for HDG and V/S are automatically written into the respective FCU window.
- As the next step, the pilot pushes the HDG knob to engage the **NAV** mode and activate the F-PLN. The vertical **V/S** mode remains active, which means the flight is conducted in a mixed mode; selected **V/S** (vertical) and managed **NAV** mode (lateral).
- A further push to the ALT knob changes the vertical mode from **V/S** to **CLB**. The Airbus now follows the F-PLN vertically and laterally.

AP Engagement		AP-Dis-engagement	
FD	ON	A/THR	OFF
AP	ON	AP	OFF
A/THR	ON	FD	OFF

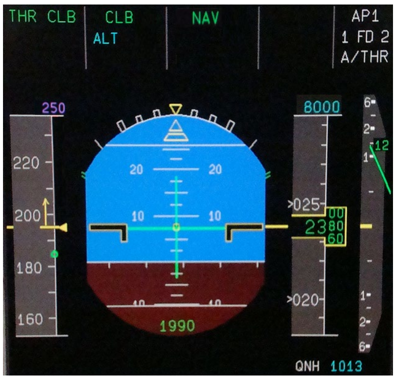
Following the procedure for the AP activation after a standard take-off.



Manual flying, Rotation



Manual flying, FD-A/THR ON



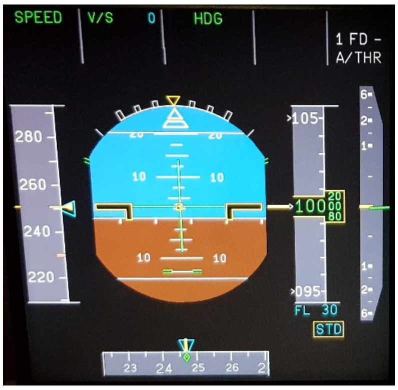
AP activated (ON)

AP Engagement		AP-Dis-engagement	
A/THR	ON	A/THR	OFF
AP	ON	AP	OFF

The A/THR is engaged when passing the THR-RED altitude (THR CLB flashing) and the AP shortly after the ACC-ALT. The THR-RED and ACC-ALT may have the same altitude.

9.1.3 AP- Activation in HDG-Mode

The exercise takes place in FL100 (10.000 feet), heading 247°, V/S 0 (level flight), 250 knots. Starting point is a stable level flight manually controlled by the pilot with the FD engaged.



Then, the pilot selects a new heading of 217° on the FCU and executes a left turn.

During the turn, the pilot switches the AP-ON, but did not exactly follow the FD command. Though, the AP will immediately follow the FD command to fly the new heading of 217°. With V/S at 0.

When the new heading is reached, the **Blue triangles** (heading bug) merge with the actual heading, **Yellow bar I**.

The pilot flies the A320 under manual control with the FD OFF. The actual heading is 217º and a new heading of 180º is selected on the FCU.

The heading bug (**Blue triangle**) is shown on the ND. On the PFD, the new heading value is displayed in **Blue numbers**, because the compass rose cut-out only covers the range between190º and 240º. Therefore, heading 180º is outside the display area.

During a climbing left turn, the pilot switches the AP-ON. Without a FD information the AP takes the actual heading of 197º and V/S 1.100 ft/min as references.

The new heading is immediately shown on the ND and PFD with a **Blue triangle** (heading bug) coinciding with the actual heading, **Yellow bar I**.

The actual V/S of **+1100** is shown on the FMA and by the **Green V/S needle** with the digital value **11**.

Both new values (HDG and V/S) are also automatically written into the FCU HDG and V/S windows replacing the previous indications.

The **HDG** Mode becomes the active lateral mode and any further HDG change is done by dialling the desired value into the HDG window. No pulling of the HDG knob is necessary. If the pilot wishes to stop the climb, he/she simply presses the V/S knob, setting the **V/S** to **0** and forcing the A320 to immediately level-off.

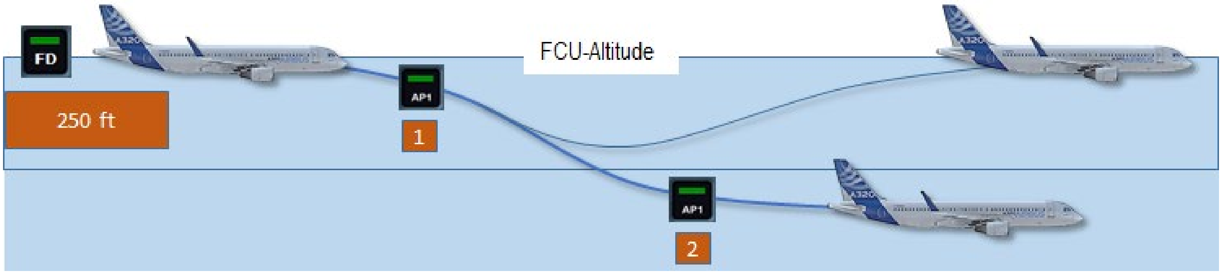
Note: *The heading line on the ND pictures is not straight as it should be. This is caused by the camera angle used for the screenshot.*

9.1.4 AP- Activation and FCU-Altitude

Whenever the AP shall be engaged and the pilot controls the flight manually with the FD ON, two conditions must be observed:

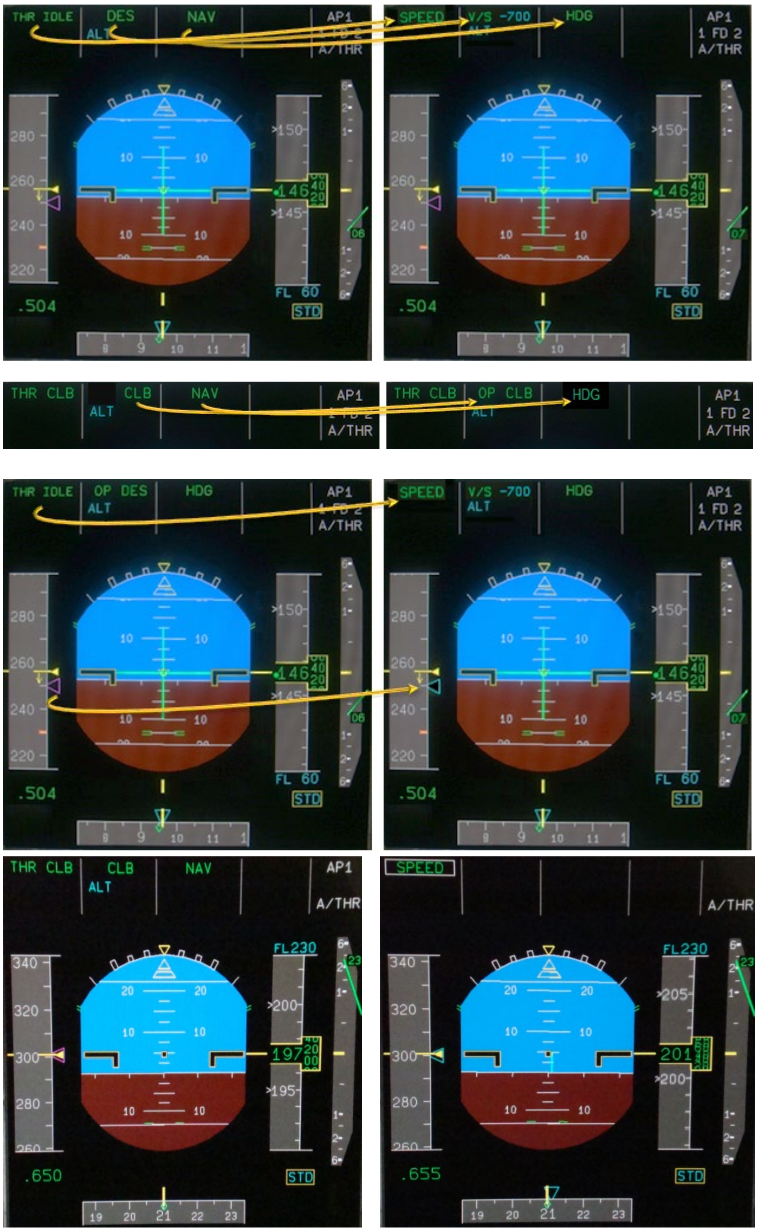
1. The Airbus flies already at the FCU-ALT within the 250 feet band. In this case, the FCU altitude becomes the target reference for the FMGS.

2. The A320 flies outside the 250 feet band. The AP commands the actual **V/S**.



9.1.2 Interaction of AP-FD-A/THR

Following is a summary of the most important aspects of the relationship between AP, FD and the A/THR. It is essential for the pilot to clearly understand this relationship, because it is the key to understand the FMGS philosophy.



When changing from the **NAV** to **HDG** mode (managed to selected) the following mode changes will occur:

- **DES** to **V/S**
  THR IDLE (maintained)
  or
  THR IDLE to **SPEED** (depending on the DES profile)

- **CLB** to **OP-CLB**
- **THR CLB** (maintained)

If the pilot pulls the FCU SPD knob, the following happens:

- **THR CLB** or **THR IDLE** changes to **SPEED**.
- The **Magenta** SPD symbol (managed) is replaced by a **Blue** (selected) symbol.
- The actual Speed is maintained.

Switching the FD and AP OFF:

- Forces the A/THR to change to **SPEED** mode.
- The **Magenta** SPD symbol (managed) is replaced by a **Blue** (selected) symbol.
- The actual Speed is maintained.

9.2 The Automatic Landing

During AutoLand, the AP controls the vertical and lateral Flight Path as well as the Flare, Roll-out and Steering on the runway. The A/THR controls the APPR-speed according to the data on the APPR-PERF page. The automatic brake (Auto Brake) is armed and takes over the braking action after touch down.

Setting the thrust lever to IDLE (disconnecting the A/THR) and activating the reverse thrust, if required, are the only actions to be performed manually by the pilot. The „RETARD“ call-out during AutoLand sounds at 10 feet instead of 20 feet for normal landing.

The AutoLand is automatically armed for all ILS approaches when the landing category (CAT I, II, III) is displayed on the FMA. If the pilot does not disengage the AP at 50 feet, the Airbus will conduct an AutoLand without further pilot action.

For CAT I and II approaches, one active AP is acceptable. However, for CAT III approaches the activation of both AP is mandatory. The second AP can only be activated after the ILS interception.

The following picture shows the cockpit configuration for a CAT III Autoland approach:

- Glideslope (**G/S**) and Localizer (**LOC**) are intercepted (alive)
- DH (RADIO-ALT) is **200** feet
- Both AP and both FD are activated as well as the landing system (LS)
- ILS approach is activated (CAT3)
- The A/THR is active and in **SPEED** mode

1. FD 1 /2 and LS 1/ 2 are selected ON
2. AP 1 / 2 selected ON
3. A/THR selected ON
4. APPR selected ON
5. Thrust levers in CL detent

Not visible in the picture above is the AutoBrake, which has been set to MED (Medium). The Altitude in **Blue (5000)** is the Missed Approach ALT, in case of a GA (G-Around). The MA is further shown on the ND and the F-PLN page.

The picture on the left shows a typical Auto-Land CATIII approach to RWY 27L at EGGL (London Heathrow).

During the roll-out manual rudder control is limited. As long as the AP is engaged and the Pilot uses the NWS or rudder pedals, the AP will always steer the Airbus back to the RWY centre line.

Steering the Airbus by more than 20º (Heading) from the RWY centre line will disconnect the AP and the pilot controls the nose wheel manually. Similarly, if the pilot tips the rudder pedals (Brakes) the AutoBrake will be switched off and the pilot continues with manual braking.

9.3 The Mode-Reversions

9.3.1 Reversion of AFS Modes

For Aircrafts with highly integrated guidance systems, system-induced mode reversions are normal events. The definition Mode-Reversion means automatic mode changes, which are initiated by the FMGS. Such mode changes are not always clearly visible to the pilot and must be specifically trained.

Starting points for FMGS initiated mode reversions are:

- System inherent changes
- Pilot actions
- Systems failures or malfunctions

Following, the most important mode reversions are listed:

- F-PLN DISCONTINUITY
- FCU altitude target changes during climb or descent
- Automatic Speed Mode Protection (FD not followed)
- Automatic Speed Protection (insufficient **V/S** - **SPEED** relation)
- Loss of NAV approach mode

In order to understand the preconditions for AFS mode changes, it is meaningful to recap the interoperability of the modes. There are 3 classes (categories) of AFS modes: A/THR, Vertical and Lateral modes.

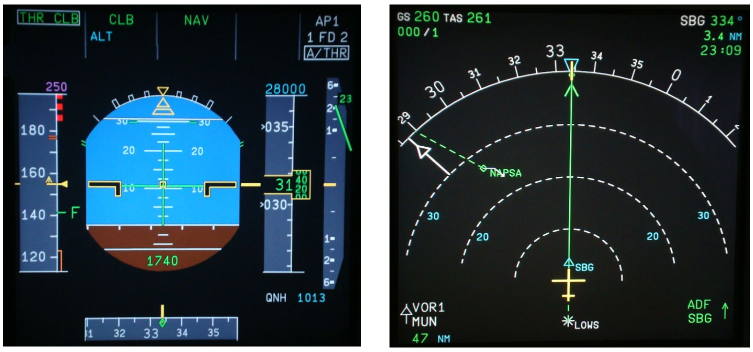
- The A/THR mode is controlled by the vertical modes, **CLB**, **OP-CLB**, **DES**, **OP-DES**, **V/S** and **G/S**.

- The vertical modes are influenced by the lateral modes, **NAV**, **HDG**, **TRK** and **LOC**.
- The lateral modes are influenced by the vertical modes, **CLB**, **OP-CLB**, **DES**, **OP-DES**, **V/S** and **G/S**.

Only the vertical modes have a direct relationship with the other AFS mode classes, the lateral and the A/THR modes.

Mode Reversion at Discontinuity

- In this example, the Airbus takes off from LOWS (Salzburg). No SID has been inserted to the FMS, expecting a vector to NAPSA from the ATC.



The PFD and ND pictures show the Airbus shortly after the ACC-ALT climbing towards the CRZ-ALT.
The F-Speed indication reveals that flap configuration 2 has been used for take-off.

After overflying WPT-**SBG** the Airbus leaves the F-PLN and enters an open segment, the F-PLN is discontinued, laterally and vertically. Therefore, the FMGS changes from **NAV** to **HDG** and as a consequence from the **CLB** to **OP-CLB** mode.

- Supposed the discontinuity happens during descent with the **DES** mode active and a sink rate of 1.000 ft/min. This is the sink rate for an early descent until reaching the calculated descent profile. If the FMGS would switch from **DES** to the **OP-DES** mode, the descent rate will increase to approximately 2.000 - 2.500 ft/min. As a result, the A320 dislodges from the FMGS profile and descent on a parallel vertical path.

  Therefore, the FMGS will change to the **V/S** mode with the actual **V/S** as target, thereby, unwanted alterations of pitch and sink rate are prevented.

  The same procedure applies following a pilot initiated lateral **NAV** to **HDG** mode change during descent. Again, the **DES** mode will be replaced by the **V/S** and not the **OP-DES** mode.

  Such issues do not exist during climb as it is based on climb power **THR CLB**, to realize the best climb performance rather than a specific profile. The result is a nearly equal climb rate for both the **CLB** and **OP-CLB.**

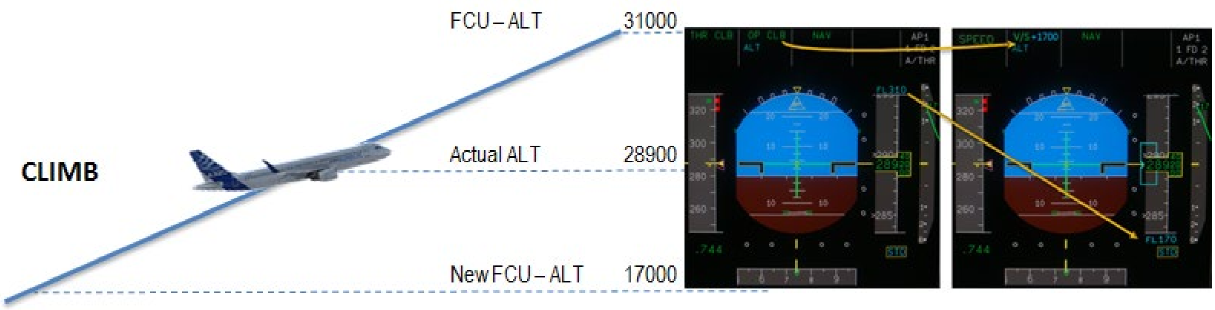
- During the FMS initiation F-PLN DISCONTINUITIES may be inserted by the FMS, whenever the F-PLN sequencing is not possible, e. g. missing SID, as in the LOWS example. Except for a few cases, DISCONTINUITIES can be deleted by the pilot.
  For instance, a DISCONTINUITY between the **PPOS** (Present Position) and a pseudo WPT such as T/C, T/D, DECEL cannot be deleted. DIR-TO towards the next WPT is the solution.
  The same applies to the DISCONTINUITY of an approach with a MANUAL leg (e.g. EDDM transition). The DISCONTINUITY also cannot be deleted and either a DIR-TO or **NAV**-**HDG** change based on a vector given by the ATC must be performed.

Mode Reversion due to FCU-ALT Target Change

During Climb

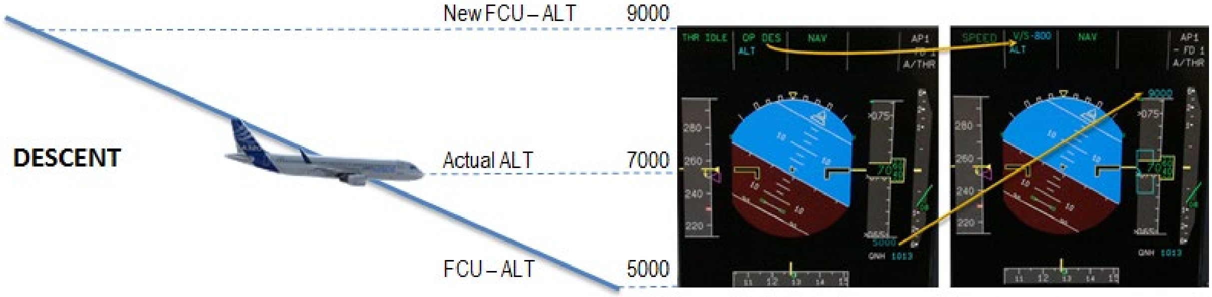
During a climb, the pilot changes the FCU ALT to an ALT lower than the actual ALT. When the **Blue** ALT indication passes through the actual ALT window (28.000), the vertical mode changes from the **OP-CLB** to the **V/S** mode. The actual climb rate of +1.700 ft/min) will be kept to avoid any unwanted pitch changes.

Afterwards, the pilot needs to correct the flight path towards the new ALT or continues the climb in case the ALT change has been entered inadvertently.



During Descent

The course of action for an ALT change during the descent mode follows a similar sequence. When passing the actual ALT window (7.000), a mode change to **V/S** occurs with the actual descent rate of -800 ft/min.



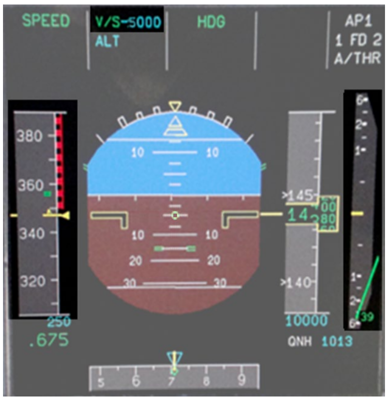
Again, the pilot needs to correct the flight path towards the new ALT or continues the descent in case the ALT change has been entered inadvertently.

If the pilot uses **TRK-FPA** instead of **HDG-V/S**, then the corresponding **FPA** value will be displayed in the FMA. For example: a descent rate of **-800** ft/min is approximately equal to an FPA of **-3°**.

9.3.2 Automatic Speed Protection

Excessive V/S

The FBW-control protects the Airbus against overspeed (V_{MO}) and to fall below a safe minimum speed (V_{LS})). When reaching defined thresholds (which differ according to actual weight) the Automatic Speed Protection will be activated.



In the first picture +4.800 ft/min are selected in the FCU, but the A320 is only able to achieve +1,800 ft/min at FL321. The **V/S** value is encircled by an **orange rectangle** as an attention getter. The **V/S** pointer shows **18** (1.800 ft/min)

The FBW gives the **V/S** priority over **Speed**. Therefore, the FMGS tries to achieve the desired **V/S** on the account of **speed**. The speed falls as low as **V_{LS}+2** before the speed stabilizes. The FMA still indicates the FCU selected **V/S** rate.

In the second picture the reciprocal case occurs. The pilot selects a sink rate of -5.000 ft/min, which is too high. Only 3.900 ft/min are possible without entering the **Red** overspeed band. Again **V/S** has priority resulting in an overspeed situation by reaching V_{MO}.

When approaching **V_{MO}+5** the speed stabilizes but the FMA indication as per FCU selection remains unchanged again.

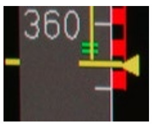
In both cases the FD will be faded-out (not switched OFF), but the AP will be switched OFF. The thrust mode for **V/S** is always **SPEED**.

FD not followed

This mode is only possible with the FD and A/THR are ON and the pilot is controlling the flight manually during climb or descent. In both cases, a Mode Reversion occurs, if the pilot does not follow the FD commands.

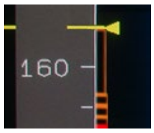
Climb: The vertical modes **CLB** or **OP-CLB** are active and the A/THR commands maximum climb thrust, **THR-CLB**.

If the pilot commands a pitch that is lower as indicated by the FD, the speed will increase. When the speed reaches **V_{MO}**, the sidestick will not accept any further down command to keep the speed within the safe area of **V_{MO}+6**. Only Up-commands will be possible.



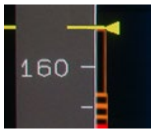
Descent: The vertical mode **DES** or **OP-DES** is active and the A/THR commands idle thrust, **THR-IDLE**.

When the pitch commanded by the pilot is less than indicated by the FD, the speed decreases and stabilizes at **V_{LS}**. Only Down-commands will be possible.



What happens in the reciprocal cases?

Climb: The pilot commands a pitch which is higher than indicated by the FD, the speed drops and stabilizes at **V_{LS}.** Only Down-commands will be possible.



Descent: The pilot commands a pitch which is too steep and the speed increases to **V_{MO}**.

When the speed reaches **V_{MO}**, the speed stabilizes at **V_{MO}+6**. Only Up-commands will be possible.

In all cases, the A/THR reverts to **SPEED** mode trying to keep the target speed and the vertical mode reverts to **V/S**. The FDs will automatically be switched OFF, because they are not followed by the pilot.

9.3.3 Mode Change during Take-off

For any take-off ***with the FD active***, the A320 FBW control requires a defined status of climb speed and climb rate (V/S). If this information is missing, not entered by the pilot or through system malfunction, the A320 defines values for speed and V/S according to the actual situation. The values are automatically written into the respective FCU windows (SPD and V/S) and serve as reference for FD/AP and A/THR.

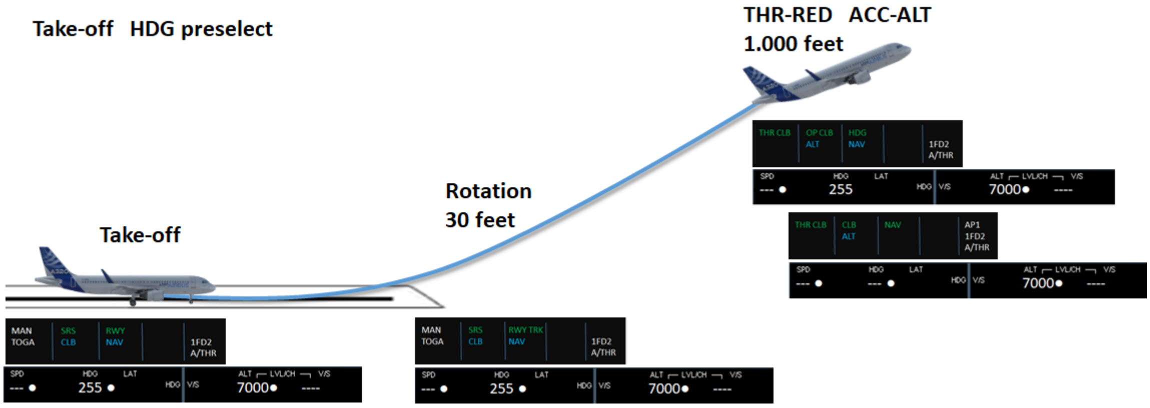
Take-off with HDG preselect

In this example the PERF-page contains all necessary information and a flight plan (F-PLN) has been inserted. In contrast to the other mode change procedures, the HDG preselect is not a system-induced mode change but the result of a pilot action.

If ATC instructed the A320 to follow a specific heading after take-off, the pilot pre-selects the heading with the HDG knob. After take-off the pilot needs to pull the HDG knob to activate the **HDG** mode, otherwise the FMGS will remain in the **RWY TRK** mode which is automatically activated at 30 feet, e.g. 255°.

The initial climb is similar to the standard take-off until reaching the ACC ALT. Passing the ACC ALT, the vertical mode change from **SRS** to **OP-CLB** instead of **CLB** due to the missing vertical profile (**NAV** is not active). The FD commands the adequate pitch and roll attitudes.

At the same time the LVR CLB indication in the FMA flashes, requesting the pilot to move the thrust levers into the CL detent, that will activate the A/THR. Even though **NAV** is not active the speed bug moves from V2 to the climb speed of 250 knots. The A320 accelerates and the flaps can be retracted according to the normal flap schedule.

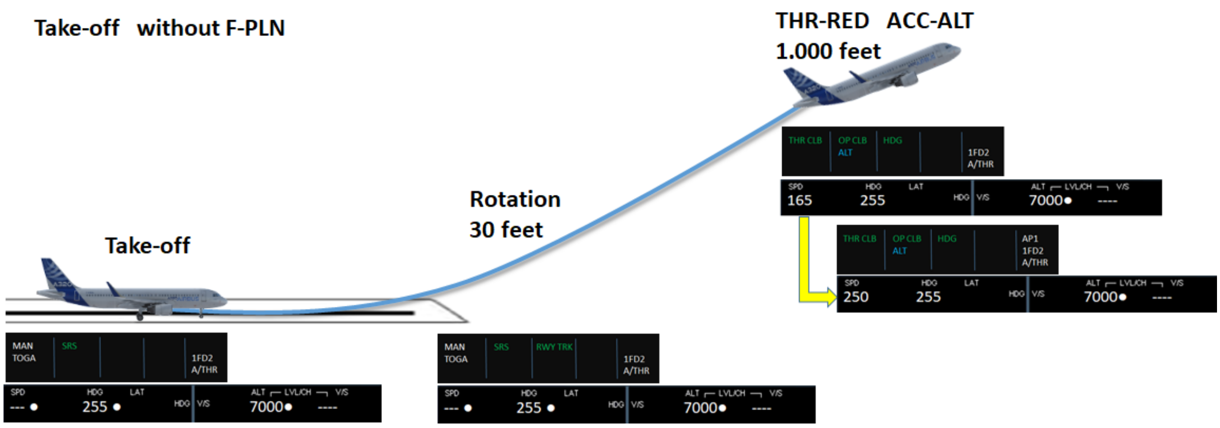


Take-off without Flight Plan

The PERF-page contains all necessary information but no flight plan (F-PLN) has been inserted, e.g. for a traffic pattern. Consequently, there are no vertical profile data available and the **NAV** mode is not available due to the missing F-PLN. The lateral mode can either be **RWY TRK** (activates in 30 feet) or **HDG** if pre-selected by the pilot. The **RWY TRK** is again 255°

The initial take-off again does not differ from the standard take-off with **SRS** as the vertical mode. After passing the ACC ALT, the vertical mode changes to **OP-CLB** and the actual speed value is written into the SPD window of the FCU.

Typically, the actual speed at ACC-ALT is slightly higher than V2+10, e.g. 165 knots. Subsequently, the pilot manually selects 250 knots (below FL100) on the FCU to accelerate and retract the flaps.



The following conditions need to be considered:

- When the pilot sets take-off power, the FMGS automatically takes over the airport data stored in the FMS data base. When passing the ACC- ALT, the **SRS** mode change to **OP-CLB** with the actual speed. The LVR CLB is flashing in the FMA.

- If no data are stored for the particular airport, the Airbus remains in the **SRS** mode until the pilot sets a new target speed.
- No F-PLN also means, no cruise altitude (CRZ ALT) has been inserted into the INIT page. With the setting of the take-off power, the FMGS takes the actual FCU ALT as the **CRZ ALT**. If the pilot changes the FCU ALT, this altitude will be the new CRZ ALT when the **ALT*** mode becomes active. The message „NEW CRZ ALT XX.xxx" is shown in the MCDU scratchpad.
- In case the FCU ALT is below the ACC ALT (FMS airport data), the FMGS assumes the Airbus standard ACC ALT of 400 feet. Then the FMA shows **ALT** instead of **CLB** as the armed vertical mode.

Note: For this and the following example, THR-RED and ACC-ALT are considered to have the same altitude.

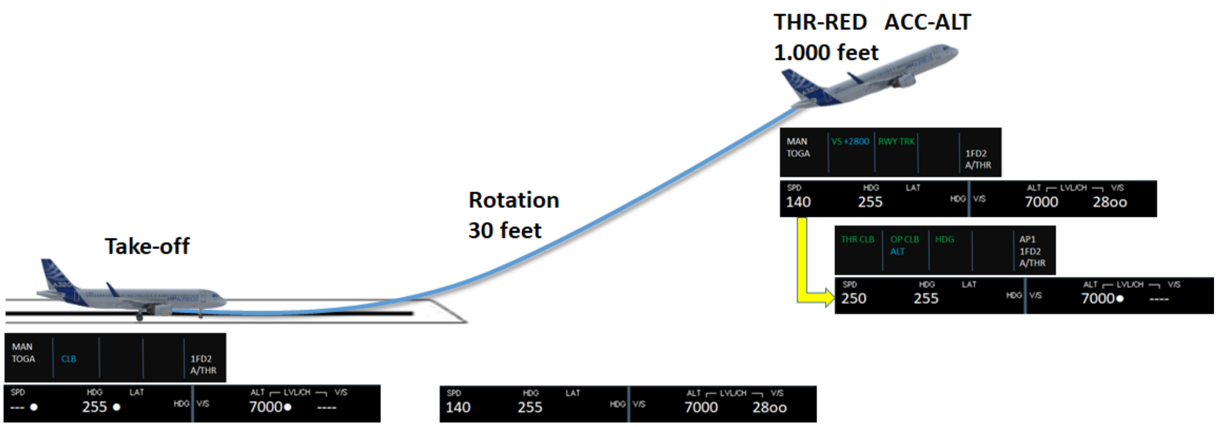
Take-off without PERF Data

In case the V2 is missing on the TO-PERF page due to lack of insertion or through a system malfunction, then the **SRS** mode is not available.

The FMGS automatically generates the required values after rotation as follows:

- At 30 feet, the FMGS takes over the actual speed as the reference speed to substitute the missing SRS mode. The value is automatically written into the FCU SPD window. For a take-off weight of 60 tonnes and TOGA, the initial speed after rotation will be 135 to 140 knots. The speed can be substantially higher, if the pilot rotated to slow (shallow).
- Also, at a height of 30 feet, the FMGS activates the **V/S** mode. The FMGS takes over the actual climb rate, e.g. 2.800 feet/min, and writes the value into the FCU V/S window.
- Without performance data, the FAC (Flight Augmentation Computer) generates the **GD**, **S** und **F** based on the actual TOW.

  The FAC is even able to calculate these speeds without the availability of the TOW on the FUEL PRED page. In this case, the FAC uses other parameters/inputs for the speed calculation.



The lateral AFS mode can be either **RWY TRK**, **HDG** or **NAV** if a flight plan F-PLN has been inserted and the performance data were lost.

In the example before, **RWY TRK** was the initial lateral mode after rotation followed by the **HDG** mode. By pulling the HDG knob, the pilot activates the **HDG** mode with the same heading/track as the **RWY TRK** mode. Any further HDG change is done by dialling the requested value into the HDG window.

If a F-PLN is available, the **NAV** mode can be activated by pushing the HDG knob, if the criteria for the F-PLN interception are fulfilled.

Annex 1

Content

Table 1: A318 Variants

Weight-Variants	Engine-Variants	Power-Rating	
59,0 t (130.070 lbs)	CFM56-5B8	21.600 lbs	10.000 kg
61,5 t (135.580 lbs)	CFM56-5B9	23.500 lbs	11.000 kg
63,0 t (138.890 lbs)	PW 6122	22.100 lbs	10.000 kg
64,5 t (142.200 lbs)	PW 6124	23.800 lbs	10.800 kg
66,0 t (145.500 lbs)			
68,0 t (149.900 lbs)			

Table 2: A319 Variants

Weight-Variants	Engine-Variants	Power-Rating	
64,0 t (141.100 lbs)	CFM56-5A4	22.000 lbs	10.000 kg
68,0 t (149.920 lbs)	CFM56-5A5	23.500 lbs	11.000 kg
70,0 t (154.450 lbs)	CFM56-5B5	22.000 lbs	10.000 kg
75,5 t (168.450 lbs)	CFM56-5B6	23.500 lbs	11.000 kg
	CFM56-5B7	27.000 lbs	12.300 kg
	IAE V2522-A5	22.000 lbs	10.000 kg
	IAE V2524-A5	23.500 lbs	11.000 kg
	IAE V2527-A5	26.500 lbs	12.000 kg

Table 3: A320 Variants

Weight-Variants	Engine-Variants	Power-Rating	
73,5 t (162.050 lbs)	CFM56-5B4	27.000 lbs	12.300 kg
75,5 t (166.450 lbs)	CFM56-5B5	22.000 lbs	10.000 kg
77,0 t (169.750 lbs)	CFM56-5B6	23.500 lbs	11.000 kg
	IAE V2500-A5	23 - 27.000 lbs	10.5 - 12.300 kg

Table 4: A321 Variants

Weight-Variants	Engine-Variants	Power-Rating	
83,0 t (183.000 lbs)	CFM56-5B4	27.000 lbs	12.300 kg
85,0 t (184.400 lbs)	CFM56-5B1	30.000 lbs	13.600 kg
89,0 t (196.200 lbs)	CFM56-5B2	31.000 lbs	14.000 kg
93,0 t (205.000 lbs)	CFM56-5B3	33.000 lbs	15.000 kg
93,5 t (206.130 lbs)	IAE V2530-A5	30.400 lbs	13.800 kg
	IAE V2533-A5	33.000 lbs	15.000 kg

Technical Data of the A320 Family

	A318	A319	A320	A321
Length	31,4 m	33,8 m	37,5 m	44,5 m
Wingspan	34,1 m	35,8 m	35,8 m	35,8 m
Height	12,5 m	11,8 m	11,8 m	11,8 m
Cabin-Width	3,7 m	3,7 m	3,7 m	3,7 m
Max. Altitude	11.900 m	11.900 m	11.900 m	11.900 m
Max. Take-off Weight	68,0 t	75,5 t	78,0 t	93,5 t
Max. Landing Weight	57,5 t	63,9 t	67,4 t	79,2 t
Max. Fuel Capacity	19,0 t	21,0 t	21,0 t	24,0 t
Max. Zero Fuel Weight	54,5 t	60,3 t	64,3 t	75,3 t
Range	5.750 km	7.750 km	6.850 km	6.850 km
Passengers (Pax)	107-132	124-156	150-180	185-220

Technical Data of the A320 NEO Family

	A319 NEO	A320 NEO	A321 NEO
MTOW Maximum Take-off Weight	64,0 t Basic Version 70,0 t Option 75,5 t Option	73,5 t Basic Version 70,0 t Option 77,0 / 79 t Option	89,0 t Basic Version 93,5 t Option
MZFW Maximum Zero Fuel Weight	58,8 t 60,3 t	62,8 t 64,3 t	73,3 t 75,6 t
MLW Maximum Landing Weight	62,8 t 63,9 t	66,3 t 67,4 t	77,3 t 79,2 t

	A318	A319	A319 Neo	A320	A320 Neo	A321	A321 Neo
Seats	107	124	124	150	150	185	185
Range NM	3.200 NM	3.700 NM	4.200 NM	3.300 NM	3.700 NM	3.200 NM	3.700 NM
Range KM	5.950 km	6.850 km	7.700 km	6.850 km	6.850 km	5.950 km	6.850 km
MTOW Basic	59,0 t	64,0 t	64,0 t	73,5 t	73,5 t	89,0 t	89,0 t
MTOW max.	68,0 t	75,5 t	75,5 t	79,0 t	79,0 t	93,5 t	93,5 t
Power-rating	22.000 lbs	24.000 lbs	24.000 lbs	27.000 lbs	27.000 lbs	33.000 lbs	33.000 lbs

Table 5: TO – Speeds

Gross-Weight (GW) tonnes		V_1 knots	V_R knots	V_2 knots	Roll distance Meter	RWY cond.
50	TOGA	115	120	125	700	dry
	FLX 65°	115	122	125	800	
60	TOGA	125	132	136	1.250	dry
	FLX 65°	130	135	136	1.500	
65	TOGA	130	138	141	1.500	dry
	FLX 63°	142	143	143	1.700	
70	TOGA	140	148	152	1.700	dry
	FLX 65°	148	153	155	1.900	

Table 6: F-S-GD - Speeds

Gross-weight	Speed in knots < FL200			> FL200 - FL280
tonnes	O Dot	S	F	O Dot
65	215	192	150	223
60	205	185	145	213
55	195	178	140	203
50	185	168	130	193

Table 7: LDG - Speeds

Landing weight	Speed in knots	
tonnes	VLS /V_{APP} 3	VLS /V_{APP} Full
60	135 / 140	130 / 135
55	130 / 135	125 / 130
50	125 / 130	120/ 125

Table 8: LDG - Distance

Landing weight	Required Landing Distance (RLD) in meter		
tonnes	Manual braking max	AutoBrake Medium	AutoBrake Low
60	1.030	1.320	1.900
55	980	1.270	1.850
50	930	1.220	1.800

	Abbrevi-ations	Definition	Short Explanation
A	ABV	Aircraft	Above Aircraft - TCAS
	AATC	Asian Aviation Trainings Centre	Airbus Pilot-Training Centre Bangkok
	A/C	Aircraft	Airbus A320
	AC	Alternate Current	Electric Power - Voltage
	AC	Air Conditioning	Pressurized Cabin
	ACARS	Aircraft Communication and Reporting System	Data-Link-System
	ACC-ALT	Acceleration Altitude	
	ACCU	Accumulator	Storage System
	ACJ	Airbus Corporate Jetliner	Airbus A319 CJ
	ACT	Actual	
	ADF	Above Field Elevation	Above Airport
	ADIRS	Air Data - Inertial Reference System	Flight Data Processing System
	AF	A-FLOOR	Angle of Attack Protection
	AFE	Automatic Flight System	Part of the FMGS
	AFS	Automatic Flight System	Part of the FMGS
	AGL	Above Ground Level	Altitude above Terrain
	ALT	Altitude	
	ALT CRZ	Cruising Altitude	
	ALT CSTR	Altitude Constraint	FMS - Altitude restriction
	AMP	Audio Management Panel	Communication control Panel
	ANN	Annunciator	Flight Status Display Gauge
	AOA	Angle of Attack	Critical A/C Attitude
	AP	Autopilot	
	APP NAV	Approach-Mode	Mode for Non-Precision Approach
	APPR	Approach	
	APT	Airbus Procedure Trainer	Stationary Procedure Trainer
	APU	Auxiliary Power Unit	
	ATC	Air Traffic Control	
	A/THR	AutoThrust	Automatic Engine control
B	Baro	Barometric Pressure	Barometric Pressure Indication
	BFO	Beat Frequency Oscillator	Mode simulation for NDB
	Block	Block Fuel	Tanked Fuel Quantity
	BLW	Below	Below Aircraft – TCAS

	BRG	Bearing	Direction to station
	BRK	Brake	Auto- or manual Braking System
	BTV	Brake to Vacate	Brake Distance Management
C	CAVOC	Clouds And Visibility OK	Commander
	CPT	Captain	Commander
	CAS	Calibrated Airspeed	
	CCQ	Cross Crew Qualification	Type-Rating for several Airbus Models, e.g. A320-A330
	CEO	Current Engine Option	Actual Airbus A320-family Models
	CFM	Jet engine CFM56	General Electric/Snecma Consortium
	CG	Centre of Gravity	
	CI	Cost Index	Fuel Management
	CLB / CL	Climb Mode	AutoFlight Mode
	CLR	Clear	MCDU Function key
	CM	Crew Member	CM 1- Captain, CM 2 – F/O
	CO	Company	
	CO RTE	Company Route	Stored Flight Plan
	CREW	Flight Crew	
	CRT	Cathode Ray Tube	Older Flight Instruments
	CRZ FL	Cruise Flight Level	Cruise Altitude
	CSM/G	Constant Speed Motor/Generator	
	CSTR	Constraint	Speed / Altitude constraint
D	DA	Decision Altitude - MSL	ILS Approach
	DC	Direct Current	Electricity
	DECEL	Deceleration Point	Flight Plan
	DES	Descent	
	DH	Decision Height- AGL	ILS Approach
	DME	Distance Measuring Equipment	
	DOW	Dry Operating Weight	
E	E/WD	Engine and Warning Display	ECAM
	EASA	European Aviation and Safety Agency	

	ECAM	Electronic Centralized Aircraft Monitoring	
	EDDF	Frankfurt Airport ICAO Code	
	EDDM	Munich Airport ICAO Code	
	EFB	Electronic Flight bag	
	EFIS	Electronic Flight Information System	
	EFOB	Estimated Fuel on Board	
	EGWPS	Enhanced Ground Proximity Warning System	
	EGT	Exhaust Gas Temperature	CFM / IAE Engines
	EIS	Electronic Information System	
		Entry into Service	First Official Aircraft Operation
	ELAC	Elevator and Aileron Computer	Fly-by-Wire Control System
	ENG	Engine	
	EPR	Engine Pressure ratio	IAE Engine
	ESS	Essential Bus	Electrical System
	ETD	Estimated Time of Departure	
	ETOPS	Extended Twin Operation	2-Engine Long-Range Operation
F	FAA	Federal Aviation Administration	USA
	FAC	Flight Augmentation Computer	Fly-by-Wire Control System
	FADEC	Full-Authority Digital Engine Control	Engine Thrust Control
	FAF	Final Approach Fix	Non-Precision Approach
	FAP	Final Approach Point	ILS Approach
	FBS	Fix-bases Simulator	Simulator without Motion System
	FBW	Fly-by-Wire	Electronic Flight Control System
	FCC	Flight Control Computer	Fly-by-Wire Control System
	FCDC	Flight Control Data Concentrator	Fly-by-Wire Control System
	FCU	Flight Control Unit	Fly-by-Wire Control System
	FD	Flight Director	Flight Information system-EFIS
	FDR	Flight Data Recorder	
	FF	Fuel Flow	Actual Fuel Consumption

	FFS	Full-Flight Simulator	Simulator with Motion System
	FG	Flight Guidance	Fly-by-Wire Control System
	FL	Flight Level	
	FLEX	Flexible Temperature - FLX	Flexible Thrust Setting
	FLX-MCT	Flex-Maximum Continuous Thrust	Engine Thrust Setting
	FMA	Flight-Mode Annunciator	Flight Information system-EFIS
	FMGC	Flight Management Guidance Computer	Fly.by-Wire Control System
	FMS	Flight Management System	
	F/O	First Officer	Crew Member / Co-Pilot
	FOB	Fuel on Board	Actual Fuel Quantity
	FPA	Flight Path Angle	Flight Information System-EFIS
	FPD	Flight Path Director	Flight Information System-EFIS
	F-PLN	Flight Plan	
	FPV	Flight Path Vector - Bird	Flight Information System-EFIS
	FQ	Fuel Quantity	
	FQI	Fuel Quantity Information System	
	FWC	Flight Warning Computer	ECAM
G	G/S	Glide-Slope	ILS Approach
	GA	General Aviation	
		Go-Around Mode	AutoFlight Mode
	GA TRK	Go-Around Track	AutoFlight Mode
	GD	Green Dot Speed	Flight Information System-EFIS
	GPS	Global Positioning System	USA
	GS	Ground Speed	
	GW	Gross Weight	Actual Aircraft Weight
H	HDG	Heading Mode	AutoFlight Mode
	hPa	Hectopascal	QNH- Air Pressure
	HSI	Horizontal Situation Indicator	Conventional Flight Instrument
	HUD	Head-up Display	
I	IAE	International Aero Engines	P&W-RR-MTU Engine Consortium

	IAF	Initial Approach Fix	
	IDG	Integrated Drive Generator	Electric Power Generator
	IDLE	IDLE	Idle-Engine-Power/Thrust
	ILS	Instrument Landing System	
	INIT	Initializing Page	FMS
	INS	Inertial Navigation System	Positioning System
	IOS	Instructor Operating System	Simulator Control System
	IRS	Inertial reference System	Positioning System
	ISA	International Standard Atmosphere	QNH Air Pressure
	IVAO	International Virtual Aviation Organization	Flight Simulator Community
K	KG	Kilogram	Weight Unit
	KVA	Kilo-Volt-Ampere	Electrical Unit
	KTS	Knots	Air-Speed, 1.8 km/h
L	L/G	Landing Gear	
	LAW	Landing Weight	Actual Aircraft Weight
	LCD	Liquid Cristal Display	
	LIO	Letter of Intent	Intent for Aircraft Purchase
	LIZFW	Loaded Index Zero Fuel Weight	Load Sheet
	LOAD	Loading Data	Load Sheet
	LOC	Localizer	ILS Approach
	LOFT	Line-oriented Flight Training	FFS Training
	LOWI	Innsbruck Airport ICAO Code	
	LOWS	Salzburg Airport ICAO Code	
	LR	Long-Range	Suffix for Aircraft
	LS	Landing System	Flight Information System-EFIS
	LSK	Line-select Key	FMS – MCDU
	LVO	Low Visibility Operation	
	LVR CLB	Lever Climb	AutoFlight Mode
M	MAC	Mean Aerodynamic Chord	Wing Section for CG Determination
	MAP	Missed Approach Point	

	MCDU	Multifunctional Control and Display Unit	FMS
	MCT	Maximum Continuous Thrust	Engine Thrust Setting
	MDA	Minimum Descent Altitude - MSL	Non-Precision Approach
	MDH	Minimum Descent Height - AGL	Non-precision Approach
	MKR	Marker	
	MM	Middle Marker	ILS Approach
	MSL	Mean Sea Level	Altitude above Sea Level
	MTU	Motoren und Turbinen Union	German Engine Manufacturer
N	NAV	Navigation	AutoFlight Mode
	ND	Navigation Display	Flight Information System-EFIS
	NDB	Non-directional Beacon	Navigation Ground Equipment
	NEO	New-Engine Option	New A320 -family aircrafts
	NM	Nautical Miles	1.8 km
	NPA	Non-Precision Approach	
	NWS	Nose-Wheel Steering	
O	OANS	Onboard Airport Navigation System	Electronic Airport Charts on ND
	OAT	Outside Air Temperature	
	OP-CLB	Open Climb	AutoFlight Mode
	OP-DES	Open descent	AutoFlight Mode
P	P&W	Pratt & Whitney	US Engine Manufacturer
	PAPI	Precision Approach Path Indicator	Visual Glide Path Indication
	PAX	Passenger	Synonym used by the Crew
	PERF	Performance Page	FMS – MCDU
	PF	Pilot Flying	
	PFD	Primary Flight Display	Flight Information System-EFIS
	PNF	Pilot non-Flying	Supporting Pilot
	PROG	Progress Page	FMS – MCDU
	PTU	Power Transfer Unit	Hydraulic Transfer Unit
	PWR	Power	
Q	QNH	Atmospheric Air Pressure – Sea level	

R	RA	Radio Altitude	
	RAAS	Runway Awareness and Advisory System	Runway Incursion Prevention System
	RAD	Radio	
	RADNAV	Radio-Navigation Function Key	Flight Information System-EFIS
	RMP	Radio Management System	Flight Information System-EFIS
	RNAV	Area Navigation	International Navigation Method
	RNP	Required Navigation Performance	Extension to RNAV
	ROPS	Runway Overrun Protection System	New Airbus Approach Support System
	ROW	Runway Overrun Warning	New Airbus Approach Support System
	RR	Rolls-Royce	UK Engine Manufacturer
	RWY	Runway	
	RWY-TRK	Runway Track	AutoFlight Mode
S	SAID	Single-Aisle Incremental Development	Airbus A320-family
	SDAC	System Data Acquisition Concentrator	Fly-by-Wire Control System
	SEC	Spoiler and Elevator Computer	Fly-by-Wire Control System
	SFO	Senior-First-Office	Enlarged-Long-Range Crew
	SID	Standard Instrument Departure Rout	FMS
	SPD	Speed	
	SPD-CSTR	Speed Constraint	FMS-Speed Restriction
	SPD LIM	Speed Limitation	FMS-Speed Restriction FL100
	SPLR	Spoiler	Air-Brakes
	STAR	Standard Terminal Arrival Routes	FMS
T	T/C	Top of Climb	FMS
	T/D	Top of Descent	FMs
	TAT	Total Air Temperature	
	TCAS	Traffic Alert and Collision Avoidance System	
	TEMP	Temperature	
	TERR	Terrain n	Ground/Terrain Proximity Alert
	THR	Thrust	

	THS	Trimmable Horizontal Stabilizer	Airbus Pitch-Trim System
	TLA	Thrust Lever Angle	Thrust Lever Position Indicator
	TLP	Thrust Lever Position	Thrust Lever Position Indicator
	TO	Take-Off	
	TOC	Top of Climb	FMS
	TOD	Top of Descent	FMS
	TOF	Take-Off Fuel	Fuel used during the Take-off Segment
	TOGA	Take-off / Go-Around	AutoFlight Thrust Mode Setting
	TOW	Take-off Weight	
	TR	Transformer / Rectifier	
	TRANS	Transition	Transition Altitude/Transition FL (Flight Level)
	TRK	Track	FMS
U	UTC	Universal Time Coordinated	Aviation Standard Time (Successor of GMT Greenwich Mean Time)
V	V	Velocity	Speed
	V1		Critical Engine Failure Speed
	V2		Minimum Take-off/Climb Speed
	VR	Velocity Rotation	Take-off Rotation Speed
	VFE	Velocity Flap Extension	Flap Extension Speed
	VLS	Velocity Lowest Select	Lowest Selectable Speed
	VSW	Velocity Stall Warning	Stall Warning Speed
	VMAX	Velocity Maximum	Maximum Operating Speed, Current Aircraft Configuration
	VAAP	Velocity Approach	Final Approach Speed
	VASI	Visual Approach Slope Indicator	Visual Glide Path Indication
	VATSIM	Virtual Air-Traffic Simulation Network	Flight-Simulator Community
	VDEV	Vertical Deviation	Flight Information System-EFIS
	VHF	Very High Frequency	
	VIB	Vibration	
	VNAV	Vertical Navigation	FMS

	VOR	Very High Frequency Omnidirectional Radio Range	Navigation Ground Equipment
W	WBC	Weight and Balance Computer	Fly.by-Wire Control System
	WPT	Waypoint	FMS
	WXR	Weather radar	
Z	ZFW	Zero Fuel Weight	Actual Aircraft Weight without Fuel
	ZFWCG	Zero Fuel Weight Centre of Gravity	CG related to actual ZFW