



Safely Flying Non-Precision Instrument Approaches

Historically the distinction between flying ILS/_{MLS} and non-precision approaches was very clear. However, many new kinds of instrument approaches are now available and this makes the distinction less obvious.

What remains true today for any approach is that disregarding basic flying techniques and procedures reduces safety margins.

This article clarifies which technologies are available to perform approaches using an Airbus aircraft. It also emphasises the safety messages that are important to remember whenever flying an approach.



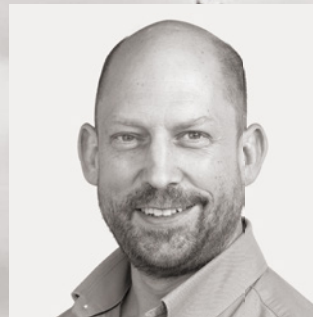
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OVERVIEW OF NAVIGATION TECHNOLOGIES

Ground based navigation technologies

Development of the earliest radio navigation systems started in the 1920s and 1930s. Initially, only the lateral course was supported by a radio navigation aid through systems such as Localiser (LOC), Non-Directional Beacons (NDB), and VHF Omni-Range (VOR). These systems provided, and continue to provide, guidance data for non-precision approaches.

With the growth of the air-transport system in the 1970s, it became necessary to reduce the number of accidents occurring due to lack of vertical guidance in approach, as well as to enable more consistent operations in poor weather.

Instrument-based Landing Systems (ILS) satisfy the requirement to provide both lateral and vertical (glide-slope)

guidance, and therefore quickly became standard equipment at airports during the early 1970s. The inclusion of glide-slope guidance created what has become known as 'precision approaches'. Later in that decade, the Microwave Landing System (MLS) was developed to reduce ILS -beam distortion and multi-path errors; but although it is in operation today, MLS has never gained a significant commercial aviation foothold and is only in limited service.

Historically, with the ground-based technologies described above providing the guidance, it was easy to differentiate between precision approaches and non-precision approaches simply on the basis of whether glide-slope guidance information was provided or not.

On-board technologies enhance Non Precision Approaches

With the increase in Flight Management System (FMS) capability through the 80's and 90's, and especially with the introduction of Global Positioning System (GPS) equipment into civil aviation, the simple distinction between precision and non-precision approaches used earlier is no longer possible. These on-board technologies have rapidly become very sophisticated and are progressively enabling vertical and lateral approach guidance at a similar level to that of an ILS precision approach.

The first enhancement of these non-ILS/MLS instrument approaches came in the 1980s, with the replacement of the step-down technique ("dive & drive") by Continuous Descent Final Approach (CDFA).

Today, the majority of non-ILS/MLS approaches are flown using a

barometric vertical guidance, for which QNH setting and temperature are key factors and this must be taken into consideration by the crew. The most sophisticated instrument approaches use geometric vertical guidance based on an augmented GPS signal to create 'ILS-like' approaches.

In addition, various new GPS based techniques offer sufficient accuracy, even to the point of taking the industry beyond the traditional 'straight-line' approaches and enabled curved approaches.

As a result of all this development, some airports may have several approach charts available for a given runway as shown in **(fig. 1)**. In addition, each chart can present several minima. Therefore, pilots must be familiar with

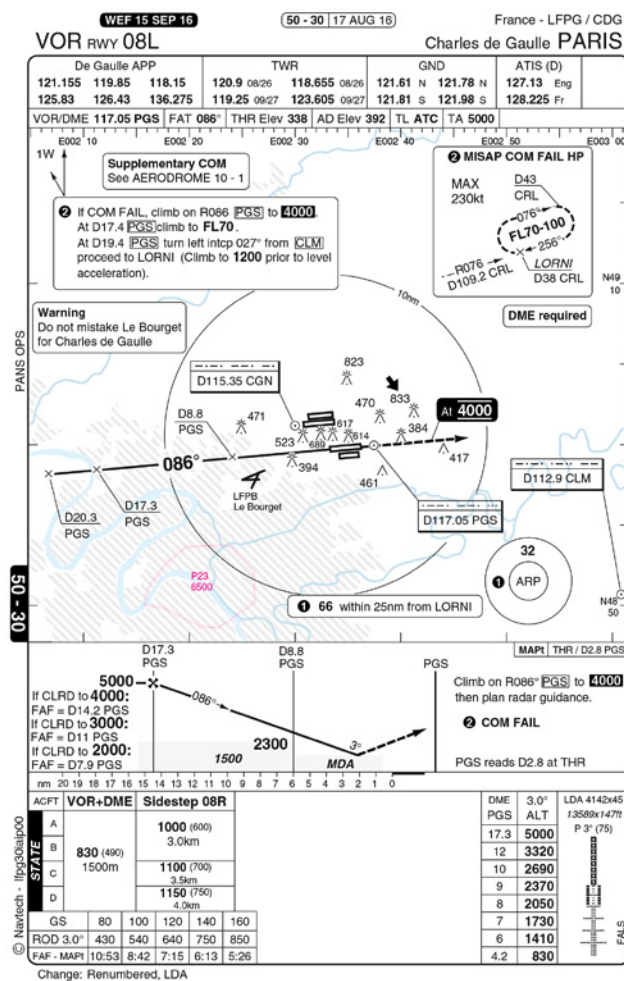
“ Historically, it was easy to differentiate between precision approaches and non-precision approaches on the basis of whether glide-slope guidance information was provided or not. ”

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the charting from their provider in order to ensure correct understanding of approach charts.

Whatever the type of technology, we can state that with the introduction of the CDFA technique, all approaches now share two common characteristics:

- Descent profiles of instrument approaches have become similar: vertical guidance is provided and there is no level-off required at minima
- If the required visual references are not acquired by the applicable minima, or indeed lost after, a missed approach must be initiated. ■



VOR and RNAV (GNSS) approach charts for LFPG RWY 08L.

Source: NAVBLUE

FLYING APPROACHES WITH AN AIRBUS

The importance of vertical guidance

ICAO Controlled Flight Into Terrain (CFIT) studies have shown that once some form of vertical guidance is added to approaches, the safety margin is increased by a factor of 8.

As a consequence, a focus was placed at Airbus in recent years to offer some guidance on the vertical path for all instrument approaches.

If we now discount ILS and MLS approaches, there are different guidance modes available on Airbus aircraft to fly all types of instrument approaches, from TRK/FPA to managed modes offering guidance on both the lateral and vertical trajectory.

Depending on the approach type, the crew has to select the appropriate one **(fig.2)**. Managed modes are recommended, but selected mode might be useful in case of system or equipment failures.

It is worth recalling that in selected mode, the Flight Path Angle (FPA) easily permits to follow the published descent gradient, but the pilot must still ensure that the vertical trajectory relative to the touchdown point is precisely followed.

The creation of new approach modes that have lateral and vertical profiles independent of nav aids followed the introduction of the Flight Management System (FMS) in the 1980s and of the GPS in the 1990s. The objective was to standardize the way of flying all approaches down to the published approach minima, whatever the airport, and whatever the equipment on the ground. The FLS (FMS Landing System) is part of that concept and today, it is an Airbus option offering a solution to fly 99% of approaches that are not ILS/MLS, with a barometric vertical profile.

It offers lateral and vertical guidance for a straight-in instrument approach, referenced from the aircraft position, along a trajectory retrieved from the FMS navigation database.

“ FLS is an Airbus option offering a solution to fly 99% of approaches that are not ILS/MLS, with barometric vertical profile. ”

(fig.2)

Guidance modes available to fly non-ILS/MLS approaches not based on augmented GPS signal

FLS Function	Lateral & Vertical Managed		Lateral Managed Vertical Selected	Lateral & Vertical Selected
	A350 XWB A380 A320 / A330] Option		A320 / A330 / A340 / A350 / A380	
	F-G/S F-LOC F-G/S LOC		FPA -3.0° NAV FPA -3.0° LOC	
	A320 A330 A340		FPA -3.0° TRK	
	A350 XWB RNP AR			

Navigating through approaches: key characteristics

Ultimately, what is needed to safely fly an approach is a clear picture of what it represents in terms of:

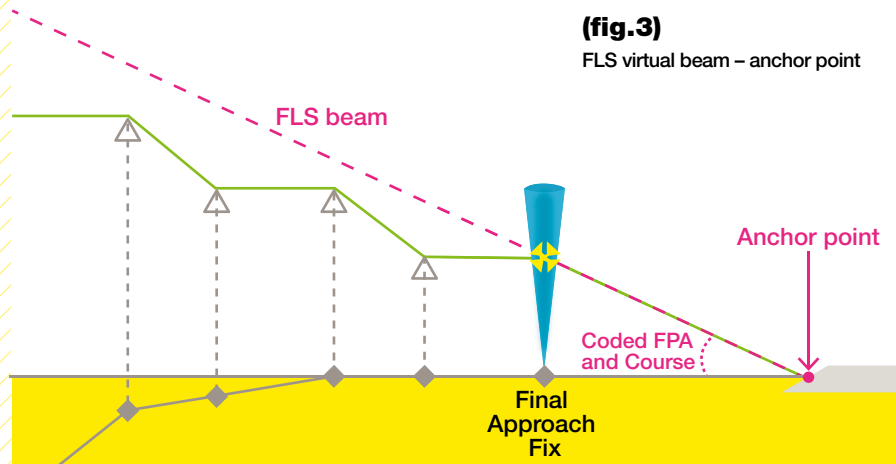
- The aircraft capabilities and crew qualifications (e.g. RNP-AR)
- The approach type
- The approach lateral axis, including potential offset with the runway axis

(or FLS anchor point position)

- Vertical profile (barometric and temperature considerations)
- Applicable minima
- Aircraft guidance mode
- The recovery scenario in case of system failures or deviations exceedance. ■

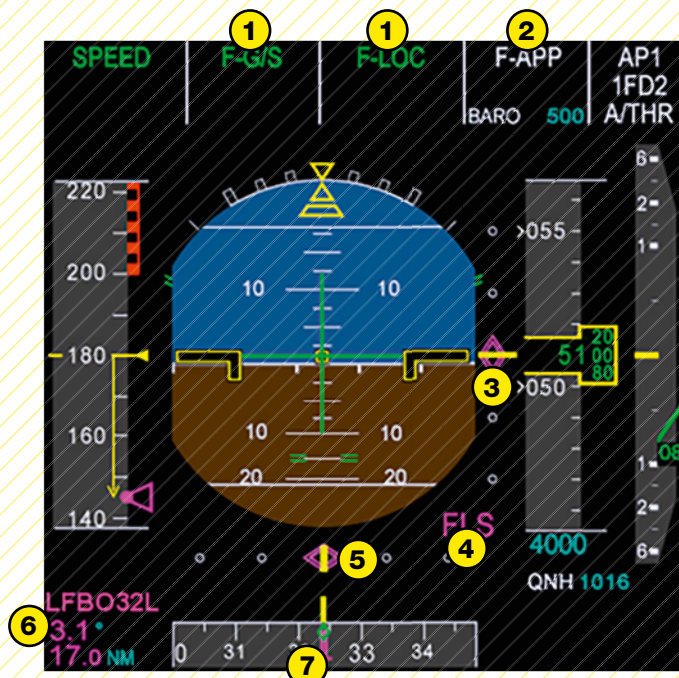
THE FMS LANDING SYSTEM (FLS) GUIDANCE MODE

FLS replicates the ILS beam concept, but using only the onboard navigation sensors with no need for additional ground aids. The FMS constructs a “pseudo beam” which has an anchor point (not necessarily aligned with the runway threshold), approach course and Flight Path Angle (FPA) **(fig.3)**, and which overlays the final segment of an instrument approach with a temperature compensation on final segment for the indicated altitude.



FLS allows a pilot to fly an approach down to minima as an ‘ILS-alike approach’ thanks to the CDFA technique. In addition, the human / machine interface has been designed similar enough for the crew to capitalize on their current techniques but different enough for the

crew not to mistake a non-precision approach flown with FLS for an ILS thanks to a distinctive symbology **(fig.4)**. In the end, this concept makes these approaches more simple to fly, thereby contributing to an increase in safety.



(fig.4)

FLS distinctive symbology

- 1 AP/FD modes
- 2 FLS approach capability
- 3 Pseudo G/S deviation scale and index
- 4 FLS message
- 5 Pseudo LOC deviation scale and index
- 6 FLS information
- 7 FLS course pointer

A characteristic of the FLS is that it can only be used for straight-in approaches but it is not compatible with curved RNP-AR approaches. Indeed, for curved approaches, crews need to undertake specific training and checking, and use

the FINAL APP (or APP-DES on A350 aircraft) mode. Nevertheless, Airbus is working towards co-existence of the two modes so that all non-ILS/MLS approaches are flown in FLS and the FINAL APP mode remains available for RNP-AR.



INFORMATION

Not all aircraft are technically capable of ensuring F-G/S, F-LOC or FINAL APP guidance. FINAL APP and F-G/S or F-LOC guidance modes availability depends on the actual configuration of the aircraft and the airline approach options chosen in the catalogue (i.e FLS or FINAL APP).

The FLS mode is basic on A380 and A350 aircraft. It is available as an option on A320 and A330 families.

The coexistence of FINAL APP and FLS modes is already available for A330 aircraft with Honeywell FMS. It is expected by end 2018 for the remainder of the A330 fleet, as well as A320 family aircraft.



FLYING AN INSTRUMENT APPROACH SAFELY

A well trained and briefed crew: why preparation is key to a successful approach, whatever its type

For a flight crew, after possibly long hours of flight or a busy day's flying schedule, the objective is to perform the most appropriate approach available at the airport according to the weather, aircraft capability, crew knowledge and training.

To fly a non-ILS/_{MLS} approach using managed guidance requires a valid FMS data base. If not, then selected guidance must be used.

The FMS data base is considered validated if the provider is compliant with Regulatory requirements and/or validated by the Operator (depending on FMS standards and approach types).

In addition, because instrument approaches that are not ILS/_{MLS} may not be flown on a daily basis they

require good preparation both on ground and in flight.

Before the flight commences, GPS coverage (Receiver Autonomous Integrity Monitoring (RAIM) / Autonomous Integrity Monitored Extrapolation (AIME)) at destination must be checked if approach requiring GPS only is expected.

When in flight, the crew should ensure that the status of the aircraft is compliant with the technical requirement to fly the approach. In accordance with SOP, the FMS waypoints have to be checked versus the applicable chart to ensure that the correct approach has been selected and that the aircraft will fly the charted trajectory. During the descent

“ FLS allows a pilot to fly a non-ILS approach down to minima as an ‘ILS-like approach’ thanks to the CDFA technique. ”

“ Managed guidance to fly a non-ILS/_{MLS} approach can be used only if the FMS database has been validated. ”

(fig.5)

Example of a cross-reference table, as available in A320 FCOM PRO-NOR-SOP-APPROACH-APPROACH GENERAL.

preparation, the crew must define and agree on the aircraft guidance mode depending on the approach type and applicable minima. For this purpose, the cross-reference table published in FCOM is helpful **(fig.5)**.

The action plan to fly the approach must also consider threats and errors

management, e.g. vertical profile, visual segment after minima and offset.

During the descent, the flight crew should check that the navigation accuracy is compliant with the approach type and use the guidance mode that was intended to be flown, as per SOP.

Guidance Modes per Approach Type					
	LOC G/S	FINAL APP	LOC FPA or LOC B/C FPA	NAV FPA	TRK FPA
ILS / MLS / GLS	Refer to FCOM 'APPR using LOC G/S'	N/A	N/A	N/A	N/A
LOC ONLY ILS G/S OUT	N/A	N/A	Refer to FCOM 'APPR using FPA guidance'	N/A	N/A
LOC B/C	N/A	N/A	Refer to FCOM 'APPR using FPA guidance'	N/A	Refer to FCOM 'APPR using FPA guidance'
RNAV (GNSS) with LNAV/VNAV minima	N/A	Refer to FCOM 'APPR using FINAL APP'	N/A	Not authorised	Not authorised
RNAV (GNSS) with LNAV minima	N/A	Refer to FCOM 'APPR using FINAL APP'	N/A	Refer to FCOM 'APPR using FPA guidance'	Not authorised
RNAV (GNSS) with LPV minima	N/A	Not authorised	N/A	Not authorised	Not authorised
VOR, VOR-DME, NDB, NDB-VME	N/A	Refer to FCOM 'APPR using FINAL APP'	N/A	Refer to FCOM 'APPR using FPA guidance'	Refer to FCOM 'APPR using FPA guidance'

Minima must be respected

With the increasing precision of the navigation means used to fly any approach (e.g. GPS positioning) and the improved reliability of aircraft on-board systems, there is an observed tendency of crews to delay the go-around decision perhaps because of increased confidence in the aircraft automation to guide them below the published minima. This tendency translates into a significant reduction of the safety margins, especially with respect to flying without visual references below the minima.

Data has shown that if visual conditions were not achieved at the minima but

were still expected, some crews waited a little bit longer, hoping for visibility to improve before they made the decision to go-around. This means that they were now flying unsafely below minima with no visual references. Likewise, if visibility is good at minima but it then reduces, some crews may decide to continue the approach, hoping for an improvement in the visibility. This tendency could also be reinforced if pilots are not go-around minded.

In reality, any "negotiation" with the visibility requirement from the minima and below for any approach is a drift into danger. ■

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GLOSSARY

CDFA	Continuous Descent Final Approach
DME	Distance Measuring Equipment
FAF	Final Approach Fix
FLS	FMS Landing System
FMA	Flight Mode Annunciator
FPA	Flight Path Angle
GLS	GBAS (Ground Based Augmentation System) Landing System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
G/S	Glideslope
ILS	Instrument Landing System

LNAV	Lateral Navigation
LOC	Localizer
LPV	Localizer Performance with Vertical guidance
NDB	Non-Directional Radio Beacon
RNAV	Area Navigation
RNP	Required Navigation Performance
RNP-AR	Required Navigation Performance Authorization Required
SLS	Satellite Landing System
VNAV	Vertical Navigation
VOR	VHF Omnidirectional Range

The most important safety messages to keep in mind to fly any kind of instrument approach are:

- Know which procedure your company allows
- Prepare the approach well in advance; on ground and in flight
- Know which parameters and deviations or systems failures should trigger a go-around decision
- Brief, share and understand the intended approach technique to be used
- Fly as you are trained. Fly the brief
- Respect the minima; from the minima and below, visual references are primary references. If they are not there or don't remain there, go-around!
- From the minima, ensure the aircraft can continue with a normal rate of descent and bank angle, to land within the touchdown zone.

Finally, the Pilot Monitoring (PM) has a vital role to play in all instrument approaches. The PM must understand what the Pilot Flying (PF) has planned to do, what the PF is doing right now and what the PF will do in the near future. The PM supports the PF in using the SOP callouts and ultimately ensuring that the minima are respected. He/she also assists the PF in monitoring the appropriate arming and engagement of guidance modes at the right time.

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