

Further Preventing Loss of Control In-flight



Loss of Control In-flight (LOC-I) has been one of the main categories of fatal accidents since the beginning of commercial jet aviation. While flight envelope protections in fourth-generation aircraft have reduced LOC-I incidents by 90% compared to third-generation aircraft, the continuous enhancement of aircraft systems is necessary to further prevent potential future accidents. Airbus has leveraged lessons learned from in-service events to implement advanced safety improvements in A350 aircraft, further mitigating the risk of LOC-I accidents. The objective is now to upgrade the A320 family, A330, and A380 aircraft to get as close as possible to the A350 standard for LOC-I prevention.

This article will describe these safety improvements, and outline a strategy for implementing them across the Airbus fleet.

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STRENGTHENED PROTECTIONS

There are three barriers against LOC-I events that are available on fourth generation commercial jet aircraft.

1. Autoflight

Autoflight assists flight crew in phases such as high altitude flying and can maintain control of the aircraft when difficult conditions are encountered, like turbulence. Flight crew workload is also reduced when autoflight is used, allowing them to focus on management of system failures should they occur.

2. Flight Crew Awareness

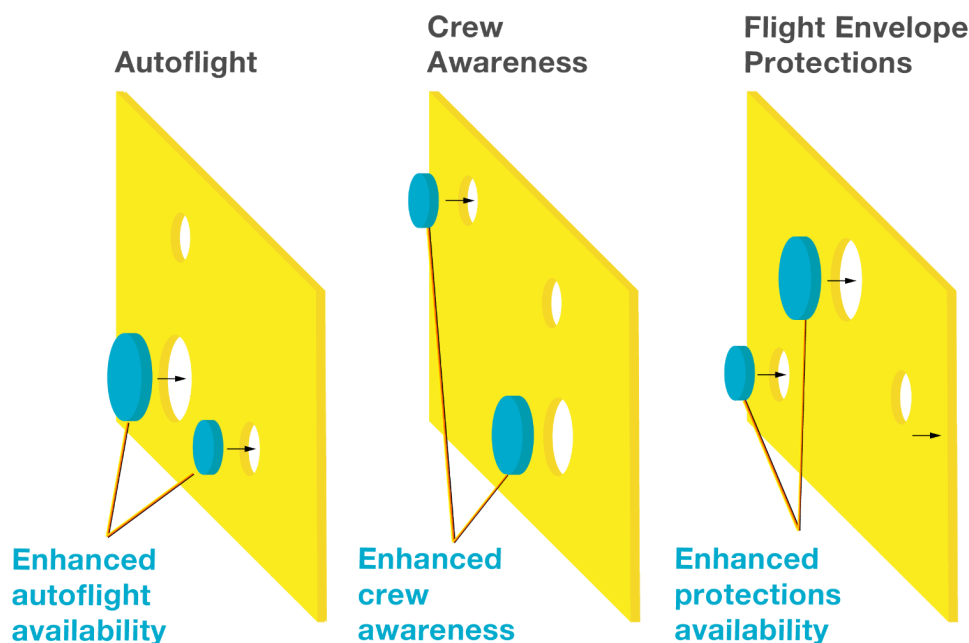
When autoflight is not used, or if autoflight capability is lost due to a system failure, or autopilot domain exceedance, the flight crew's awareness of the situation will enable them to react and perform appropriate manual flying inputs.

3. Flight Envelope Protections

In certain, but rare conditions, the flight crew may lose situational awareness, which can cause them to make inappropriate inputs on the flight controls. The crew may also need to make rapid flight control inputs to perform an avoidance maneuver. In these cases, the flight envelope protection introduced on the fourth generation of jet aircraft, provides the third barrier to prevent LOC-I events.

Lessons learned from inservice events have driven the design of additional enhancements for each of the three safety barriers on the A350 aircraft. The objective of the Safety Beyond Standard initiative is to also implement these enhancements on the eligible A320 Family, A330 and A380 aircraft to bring most of the Airbus fleet closer to the A350 standard. ■

(fig.1) The three barriers against LOC-I that are available on fourth generation jet aircraft and strengthened protections available.



Safety Beyond Standard

ENHANCED AUTOFLIGHT AVAILABILITY

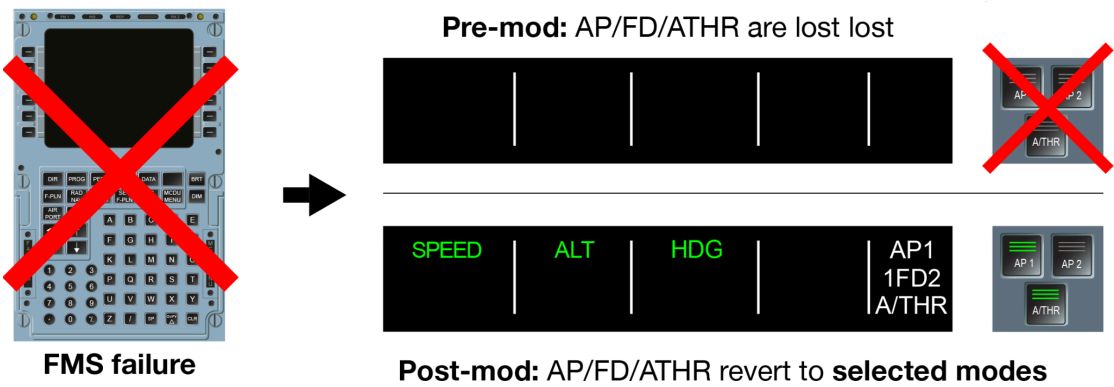
This increases the availability of the autopilot and autothrust, and reduces the risk of flight crew startle due to a sudden loss of autopilot and autothrust. The difference of the original configuration (pre-mod) and the increased availability after implementation (post-mod) is described for each enhancement.

Enhanced Autoflight: Robustness to FMS Failures

A majority of cases reporting loss of autoflight system are due to a failure or reset of the Flight Management System (FMS). In pre-mod configuration, when the FMS fails or resets, the autopilot (AP), Flight Director (FD) and autothrust (ATHR) disconnect (fig.2).

In post-mod configuration, the AP/FD/ATHR remain available in selected mode if the FMS fails or resets.

(fig.2) Enhanced Autoflight Robustness to FMS Failures



Availability of the robustness to FMS failures

This enhancement is available on all A320 family aircraft manufactured from 2021. It is available for retrofit on all A320 family aircraft manufactured before 2021.

A330 aircraft with GENEPI FMGEC hardware, which represents around 70% of the fleet, can have the enhancement after upgrade to the H7 FMGEC standard that is available from 2022.

This enhancement was installed as standard (or basic) on all A380 aircraft.

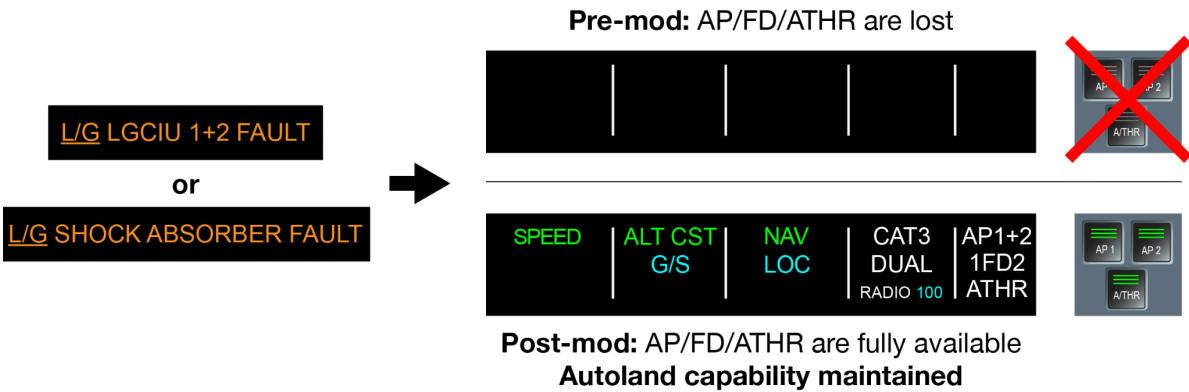
A320				A330				A380			
% Fleet	Computer	Standard	Avail. date	% Fleet	Computer	Standard	Avail. date	% Fleet	Computer	Standard	Avail. date
100 %	FMGC	FG3G: PC20/PI18	Avail.	70 %	FMGEC "GENEPI" hardware only	H7	Avail.	100% (basic)	PRIM	All	Basic
		FG2G: C15/I16	2025								

Enhanced Autoflight Robustness to LGCIU Failures

Autoflight needs landing gear information (extended/retracted and compressed/uncompressed). As a consequence, in the initial design, AP/FD/ATHR are lost in the case of a **LDG LGCIU 1+2 FAULT** or **LDG SHOCK ABSORBER FAULT** (fig.3).

In post-mod configuration, the flight guidance uses an additional source for landing gear information. AP/FD/ATHR will remain available if both Landing Gear Control Interface Unit (LGCIU) fail or in the case of a **LDG SHOCK ABSORBER FAULT** ECAM alert, maintaining capacity to perform CAT II or CAT III operations. This enhancement was installed as standard (basic) on all A330 and A380 aircraft.

(fig.3) Enhanced autoflight robustness to dual LGCIU failure



Availability of the robustness to LGCIU failures

This enhancement is standard (basic) on all A320 family aircraft manufactured from 2021. It can be retrofitted on all previously built A320 family aircraft.

This enhancement was installed as standard (basic) on all A330 and A380 aircraft.

A320				A330				A380			
% Fleet	Computer	Standard	Avail. date	% Fleet	Computer	Standard	Avail. date	% Fleet	Computer	Standard	Avail. date
100 %	FMGC	FG3G: PC20/PI18	Avail.	100% (basic)	FMGEC	All	Basic	100% (basic)	PRIM	All	Basic
		FG2G: C15/I16	2025								



Enhanced Autoflight Robustness to Air Data Failures

In pre-mod configuration, AP/FD/ATHR requires at least two independent and consistent airspeed sources to be available. As a consequence, AP/FD/ATHR are lost in the case of a loss of the data from 2 ADRs.

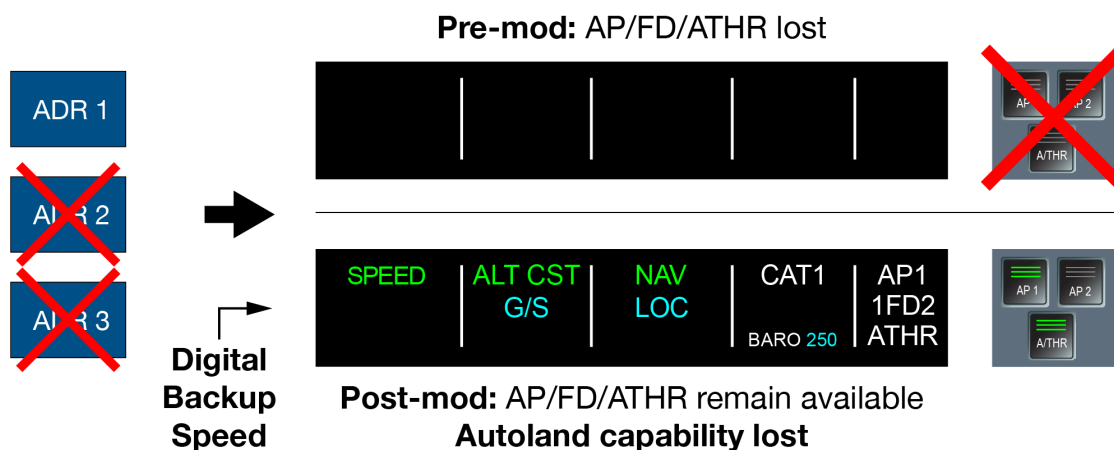
Speed Monitoring function (Unreliable Airspeed Mitigation Mean (UAMM) step 2)

In post-mod configuration, the use of an independent airspeed estimator, called **“Digital Back-Up Speed” (DBUS)**, is based mainly on angle-of-attack, load factor value, aircraft weight and configuration, which enables **monitoring of the remaining ADR speed data**. As a consequence, the following autoflight availability is reinforced in the case of loss of air data as follows:

Only one ADR available

The AP/FD/ATHR will remain available even if two ADRs are lost. Automatic landing is however no longer available. CAT I operations remain possible (G/S and LOC modes remain available).

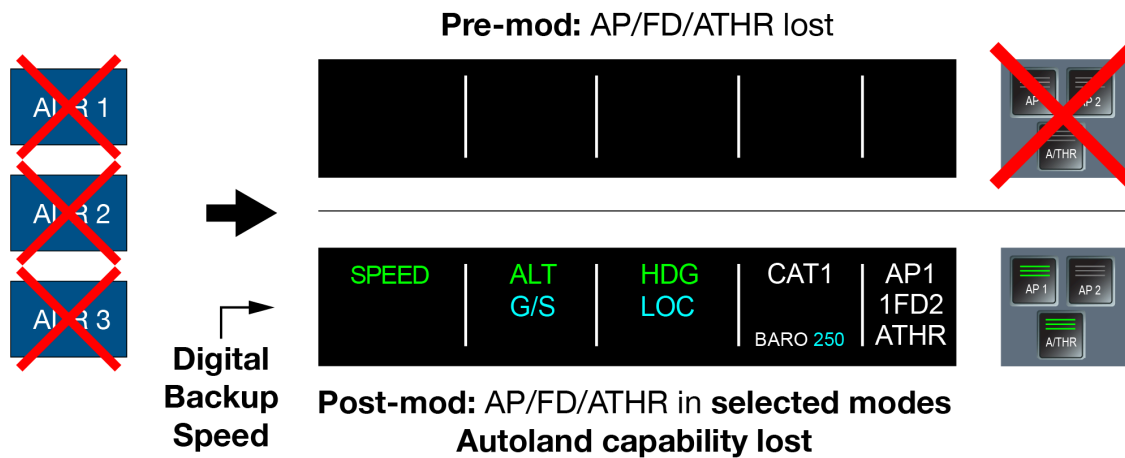
(fig.4) Enhanced autoflight robustness to dual air data failure



Only digital backup speed available

If only the digital backup speed is available, the AP/FD/ATHR remain available, but in only selected modes. Automatic landing is however no longer available. CAT I operations remain possible (G/S and LOC modes remain available).

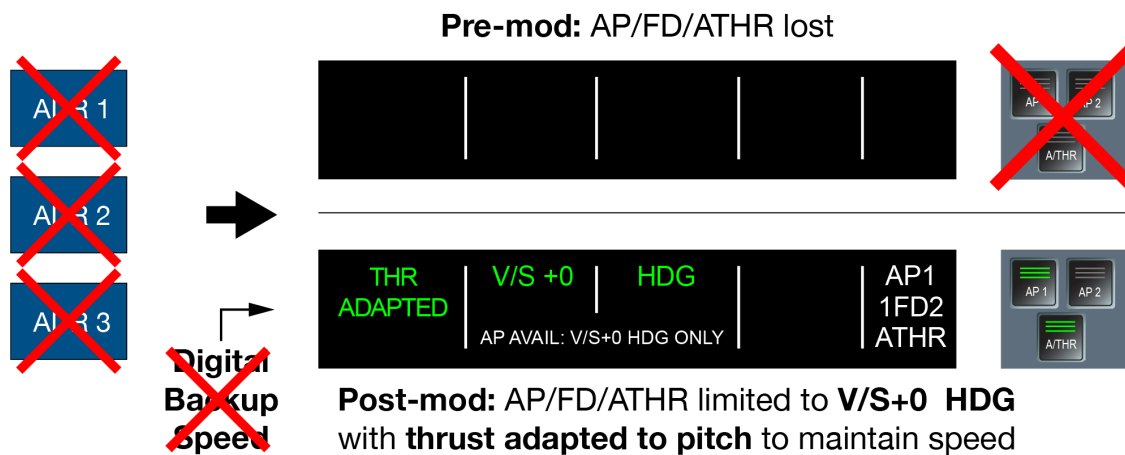
(fig.5) Enhanced autoflight robustness to triple air data failure



No air data available

If no air data is available, including the digital backup speed, the AP/FD/ATHR remains available in clean configuration, but it will be in a degraded mode that maintains the aircraft in level flight and heading only. The ATHR will adapt thrust to maintain the aircraft in the middle of the flight envelope. ■

(fig.6) Enhanced autoflight robustness to triple air data failure (digital backup speed not available)



Availability of the robustness to air data failures

A320	A330				A380
	% Fleet	Computer	Standard	Avail. date	
Not available	A330-900: 100%	FMGEC (Genepi hardware only)	H7	Available	Not available
		EIS2	L14		
		FWC	T9		
		FCPC	M30neo		

ENHANCED CREW AWARENESS

Unexpected events in flight require appropriate action from the flight crew. Examples of events include: Approach to stall, unreliable airspeed and excessive bank angle. When these situations occur, flight crews must apply recovery actions in a controlled and calm manner. Improved alerting cues and additional speed information will assist flight crews to manage these unexpected events.

These enhancements improve situational awareness and aid in assessing the situation quickly. With better awareness and assessment, flight crews can apply the correct procedures safely and more effectively.

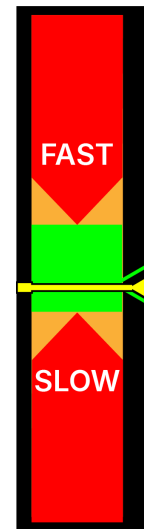
Digital Back-Up Speed/Altitude Display and Assistance to Speed Information Selection

In pre-mod configuration, the aircraft are equipped with a backup speed scale based on angle-of-attack value, providing speed information to the flight crew using color bands that they can use below FL 250 (fig.7).

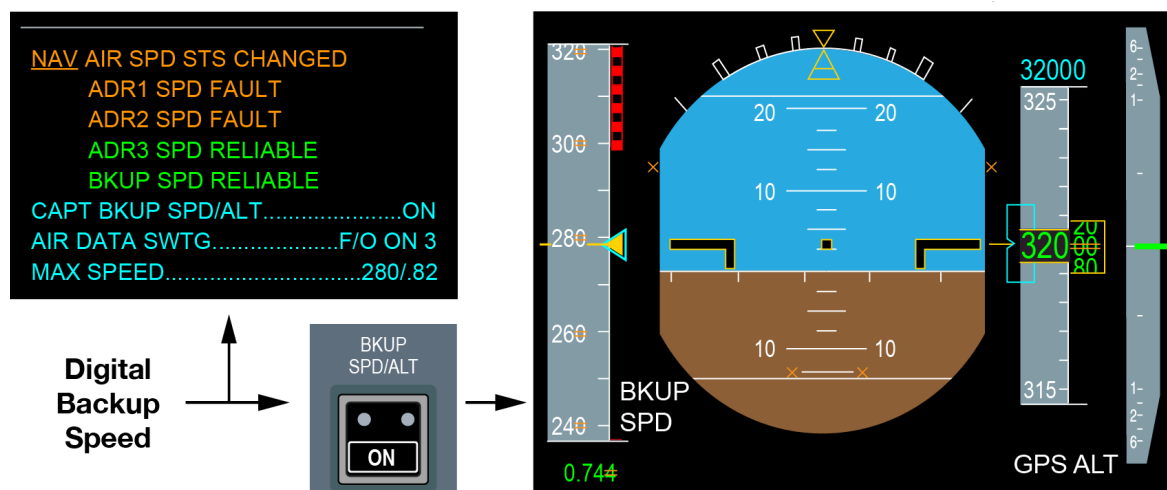
In post-mod configuration, the introduction of a digital backup speed (fig.8) computed with angle of attack value, aircraft weight and load factor provides an additional speed indication to the flight crew that can be displayed on the PFD when necessary. The digital backup speed has an accuracy of +/- 15 kt, which means that the last digit of the speedscale is shown with a strikethrough line on the PFD. The flight crew can display or remove the digital backup speed by pressing a dedicated pushbutton for each PFD.

As the majority of pitot freezing events observed in-flight are temporary in nature, the display of digital backup speed is reversible, which enables it to be switched off and revert to the anemometric speed if the ADR data is recovered and reliable.

The independent airspeed source provided by the digital back-up speed also enables additional monitoring of the data from the ADRs. An enhanced ECAM procedure provides a status of the speed data from the 3 ADRs and of the digital backup speed. It also provides guidance to the flight crew for selection of the correct air data and will request the flight crew to switch the digital backup speed indication to ON when necessary.



(fig.7) pre-mod backup speed scale



(fig.8) post-mod digital back-up speed indication and assistance to ADR switching

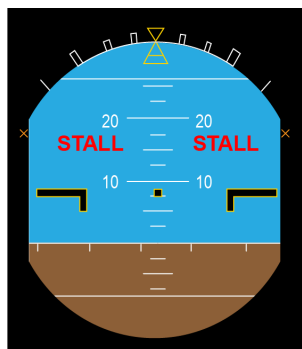
A380 aircraft: Same ADR monitoring and automatic airspeed switching as on A350 aircraft

On A380 aircraft, the same ADR monitoring function and automatic PFD airspeed display as on A350 aircraft will be available from Avionic batch 8.

Availability of the Digital Back-Up Speed/Altitude Display and Assistance to Speed Information Selection

A320				A330				A380		
% Fleet	Computer	Standard	Avail. date	% Fleet	Computer	Standard	Avail. date	% Fleet	Standard	Avail. date
45 %	FAC C	CAA13	Avail.	A330-900: 100%	FCPC	M28 neo	Avail.	100%	Avionic Batch 8	2027
	FWC	H2F13			FWC	T9				
	EIS2	S16			EIS2	L13				
	FDIMU	FS3.1			FDIMU	FL4				
	Wiring & Push buttons				FCDC	L27 HS				
					Wiring & Push buttons					

STALL message on PFD



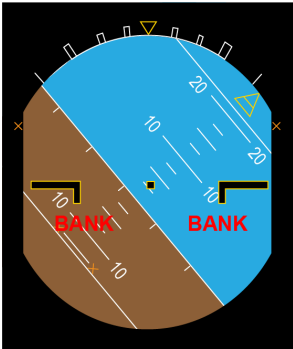
An update of the EIS introduces a visual red alert on the PFD in addition to the existing aural stall warning. This improves the warning of an approaching stall situation and alerts the flight crew that they must apply corrective or recovery actions to avoid the stall condition.

(fig.9) "STALL" message on the PFD

Availability of the STALL message on the PFD

A320				A330				A380			
% Fleet	Computer	Standard	Avail. date	% Fleet	Computer	Standard	Avail. date	% Fleet	Computer	Standard	Avail. date
100 % (12% with EIS1 LRU upgrade)	EIS	EIS2 S12 EIS1 V80	Avail	100%	EIS	EIS1 V114/V515 EIS2/EEIS L9E	Avail	100%	Basic		

Excessive Bank Angle Alert in Alternate and Direct Laws



This enhancement introduces a message on the PFD and a “**BANK BANK**” aural alert when the aircraft reaches an excessive bank angle (above 45°) in alternate and direct laws where no excessive bank angle protections are provided.

(fig.10) “BANK BANK” message on the PFD

Availability of the excessive bank angle alert in alternate and direct laws

This enhancement is available for all manufactured aircraft , or for retrofit on all of the existing A320 family and A330 aircraft fleets. However, aircraft fitted with EIS 1 standard will only have the audio alert. This enhancement was installed as standard (basic) on all A380 aircraft. ■

A320				A330				A380			
% Fleet	Computer	Standard	Avail. date	% Fleet	Computer	Standard	Avail. date	% Fleet	Computer	Standard	Avail. date
100% (12% EIS1 audio only)	FAC B hardware	Next standard	TBD	A330-800 & -900: 100%	FCPC	P17A/M28neo	Avail.	100%	Basic		
	FAC C hardware	CAA13	Avail.		FWC	T9-2					
	FWC	F13			EIS2	L13					
	EIS2	S16			FCDC	L27					

ENHANCED FLIGHT ENVELOPE PROTECTION AVAILABILITY

Enhancement of the flight envelope protection availability strengthens the third safety barrier that prevents LOC-I events.

Pitch Attitude Limitation in Alternate Law

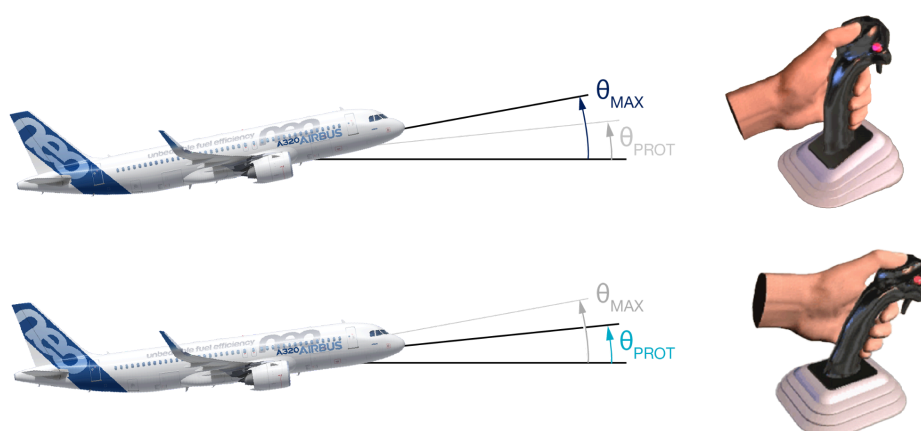
In pre-modification configuration, there is no flight envelope protection available for the pitch axis in alternate law.

In post modification configuration, a pitch angle limitation is available in alternate law when the aircraft is in clean configuration (fig.11). This prevents rapid speed decay, reducing the risk of going too far outside of the flight envelope. Two limitations are introduced:

- **θmax** is the maximum pitch angle that can be reached with the sidestick maintaining a pitch-up demand

- θ_{prot} is the maximum pitch angle that can be maintained with the sidestick in the neutral position.

Both maximum pitch angles vary as a function of altitude. Potential stall situations are therefore limited in case of inappropriate flight crew nose-up inputs.



(fig.11) Pitch attitude limitation in Alternate law

Availability of the pitch attitude limitation in alternate law

A320				A330				A380		
% Fleet	Computer	Std.	Avail. date	% Fleet	Computer	Std.	Avail. date	% Fleet	Std.	Avail. date
100 % (except A318)	ELAC	L104	Avail	A330-200 electrical rudder: 100 %	FCPC	P19	2025	100 %	Avionic Batch 8	2027

Flight envelope protections maintained in the case of yaw damping function loss on A320 family aircraft

In pre-mod configuration, in the case of a loss of the yaw damping function caused by **loss of both yaw dampers** or **loss of both FAC computers**, normal law and flight envelope protections are lost, leading to a reversion to Alternate law.

In post-mod configuration, the aircraft also reverts to Alternate law, but **the protections from the normal law remain available** with possible reduced efficiency due to the absence of yaw damping.

Availability of the maintained protections in case of yaw damping function loss

A320				A330	A380
% Fleet	Computer	Standard	Avail. date		
100% (except A318)	ELAC	L104	Avail	Not available	Not available

Avoid undue simultaneous FAC Resets on A320 family aircraft

In the case of a Rudder travel limiter fault on A320 aircraft, the ECAM procedure requests the flight crew to reset each FACs in a sequence to try to recover the function. The enhancement introduced improves the procedure by adding an "IF UNSUCCESSFUL:" line to make it more obvious to the flight crew to avoid performing simultaneous resets of the FACs, which results in a temporary loss of the normal law and its associated flight envelope protections.

Pre-mod

```
AUTO FLT AP OFF
AUTO FLT RUD TRV LIM SYS
RUD WITH CARE ABV 140 KT
- FAC 1 .....OFF THEN ON
- FAC 2 .....OFF THEN ON
```

Post-mod

```
AUTO FLT AP OFF
AUTO FLT RUD TRV LIM SYS
RUD WITH CARE ABV 140 KT
- FAC 1 .....OFF THEN ON
. IF UNSUCCESSFUL :
- FAC 2 .....OFF THEN ON
```

(fig.12) enhanced ECAM procedure to prevent simultaneous FAC reset

Availability of the enhanced AUTO FLT RUD TRV LIM SYS ECAM alert

A320				A330	A380
% Fleet	Computer	Standard	Avail. date		
100 %	FWC	F12	Avail	Not applicable	Not applicable

ENHANCEMENTS IMPLEMENTATION

Making these safety enhancements available is part of the continuous enhancement of all Airbus aircraft. The opportunity to implement these enhancements as a retrofit solution on the existing Airbus fleet is key to further prevention of LOC-I events. Airbus has several monitored retrofit campaigns to encourage and assist Operators to implement these enhancements for their operational aircraft.

Software provided free of charge

To facilitate the retrofit of these enhancements on the compatible aircraft, Airbus provides the software updates free of charge to Operators.

Limited grounding time

The software updates that introduce these enhancements can be done in a relatively short time, limiting the time of aircraft on ground and limiting the cost of labor hours.

For more information on the monitored retrofit campaign, please contact the Retrofit Operations team at monitored.retrofit@airbus.com.

Mixed Fleet considerations

Operators may have aircraft with different technical configurations that are not all compatible with the retrofit of certain enhancements. This should not prevent them from implementing the enhancement on their aircraft that are compatible. It is an essential step to take safety beyond the standard for those aircraft that are configured and capable of being retrofitted. This will enhance the overall safety resilience of the fleet.

Limited operational impact

All the listed enhancements have a limited operational impact since most of them are enhancement of the availability of already existing functions. The new displays, and new or updated procedures are described in the FCOM and QRH.

Limited training requirement

Analysis of the training requirements showed that either a **level A** (self Instruction) or **level B** (aided instruction) training is required to familiarize flight crews with these enhancements.

	Enhancements	Training level	Documentation Impact
Enhanced autoflight availability	Enhanced Autoflight Robustness to FMS Failures and LGCIU failures	B	FCOM, FCTM
	Enhanced Autoflight Robustness to Air Data Failures (Alternate AP)	B	FCOM, FCTM, AFM, QRH
Enhanced crew awareness	Digital Back-Up Speed (UAMM step 2)	B	FCOM, FCTM, QRH, AFM, MMEL
	Excessive Bank Angle Alert	A	FCOM, FCTM, AFM
	Stall message on PFD	A	FCOM
Enhanced flight envelope protections availability	Avoid undue simultaneous FAC Resets on A320 family aircraft	A	FCOM
	Pitch Attitude Limitation in Alternate Law (PALAL)	A	FCOM
	Flight envelope protections maintained in the case of yaw damping function loss on A320 family aircraft	A	FCOM

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Airbus has developed safety enhancements for the eligible A320 family, A330, and A380 aircraft to address Loss of Control In-flight (LOC-I) risks. The objective of these enhancements is to bring the entire Airbus fleet as close as possible with A350 safety standards with a focus on the three key areas of: Enhanced autoflight availability, improved flight crew awareness, and strengthened flight envelope protection.

Implementation of these enhancements on the aircraft with capable configurations are designed to allow retrofit with minimal operational impact, optimized costs of integration (e.g. software updates provided free-of-charge by Airbus), require limited additional crew training (Level A or B).

These enhancements enhance LOC-I prevention, which is why operators with partially compatible or mixed fleet configurations are encouraged to implement upgrades where possible, as the safety benefits outweigh any potential fleet inconsistencies.

By adopting these improvements, operators contribute to an increase in overall fleet safety. The enhancements are an essential step in taking safety beyond standard, through leveraging operational experience and technology to further prevent LOC-I events. Airbus has launched monitored retrofit campaigns, working with operators to implement these safety enhancements at the earliest opportunity, reinforcing our collective commitment to aviation safety.

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Safety first

The Airbus Safety magazine

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