

**Docket No. SA-532**

**Exhibit No. 2-X**

**NATIONAL TRANSPORTATION SAFETY BOARD**

**Washington, D.C.**

Operations/Human Performance Group Chairmen  
Airbus Flight Crew Operating Manual Volume 1  
Flight Controls  
Normal Law

(8 Pages)

## **Attachment 23**

**to Operations / Human Performance Group Factual Report**

**DCA09MA026**

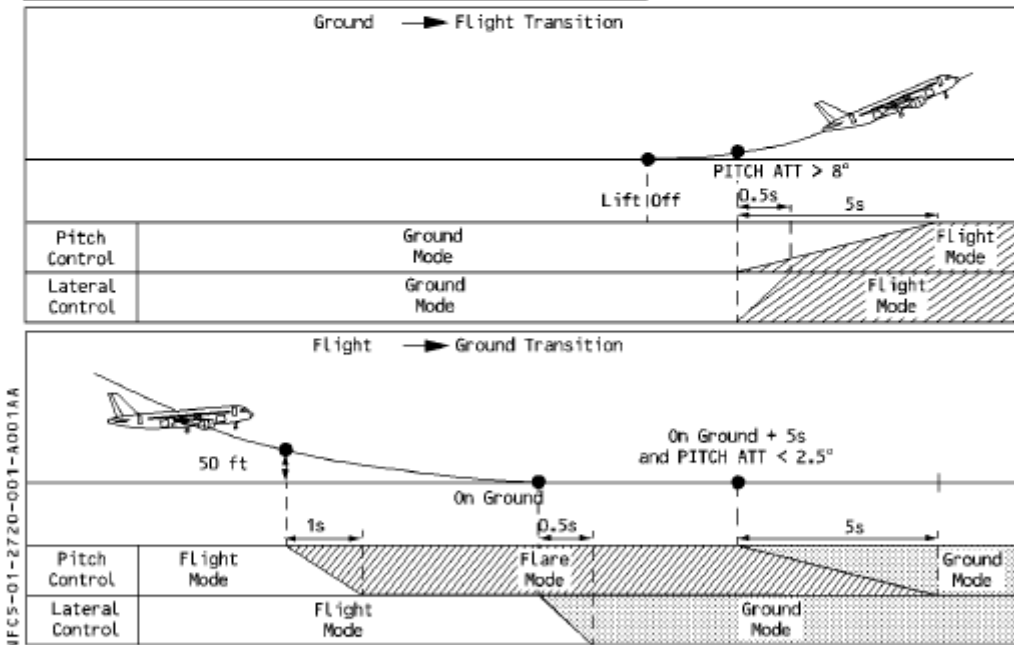
**AIRBUS FCOM 1.27.20  
FLIGHT CONTROLS  
NORMAL LAW**

**GENERAL**


- Flight control normal law covers :
- three-axis control
  - flight envelope protection
  - alleviation of maneuver loads

R

NORMAL LAW protection	Pitch Control			NORMAL LAW Protection	Lateral Control	
	Ground Mode	Flight Mode	Flare Mode		Ground Mode	Flight Mode
Pitch Attitude		×		Bank Angle		×
Load Factor		×				
High Speed		×				
High Angle Of Attack		×	×			



USA ALL

<b>A319/A320/A321</b>  <b>U.S AIRWAYS</b> <small>FLIGHT CREW OPERATING MANUAL</small>	<b>FLIGHT CONTROLS</b>  <b>NORMAL LAW</b>	1.27.20	P 2
		SEQ 103	REV 42

## PITCH CONTROL

### **GROUND MODE**

Ground mode is a direct relationship between sidestick deflection and elevator deflection, without auto trim.

It automatically sets the trimmable horizontal stabilizer (THS) at 0° (inside the green band). After landing, the automatic pitch trim resetting to 0° stops as soon as the pitch attitude exceeds 2.5°. In this case, the THS setting is frozen.

The automatic resetting to 0° restarts as soon as the pitch attitude goes below 2.5°.

A setting that the pilot enters manually to adjust for CG has priority for takeoff.

When the aircraft reaches 75 knots during the takeoff roll, the system reduces the maximum up elevator deflection from 30° to 20°.

### **FLIGHT MODE**

The normal-law flight mode is a load-factor-demand mode with automatic trim and protection throughout the flight envelope.

Following normal law, the sidestick controllers set the elevator and THS to maintain load factor proportional to stick deflection and independent of speed.

With the sidestick at neutral, wings level, the system maintains 1 g in pitch (corrected for pitch attitude), and there is no need for the pilot to trim by changing speed or configuration. Pitch trim is automatic both in manual mode and when the autopilot is engaged. In normal turns (up to 33° of bank) the pilot does not have to make any pitch corrections once the turn is established.


The flight mode is active from takeoff to landing, and follows the logic shown schematically on page 1, above.

Automatic pitch trim freezes in the following situations :

- The pilot enters a manual trim order.
- The radio altitude is below 50 feet (100 feet with autopilot engaged).
- The load factor goes below 0.5 g.
- The aircraft is under high-speed or high-Mach protection.

When angle-of-attack protection is active, the THS setting is limited between the setting at the aircraft's entry into this protection and 3.5° nose down. (Neither the pilot nor the system can apply additional nose-up trim).

Similarly, when the load factor is higher than 1.25 g or when the aircraft exceeds 33° of bank, the THS setting is limited to values between the actual setting and 3.5° nose down.

<b>A319/A320/A321</b>  <b>U.S AIRWAYS</b> <small>FLIGHT CREW OPERATING MANUAL</small>	<b>FLIGHT CONTROLS</b>  <b>NORMAL LAW</b>	1.27.20	P 3
		SEQ 001	REV 42

**Control with autopilot engaged**

- The ELACs and SECs limit what the autopilot can order.
- The pilot has to overcome a restraining force, in order to move the sidestick when the autopilot is engaged. If he overcomes this force, he disconnects the autopilot.
- The pilot can also disconnect the autopilot by pushing on the rudder pedals (10° out of trim), or by moving the pitch trim wheel beyond a certain threshold.
- All protections of normal laws remain effective except pitch attitude protection.

**FLARE MODE**

The flight mode changes to flare mode when the aircraft passes 50 feet RA as it descends to land.

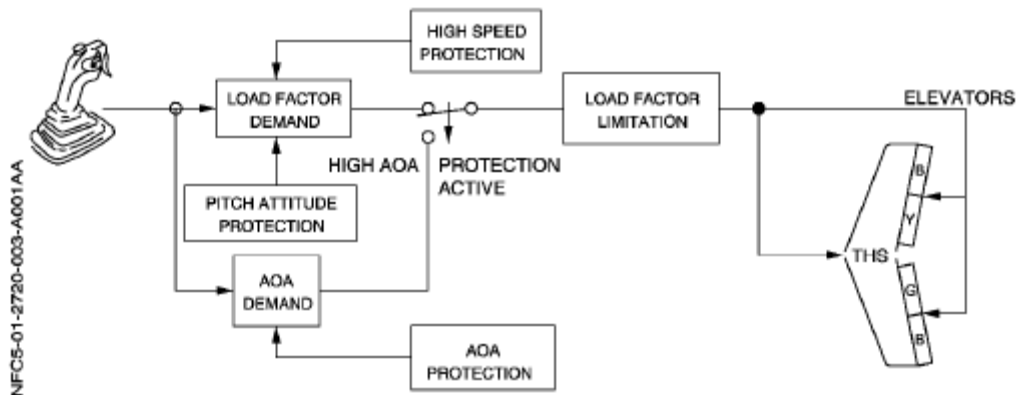
The system memorizes the attitude at 50 feet, and that attitude becomes the initial reference for pitch attitude control.

As the aircraft descends through 30 feet, the system begins to reduce the pitch attitude, reducing it to 2° nose down over a period of 8 seconds. This means that it takes gentle nose-up action by the pilot to flare the aircraft.

**PROTECTIONS**

The normal law protects the aircraft throughout the flight envelope, as follows :


- load factor limitation
- pitch attitude protection
- high-angle-of-attack (AOA) protection
- high-speed protection.



**LOAD FACTOR LIMITATION**

The load factor is automatically limited to :

- + 2.5 g to - 1 g for clean configuration.
- R + 2 g to 0 for other configurations.

<b>A319/A320/A321</b>  <b>U.S AIRWAYS</b> <small>FLIGHT CREW OPERATING MANUAL</small>	<b>FLIGHT CONTROLS</b>  <b>NORMAL LAW</b>	1.27.20	P 4
		SEQ 100	REV 42

## PITCH ATTITUDE PROTECTION

Pitch attitude is limited to :

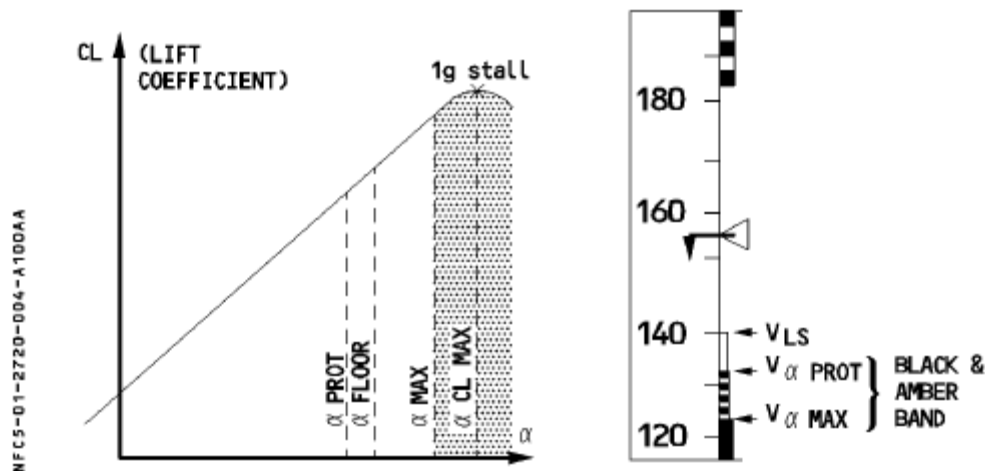
- 30° nose up in conf 0 to 3 (progressively reduced to 25° at low speed).
- 25° nose up in conf FULL (progressively reduced to 20° at low speed).
- 15° nose down (indicated by green symbols "=" on the PFD's pitch scale).

The flight director bars disappear from the PFD when the pitch attitude exceeds 25° up or 13° down. They return to the display when the pitch angle returns to the region between 22° up and 10° down.

## HIGH ANGLE OF ATTACK PROTECTION

Under normal law, when the angle of attack becomes greater than  $\alpha_{prot}$ , the system switches elevator control from normal mode to a protection mode, in which the angle of attack is proportional to sidestick deflection. That is, in the  $\alpha_{prot}$  range, from  $\alpha_{prot}$  to  $\alpha_{max}$ , the sidestick commands  $\alpha$  directly. However, the angle of attack will not exceed  $\alpha_{max}$ , even if the pilot gently pulls the sidestick all the way back. If the pilot releases the sidestick, the angle of attack returns to  $\alpha_{prot}$  and stays there.

This protection against stall and windshear has priority over all other protections. The autopilot disconnects at  $\alpha_{prot} + 1^\circ$ .



$V_{\alpha prot}$ ,  $V_{\alpha floor}$ ,  $V_{\alpha max}$  vary according to the weight and the configuration.


To deactivate the angle of attack protection, the pilot must push the sidestick :

- More than 8° forward, or
- More than 0.5° forward for at least 0.5 second, when  $\alpha < \alpha_{max}$ .

In addition, below 200 feet, the angle of attack protection is also deactivated, when :

- Sidestick deflection is less than half nose-up, and

R - Actual  $\alpha$  is less than  $\alpha_{prot} - 2^\circ$ .

<b>A319/A320/A321</b>  U-S AIRWAYS <small>FLIGHT CREW OPERATING MANUAL</small>	<b>FLIGHT CONTROLS</b>  NORMAL LAW	1.27.20	P 5
		SEQ 001	REV 42

- Note : 1. At takeoff,  $\alpha_{prot}$  is equal to  $\alpha_{max}$  for 5 seconds.  
 2.  $\alpha_{floor}$  is activated through the A/THR system, when :
- $\alpha$  is greater than  $\alpha_{floor}$  ( $9.5^\circ$  in configuration 0;  $15^\circ$  in configuration 1, 2;  $14^\circ$  in configuration 3 ;  $13^\circ$  in configuration FULL), or
  - Sidestick deflection is greater than  $14^\circ$  nose up, with either the pitch attitude or the angle-of-attack protection active.
- The  $\alpha_{floor}$  function is available from lift-off to 100 feet RA before landing.

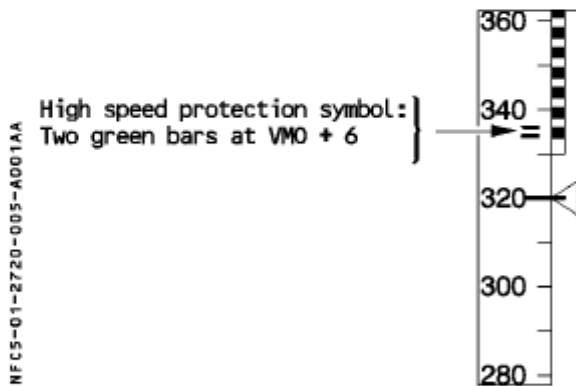
### HIGH-SPEED PROTECTION

The aircraft automatically recovers following a high speed upset. Depending on the flight conditions (high acceleration, low pitch attitude), the High Speed Protection is activated at/or above VMO/MMO.

When it is activated, the pitch trim is frozen. Positive spiral static stability is introduced to  $0^\circ$  bank angle (instead of  $33^\circ$  in normal law), so that with the sidestick released, the aircraft always returns to a bank angle of  $0^\circ$ . The bank angle limit is reduced from  $67^\circ$  to  $40^\circ$ . As the speed increases above VMO/MMO, the sidestick nose-down authority is progressively reduced, and a permanent nose-up order is applied to aid recovery to normal flight conditions.

The High Speed Protection is deactivated when the aircraft speed decreases below VMO/MMO, where the usual normal control laws are recovered.


The autopilot disconnects when high speed protection goes active.



Note : The ECAM displays an "O/SPEED" warning at VMO + 4 knots and MMO + 0.006.

### LOW ENERGY WARNING

The low energy warning is computed by the FAC, see 1.22.40.

<b>A319/A320/A321</b>  <b>U.S AIRWAYS</b> <small>FLIGHT CREW OPERATING MANUAL</small>	<b>FLIGHT CONTROLS</b>  <b>NORMAL LAW</b>	1.27.20	P 6
		SEQ 001	REV 40

**LATERAL CONTROL**

**NORMAL LAW**

When the aircraft is on the ground (in "on ground" mode), the sidestick commands the aileron and roll spoiler surface deflection. The amount of control surface deflection that results from a given amount of sidestick deflection depends upon aircraft speed. The pedals control rudder deflection through a direct mechanical linkage. The aircraft smoothly transitions to "in flight" mode shortly after liftoff.

When the aircraft is in the "in flight" mode, normal law combines control of the ailerons, spoilers (except N° 1 spoilers), and rudder (for turn coordination) in the sidestick. While the system thereby gives the pilot control of the roll and heading, it also limits the roll rate and bank angle, coordinates the turns, and damps the dutch roll.

The roll rate requested by the pilot during flight is proportional to the sidestick deflection, with a maximum rate of 15° per second when the sidestick is at the stop.

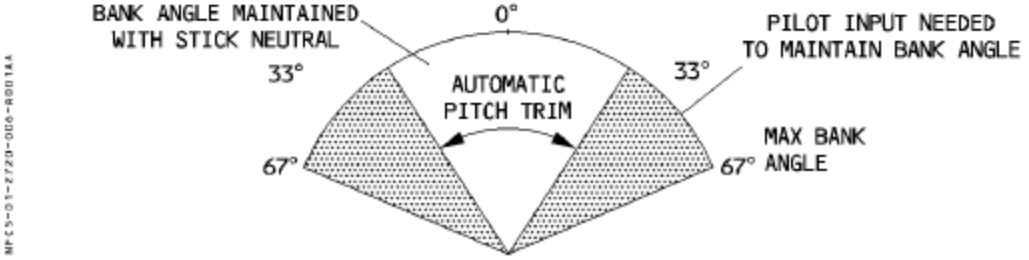
When the aircraft is in "flare" mode, the lateral control is the same as in "in flight" mode. After touchdown, the aircraft smoothly transitions from "in flight" mode to "ground" mode.

**BANK ANGLE PROTECTION**


Inside the normal flight envelope, the system maintains positive spiral static stability for bank angles above 33°. If the pilot releases the sidestick at a bank angle greater than 33°, the bank angle automatically reduces to 33°. Up to 33°, the system holds the roll attitude constant when the sidestick is at neutral. If the pilot holds full lateral sidestick deflection, the bank angle goes to 67° (indicated by a pair of green bar lines "=" on the PFD) and no further.

If Angle-of-Attack protection is active, and the pilot maintains full lateral deflection on the sidestick, the bank angle will not go beyond 45 degrees. If High Speed Protection is active, and the pilot maintains full lateral deflection on the sidestick, the bank angle will not go beyond 40 degrees. If high speed protection is operative, the system maintains positive spiral static stability from a bank angle of 0°, so that with the sidestick released, the aircraft always returns to a bank angle of 0°.


When bank angle protection is active, auto trim is inoperative. If the bank angle exceeds 45°, the autopilot disconnects and the FD bars disappear. The FD bars return when the bank angle decreases to less than 40°.





<b>A319/A320/A321</b>  <b>U-S AIRWAYS</b> FLIGHT CREW OPERATING MANUAL	<b>FLIGHT CONTROLS</b>  NORMAL LAW	1.27.20	P 7
		SEQ 100	REV 24

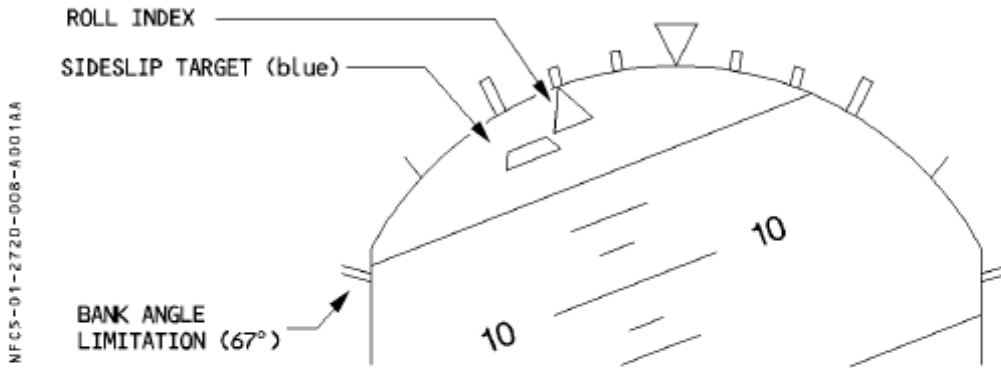
**INTENTIONALLY LEFT BLANK**

<b>A319/A320/A321</b>  <b>U.S AIRWAYS</b> <small>FLIGHT CREW OPERATING MANUAL</small>	<b>FLIGHT CONTROLS</b>  <b>NORMAL LAW</b>	1.27.20	P 8
		SEQ 001	REV 40

**SIDESLIP TARGET**

If one engine fails, the FAC modifies the sideslip indication slightly to show the pilot how much rudder to use to get the best climb performance (ailerons to neutral and spoilers retracted).

In the case of an engine failure at takeoff, or at go-around, the sideslip index on the PFD changes from yellow to blue (Refer to 1.31.40 that provides the conditions for the blue display of the sideslip target).



- R In flight, the lateral normal law commands some rudder surface deflection to minimize the sideslip. The pilot's response is normal and instinctive : zero the slip indication by applying the right amount of rudder to get the best climb performance.
- R