AIRBUS FLIGHT CONTROL LAWS		

As I use to say, "Never say no, there is always a chance"
- Bruno Mecha -

High AOA Protection	Load Factor Limitation	Pitch Attitude Protection
NORMAL LAW		
High Speed Protection	Flight Augmentation (Yaw)	Bank Angle Protection

Low Speed Stability	Load Factor Limitation	
ALTERNATE LAW		
High Speed Stability	Yaw Damping Only	

	Load Factor Limitation	
ABNORMAL ALTERNATE LAW w/o Speed Stability		
	Yaw Damping Only	

DIRECT LAW		

FLIGHT CONTROL LAWS SUMMARY	
NORMAL LAW	
Normal operating configuration of the system. Failure of any single computer does not affect normal law. **Covers 3-axis control, flight envelope protection, and load alleviation. Has 3 modes according to phase of flight.**	
Ground Mode	- Active when aircraft is on the ground. - Direct proportional relationship between the sidestick deflection and deflection of the flight controls. - Is active until shortly after liftoff. - After touchdown, ground mode is reactivated and resets the stabilizer trim to zero.
Flight Mode	- Becomes active shortly after takeoff and remains active until shortly before touchdown. - Sidestick deflection and load factor imposed on the aircraft are directly proportional, regardless of airspeed. - With sidestick neutral and wings level, system maintains a 1 g load in pitch. - No requirement to change pitch trim for changes in airspeed, configuration, or bank up to 33 degrees. - At full aft/fwd sidestick deflection system maintains maximum load factor for flap position.

	- Sidestick roll input commands a roll rate request. - Roll rate is independent of airspeed. - A given sidestick deflection always results in the same roll rate response. - Turn coordination and yaw damping are computed by the ELACs and transmitted to the FACs. - No rudder pedal feedback for the yaw damping and turn coordination functions.
Flare Mode	- Transition to flare mode occurs at 50' RA during landing. - System memorizes pitch attitude at 50' and begins to progressively reduce pitch, forcing pilot to flare the aircraft - In the event of a go-around, transition to flight mode occurs again at 50' RA.
Protections	**Load factor Limitation** - Prevents pilot from overstressing the aircraft even if full sidestick deflections are applied. **Attitude Protection** - Pitch limited to 30 deg up, 15 deg down, and 67 deg of bank. - These limits are indicated by green = signs on the PFD. - Bank angles in excess of 33 deg require constant sidestick input. - If input is released the aircraft returns to and maintains 33 deg of bank. **High Angle of Attack Protection (alpha):** - When alpha exceeds alpha prot, elevator control switches to alpha protection mode in which angle of attack is proportional to sidestick deflection. - Alpha max will not be exceeded even if the pilot applies full aft deflection **High Speed Protection:** - Prevents exceeding V_{MO} or M_{MO} by introducing a pitch up load factor demand. - The pilot can NOT override the pitch up command. **Low Energy Warning:** - Available in CONF 2,3, or FULL between 100' and 2,000' RA when TOGA not selected. - Produces aural "SPEED SPEED SPEED" when change in flight path alone is insufficient to regain a positive flight path (Thrust must be increased).

ALTERNATE LAW
If *Multiple Failures of Redundant Systems* occur, the flight controls revert to Alternate Law. **The ECAM displays the message: ALTN LAW: PROT LOST**

Ground Mode	The ground mode is identical to Normal Law.
Flight Mode	- In pitch alternate law the flight mode is a load factor demand law similar to the Normal Law flight mode, with reduced protections. - Pitch alternate law degrades to pitch direct law when the landing gear is extended to provide feel for flare and landing, since there is no flare mode when pitch normal law is lost. - Automatic pitch trim and yaw damping (with limited authority) is available. - Turn coordination is lost.

	• When pitch law degrades from normal law, roll degrades to Direct Law - roll rate depends on airspeed.

Protections	• All protections except for load factor maneuvering protection are lost.
	• The load factor limitation is similar to to that under Normal Law.
	• Amber **XX's** replace the green = attitude limits on the PFD.
	• A low speed stability function replaces the normal angle-of-attack protection
	    ○ System introduces a progressive nose down command which attempts to prevent the speed from decaying further.
	    ○ This command CAN be overridden by sidestick input.
	    ○ **The airplane CAN be stalled in Alternate Law.**
	    ○ An audio stall warning consisting of "crickets" and a "STALL" aural message is activated.
	    ○ The Alpha Floor function is inoperative.
	• The PFD airspeed scale is modified:
	    ○ V_{LS} remains displayed
	    ○ $V_{ALPHA\ PROT}$ and $V_{ALPHA\ MAX}$ are removed
	    ○ They are replaced by a red and black barber pole, the top indicating the stall warning speed V_{SW}
	• A nose up command is introduced any time the airplane exceeds V_{MO}/M_{MO} to keep the speed from increasing further, which CAN be overridden by the sidestick.
	• Bank angle protection is lost.
	• Certain failures cause the system to revert to Alternate Law without speed stability.
	• Yaw damping is lost if the fault is a triple ADR failure.

ABNORMAL ALTERNATE LAW
Abnormal Alternate Law is activated if the airplane enters an unusual attitude, allowing recovery from the unusual attitude.

	• Pitch law becomes Alternate (without autotrim or protection other than Load Factor protection).
	• Roll law becomes Direct law with mechanical yaw control.
	• After recovery from the unusual attitude, the following laws are active for the remainder of the flight:
	    ○ Pitch: Alternate law without protections and with autotrim.
	    ○ Roll: Direct law
	    ○ Yaw: Alternate law
	• There is no reversion to Direct law when the landing gear is extended.

DIRECT LAW
Direct law is the lowest level of computer flight control and occurs with certain multiple failures.

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	• Pilot control inputs are transmitted unmodified to the control surfaces, providing a direct relationship between sidestick and control surface. • Control sensitivity depends on airspeed and NO autotrimming is available. • An amber message **USE MAN PITCH TRIM** appears on the PFD. • If the flight controls degrade to Alternate Law, Direct Law automatically becomes active when the landing gear is extended if no autopilots are engaged. If an autopilot is engaged, the airplane will remain in Alternate Law until the autopilot is disconnected. • There are no protections provided in Direct Law, however overspeed and stall aural warnings are provided. • The PFD airspeed scale remains the same as in Alternate Law.

MECHANICAL BACKUP
In case of a complete loss of electrical flight control signals, the aircraft can be temporarily controlled by mechanical mode.

	• Pitch control is achieved through the horizontal stabilizer by using the manual trim wheel.

	• Lateral control is accomplished using the rudder pedals. • Both controls require hydraulic power. • A red **MAN PITCH TRIM ONLY** warning appears on the PFD.
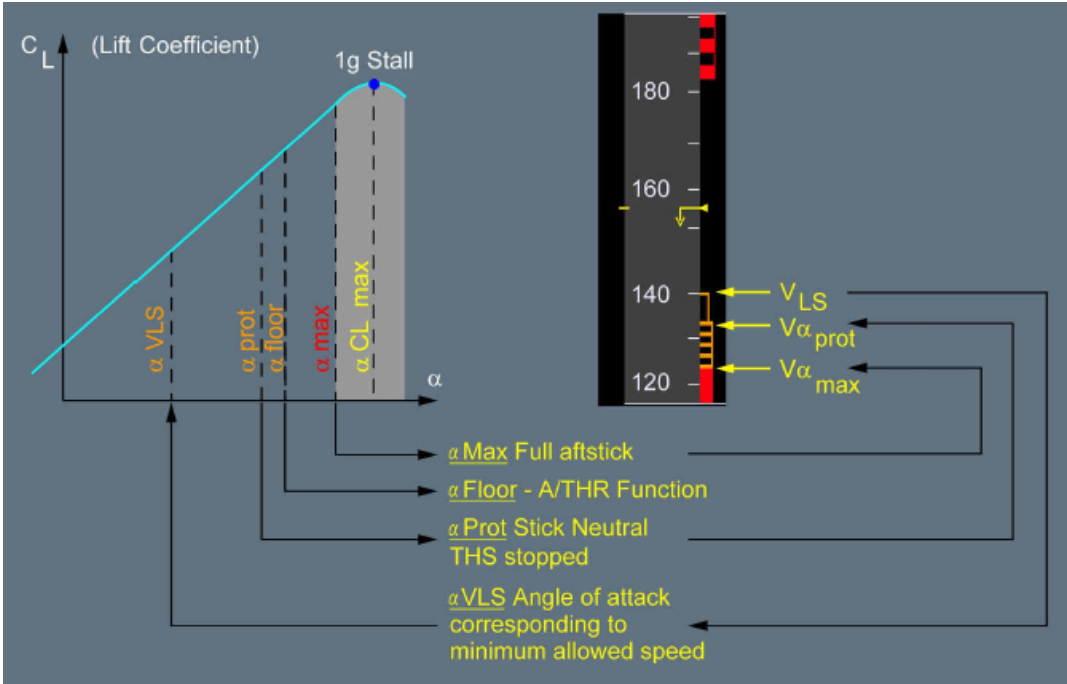
⑨ A319/A320/A321 normal law – pitch axis

- Manoeuvre demand law as basic flight mode

  - neutral speed stability with full flight envelope protection

- Vertical load factor control proportional to stick deflection : C* law

  - independent of speed, weight, center of gravity ;

    stick displacement :　　$\Delta N_z = n$　　$N_z = n + 1g$

    stick neutral :　　　　　$\Delta N_z = O$　　$N_z = 1g$

- Flight path stability instead of speed stability

  - control inputs are made to alter the flight path, not to hold it.

- Medium-term flight path stability :

  - maintenance of parallel trajectory 1g in pitch even after atmosphere disturbance.

- Automatic pitch trim eliminating need to correct for speed or configuration changes :

  - electric autotrim function holding elevator position for constant flight path,
  - control surface autotrim function returning elevators to the THS trail.

- Automatic elevator for bank angle compensation up to 33°.

⑨ A319/A320/A321 normal law – pitch axis

● Adaptation of basic control law objectives to :

- Ground phase : **ground mode**

  Direct relationship between stick and elevator available before lift-off and after touch-down

- Take-off phase : **take-off mode**

  For smooth transition, blend of ground phase law and N_z command law over 5 seconds after lift off.

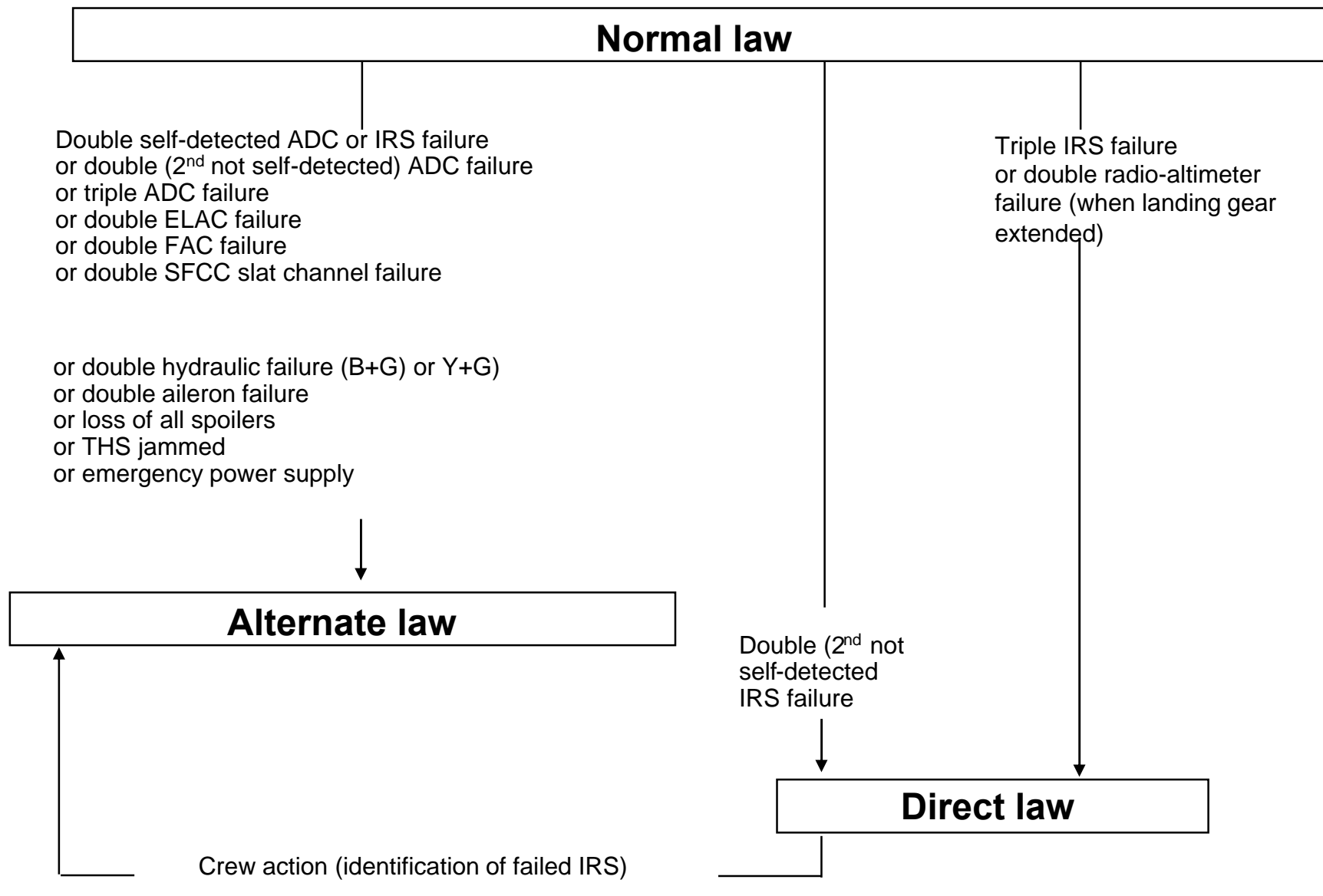- Landing phase : **landing mode**

  At 50ft the attitude is memorized as reference pitch attitude.

  At 30ft this value is progressively reduced to 2° nose down to induce gentle positive pilot action for a conventional flare.

A319/A320/A321 normal law – roll and yaw axes

- Roll rate demand (15° / Sec max.) as basic flight mode :

- Coordinated roll and yaw surfaces deflections :

  - to achieve and maintain bank angle up to 33°, stick released

- Bank angle protection above 33° :

  - positive spiral stability restored up to 67° inside normal flight envelope
  - limit of 67° bank angle

- Lateral control laws providing handling quality features such as :

  - bank angle resistance to disturbance, stick free,
  - precise piloting
  - good turn coordination,
  - dutch roll damping,
  - sideslip minimization.

- Sidestick free with pedal deflection results in stabilized sideslip and bank angle facilitating "de-crabbing" in crosswind landings.

- Engine failure or aircraft asymmetry compensation consisting of :

  - If no pilot action :
    - stabilized sideslip and bank angle followed by,
    - automatic rudder trimming to compensate asymmetric thrust
    - slowly diverging heading.

  - Recommended action :
    - zero sideslip target with pedals (take-offf, go-around),
    - heading stabilization with stick input,
    - steady flight stick free / no pedal forces (rudder trim).

- Adaptation of basic control law objectives to :

  - Ground phase : **ground mode**
    - Direct relationship between stick and roll control surfaces
    - Rudder : mechanical control from pedals + yaw damper function

- Transition from **ground to in-flight law** (and vice versa)
  Switching over in 0.5 second after lift-off or touch-down.

A319/A320/A321 control laws – reconfiguration logics

Normal law

Double self-detected ADC or IRS failure
or double (2nd not self-detected) ADC failure
or triple ADC failure
or double ELAC failure
or double FAC failure
or double SFCC slat channel failure

or double hydraulic failure (B+G) or Y+G)
or double aileron failure
or loss of all spoilers
or THS jammed
or emergency power supply

Triple IRS failure
or double radio-altimeter
failure (when landing gear
extended)

Alternate law

Double (2nd not
self-detected
IRS failure

Direct law

Crew action (identification of failed IRS)

A319/A320/A321 alternate law

- Flight mode as basic control laws :

  - pitch axis : as normal law, stick deflection to change N_z,
  - roll/yaw axes : direct stick-to-roll-surface relationship, speed, configuration and surface availability dependent,
  - automatic pitch trim.

- Loss of flight envelope protections except :

  - manoeuvre protection against excessive load factor
  - low speed stability
  - conventional aural stall and overspeed warning

- Reversion of basic control law :

  - alternate law not being adapted to landing phase - automatic reversion to direct law after landing gear extension.

- Automatic reconfigurations after loss of basic control law in either axis.

A319/A320/A321 direct law and mechanical back-up

Direct law

- On all axes :

  - direct stick to elevator or roll control surface relationship,
  - center of gravity, configuration and surface availability dependent.

- Manual trimming through trim wheel :

  - amber message on PFD ("USE MAN PITCH TRIM")

- Loss of all flight envelope protections :

  - conventional aural stall and overspeed warning.

- Automatic reconfiguration after loss of basic control law in either axis.

Mechanical back-up

- Highly improbable operational necessity.

- To sustain the aircraft during a temporary complete loss of electrical power.

- Longitudinal control of the aircraft through trim wheel. Elevators kept at zero deflection..

- Lateral control from pedals.

- Manual trimming through trim wheel :

  - red message on PFD ("MAN PITCH TRIM ONLY")