

# A330 FLIGHT LAWS

PROTECTIONS	PITCH ATTITUDE <sup>1</sup>	LOAD FACTOR <sup>2</sup>	AOA <sup>3</sup>	HIGH SPEED <sup>4</sup>	LOW ENERGY <sup>5</sup>	LOW SPEED STABILITY <sup>6</sup>	HIGH SPEED STABILITY <sup>7</sup>	ANGLE OF BANK <sup>8</sup>	MAN'UVER LOAD ALLEVIATION <sup>9</sup>	TURBULENCE DAMPING <sup>10</sup>	YAW DAMPING	TURN COORD <sup>11</sup>
NORMAL LAW <sup>12</sup>	✓	✓	✓	✓	✓	NOT REQUIRED	NOT REQUIRED	✓	✓	✓	✓	✓
ALTERNATE LAW 1 <sup>13</sup>	PROTECTION LOST	✓	(a)	PROTECTION LOST	PROTECTION LOST	✓	✓	✓ <sup>14</sup>	✓	PROTECTION LOST	✓ <sup>15</sup>	✓
ALTERNATE LAW 2 <sup>16</sup>	PROTECTION LOST	✓	(a) <sup>17</sup>	PROTECTION LOST	PROTECTION LOST	✓ <sup>18</sup>	✓ <sup>19</sup>	PROTECTION LOST	✓	PROTECTION LOST	DEGRADED <sup>20</sup>	DEGRADED <sup>21</sup>
DIRECT LAW <sup>22</sup>	PROTECTION LOST	PROTECTION LOST	(a) <sup>23</sup>	PROTECTION LOST	PROTECTION LOST	✓ <sup>24</sup>	✓ <sup>25</sup>	PROTECTION LOST	PROTECTION LOST	PROTECTION LOST	DEGRADED	PROTECTION LOST
MECH BACKUP <sup>26</sup>	NO PROTECTIONS AVAILABLE											

(a) alpha floor is lost. AOA is still monitored but warnings relate now to stall speed rather than AOA. Refer LOW SPEED STABILITY. If VS1G cannot be calculated due to loss of weight or slat/flap position information then there is no AOA protection at all.

 = PROTECTION LOST

## **ABNORMAL ATTITUDE FLIGHT LAW**

A completely different law emerges automatically when the aircraft is in an extreme upset as follows:

- \* pitch attitude > 50 deg nose up or > 30 deg nose down
- \* bank angle > 125 deg
- \* AOA > 30 deg or >-10 deg
- \* speed > 440 kts or < 60 kts
- \* mach > M0.96 or < M0.1

The abnormal attitude law is:

- PITCH ALTERNATE with no protection except LOAD FACTOR protection. No automatic pitch trim.
- ROLL DIRECT with full authority
- YAW ALTERNATE

After recovery the flight law reverts to:

- PITCH ALTERNATE law
- ROLL DIRECT law
- YAW ALTERNATE

The aircraft returns to a degraded mode (not normal law as usual) because there is a certain level of suspicion about its ability to control the aircraft (that is how could it have got to the extreme flight state in the first place? The protections should have intervened well before the pitch, bank, AOA, speed and mach limits above).

## NOTES

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- <sup>1</sup> Limited to 30 degrees nose up (reducing to 25 degrees nose up at low speed) and 15 degrees nose down
- <sup>2</sup> Limited to +2.5G and -1G with slats retracted. Limited to +2G and 0G with slats extended
- <sup>3</sup> Between alpha prot and alpha max, the sidestick commands AOA directly. Autopilot disconnects. TOGA lock is activated when AOA reaches alpha floor. This protection never allows alpha max to be exceeded. Stall AOA is greater than alpha max
- <sup>4</sup> When speed goes above VMO + 4 kts / MMO + M0.006 the autopilot disconnects and nose up input is made by the envelope control system. Bank angle is automatically limited to 45 degrees (instead of 67 degrees)
- <sup>5</sup> Available in CONF 2, 3 or FULL between 100' and 2,000' RA. Inhibited below 100' RA or when both RA's failed. "SPEED SPEED SPEED" repeated every 5 seconds until aircraft energy (speed and thrust combination) is increased. AOA protection still underpins this protection in NORMAL LAW. Also inhibited when TOGA selected, Alpha-floor or GPWS triggered.
- <sup>6</sup> An automatic nose down command is introduced to increase speed. No reference to AOA, only speed. Operates 5 to 10 kts above stall warning depending on weight & slat/flap configuration. The pilot can override.  
"STALL" announces and crickets heard prior to stall speed being reached. PFD shows black and red barber's pole for stall warning speed. V-apha-prot and V-alpha-max are replaced by Vsw (stall warning speed). No alpha-floor protection is available.
- <sup>7</sup> An automatic nose up command is introduced to decrease speed. The pilot can override. Although the VMO+4 protection symbol disappears the overspeed warning at VMO+4 or MMO+0.006 remains active.
- <sup>8</sup> Up to 33 degrees normal. 34 to 67 degrees permitted but sidestick required to hold the angle of bank. Pitch input required to maintain altitude when above 33 degrees AOB
- <sup>9</sup> Utilises spoilers 4, 5 and 6 and the ailerons to unload the wings when the load factors is more than 2G and the sidestick is pulled past 8 degrees, speed is above 250 kts (IAS), FLAP lever position ZERO. Elevator compensation is also included because of spoiler rise. MLA takes priority over other speedbrake functions.
- <sup>10</sup> Adds commands to elevator and yaw damper unit to null out structural modes induced by turbulence. Operates when a/c is above 200 kts, autopilot is engaged and aircraft within the normal flight envelope.
- <sup>11</sup> Turn coordination only with AOB less than 33 degrees
- <sup>12</sup> Ground mode (sidestick controls elevator directly – no auto-trim. Sidestick controls ailerons/spoilers for roll directly – deflection proportional to speed. Rudder pedals control rudder deflection directly - mechanically), Flight mode (sidestick is load factor demand with full auto-trim. Sidestick controls ailerons/spoilers – not No.1 spoiler - for a given roll rate: maximum 15 deg per second. Turn coordination and dutch roll damping provided), Flare mode (sidestick controls elevator directly with some damping provided by load factor and pitch-rate feedbacks). At 50' a slight pitch down elevator is introduced so as pilot has to move the stick rearwards to maintain a constant path – reproduces conventional aircraft aerodynamics. In flare mode, roll control is as in flight mode.
- <sup>13</sup> ALTERNATE 1 has ROLL as in NORMAL LAW. Positive spiral static stability is lost due lost high AOA protection and lost high speed protection. Pitch is as in normal law except with limited pitch rate feedback and gains (proportional to speed & configuration).
- <sup>14</sup> X still displayed on the PFD at 67 degrees even though bank angle protection active in ALT1
- <sup>15</sup> If yaw dampers not available then yaw damping is achieved with the back-up yaw damper unit (BYDU) and ailerons. Eliminates dutch roll also.
- <sup>16</sup> ALTERNATE 2 has ROLL as in DIRECT LAW. Gains proportional to slat/flap setting. Roll rate limited to between 20 and 25 deg (proportional to slat/flap config). Spoilers 2,3 & 6 are inhibited unless other failures are affecting lateral control.
- <sup>17</sup> Protection totally lost if DUAL ADR failure or ADR disagree.
- <sup>18</sup> If dual ADR failure then low speed stability is lost
- <sup>19</sup> If triple ADR failure then high speed stability is lost
- <sup>20</sup> Dutch roll damping still available. Damper authority limited to +/- 4 deg of rudder (CONF 0) and +/- 15 deg of rudder (other slat/flap configuration).
- <sup>21</sup> Turn coordination does not work in CONFIG 0 (not needed at high speeds anyway)
- <sup>22</sup> ROLL is direct. Pitch law is direct (direct elevator control). Maximum elevator deflection depends on CofG. YAW is alternate. "USE MAN PITCH TRIM" in amber on both PFDs. High and low speed stability as per ALTERNATE 2. Pitch law reverts to same as MECH BACKUP (MAN PITCH TRIM ONLY in red on PFDs) if L+R ELEV fault detected.
- <sup>23</sup> Note: Vsw = stall warning speed
- <sup>24</sup> Lost if DUAL ADR FAILURE
- <sup>25</sup> Lost if TRIPLE ADR FAILURE
- <sup>26</sup> "MAN PITCH TRIM ONLY" displayed in red on both PFDs. The -300 has a Backup Control Module (BCM) computer which provides yaw damping and direct rudder command with pedals (that's why the -300 rudder pedals feel different to the -200). This computer has its own electrical generator which is supplied by the B or Y hydraulic system.