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SATA International Virtual

Flight Techniques Manual

AIRBUS A320-200

Index

Introduction

Launched in 1984, the A320 entered airline service in April 1988 and rapidly established itself as the industry standard for passenger comfort and economy on short and medium-haul routes. Typically seating 150 passengers in two classes with a range of up to 5,700km/3,050nm, the A320 is in widespread service on six continents.

Designed to optimise revenue through passenger comfort and cabin adaptability as well as ensure savings in every element of direct operating cost, the A318, A319, A320 and A321 make up the world's most profitable single-aisle aircraft family. They provide operators with the highest degree of commonality and economy for aircraft in the 100-220 seat category.

The Airbus A320 cabin is the widest of any single-aisle aircraft, allowing SATA International to install wider seats for greater passenger comfort without compromising capacity. The single-aisle arrangement of the Airbus A320 allows for a flexible six-abreast configuration in Economy Class.

The twin-engine A319, A320 and A321 can be powered by either CFM International CFM56 or International Aero Engines V2500 engines, while the A318 is offered with CFM56 engines or Pratt & Whitney PW6000 engines.

The Airbus A320 is the world's first commercial airliner to incorporate a fly by wire (FBW) digital flight control system. This technology replaces traditional flight instrument gauges with digital display panels. Other changes resulting from the fly by wire system include the use of side-stick controllers in place of conventional control columns (yokes).

Building on the proven success of the A320, Airbus has since applied fly by wire technology to all its subsequent offerings. This allows the different classes of Airbus aircraft to maintain the same flight deck layout and possess similar handling qualities. As a result, minimal training is required when A320 pilots are re-assigned to fly other classes of Airbus aircraft.

The A320-200 fleet, attempt to simulate the more realastic possible the real airline fleet, the respective procedures and operations.

Characteristics

A320

Aircraft dimensions

	ft	m
Overall Length	123ft 3in	37,57m
Cabin Length	90ft 3in	27,50m
Fuselage Diameter	13ft 0in	3,96m
Max. Cabin Width	12ft 1in	3,70m
Height	38ft 7in	11,76m
Wheelbase	41ft 6in	12,65m
Track	24ft 11in	7,59m

Wing dimensions

	ft	m
Wing Span (geometric)	111ft 10in	34,09m
Wing Area (reference)	1320ft^2	122,6m^2
Sweep (25% chord)	25 degrees	

Design weights

	lb X 1000	tonnes
Max. Ramp Weight	162,9 (170,6)	73,9 (77,4)
Max. Take-off Weight	162,0 (169,8)	73,5 (77)
Max. Landing Weight	142,2 (145,5)	64,5 (66,0)
Max. Zero fuel Weight	134,5 (137,8)	61,0 (62,5)
Max. fuel Capacity		6 300 (7 835) USg 23 860 (29 660) Litres
Typical operating Weight Empty	90,4	41,0
Typical Volumetric Payload	35,9	16,3

Basic operating data

Powerplants	two CFM56-5 or IAE V2500
Thrust Range	22 000-27 000 lb slst
Typical Seating (two class)	150
Range (max. pax)	2 650 (3 050)nm 4 900 (5 700)km
Max. Operating Mach n° (Mmo)	0,82Mo
Containers Capacity Underfloor	Four LD3-46/46W
Bulk Hold Volume - Standard/Option	1 322ft3 37,42m3
Total Volume (LD3 + Bulk)	978 (1 097)ft3 27,69 (31,06)m3

Limits

Operation Limits

- Max 90º crosswind component for Take-Off (Including Gusts)*: **29 Knots**
- Max 90º crosswind component for Landing (Including Gusts)*: **33 Knots**
- Max crosswind with gusts*: **38 Knots**
- Max 90º crosswind component for CAT II/III (Including Gusts)*: **15 Knots**
- Limiting Tailwind component for Take-Off and Landing*: **10 Knots**
- Max Operating altitude: **39,100 ft**
- Max Pressure Altitude for Takeoff/Landing: **8,000 ft**

*Max crosswind values have been demonstrated with flight controls in normal law as well as in direct law with and without yaw damper

Speed Limits

- Max Operating Speed (V_{MO}): **350 KIAS**
- Max Operating Speed (M_{MO}): **0.82 Mach**
- Max Gear Extension (V_{LO}): **250 KIAS**
- Max Gear Retraction (V_{LO}): **220 KIAS**

- Max Gear Extended (V_{LE}): **280 KIAS/ 0.67 Mach**
- Max Tire Speed: **195 Knots**
- Minimum Control Speed Air (V_{MCA}): **119 KIAS**
- Minimum Control Speed Ground (V_{MCG}): **114 KIAS**
- Max Cockpit Window Open Speed: **200 KIAS**
- Max Taxi Speed on straightaway: **30 Knots**
- Max Taxi Speed on turns approx.: **10 Knots**

Landing Speed Definitions

V_{ls} (REF Speed) – The speed for a specific flap configuration, which provides adequate stall margin for landing. V_{ls} is computed by the FMGC to provide 1.23 Vs protection for the selected landing configuration. It is the basis for computing V_{app} and threshold speeds. V_{ls} is not modifiable by the crew.

V_{ref} – V_{ls} for configuration FULL.

V_{app} (Target Speed) – The speed at which the approach is flown. V_{app}, as computed by the FMGC, is V_{ls} + 5 knots plus 1/3 the headwind component, not to exceed V_{ls} +20. No additions are made for gusts.

Turbulence Penetration - KIAS:

	At or above F200	Below F200
A320	275 / 0.76M	250

Max Flaps / Slats (V_{FE}) – KIAS:

Model	Config	1	1+F	2	3	FULL
A320	V_{FE}	230	215	200	185	177
	Slats	18º	18º	22º	22º	27º
	Flaps	0º	10º	15º	20º	40º
	RMK	Initial APP	Takeoff	Takeoff/APP	Takeoff/APP Landing	Landing

Operating Speeds (KIAS/Mach)

Optimum Climb (FMGC Operative)	ECON CLIMB
Standard Climb (FMGC Inoperative) F100 to F290 / F290 and above	0.78 290
Best Climb Rate	280
Best Climb Angle	220
Optimum Cruise (ECON)	Cost Index = 35
Standard Cruise F100 to F310 / F310 and above	0.80 300
Optimum Descent (FMGC Operative)	ECON DES
Standard Descent (FMGC Inoperative) F100 and above	0.78 280

Stall Speeds

Stall speeds apply to takeoff and landing altitudes only						
Gross Weight Tonnes	Flap Position					
	0	1	1+F	2	3	FULL
77	179	140	134	125	124	121
72.5	170	136	130	120	119	117
68	161	132	125	116	115	113
63.5	154	127	119	112	111	109
59	144	121	115	108	107	105
54.5	138	116	110	104	103	101
50	132	111	105	99	98	96

45.5	**126**	**106**	**100**	**95**	**94**	**92**
41	**119**	**100**	**95**	**90**	**89**	**87**
36.3	**114**	**95**	**90**	**85**	**84**	**82**

Fuel

Outer Wing Tank	Inner Wing Tank	Center Tank	Inner Wing Tank	Outer Wing Tank
710 Kg	**5530 Kg**	**6580 Kg**	**5530 Kg**	**710 Kg**
6240 Kg			**6240 Kg**	
19060 Kg				

- Max Fuel Imbalance between wing tanks for takeoff and landing: **450 Kg**
- Takeoff with center tank supplying the engines is **PROHIBITED.**
- Fuel in center last, fuel in center burned first.
- Fuel is kept in outer wing tanks as long as possible to reduce wing bending moment.

Landing Fuel - Kg

Fuel at Touchdown [1]	**180**
To execute a Go-Around [2]	**365**
Fuel Quantity Indicator Error [3]	**180**
Minimum Desired Landing Fuel (Indicated) [4]	**725**

[1] **Fuel at Touchdown:** Ensures adequate fuel boost pump coverage during reverse thrust and landing roll.

[2] **To Execute Go-Around:** The required amount of fuel to execute a go-around at runway threshold to 1000' AGL, fly a VFR pattern, intercept a 3º glideslope at approx. 2,5 nm from the runway and continue to landing.

[3] **Fuel Quantity Indicator Error:** The maximum design quantity error for all tanks.

[4] **Minimum Desired Landing Fuel:** Ensures sufficient fuel on board at the threshold in a worst case scenario with max fuel quantity indicator error.

Fuel Temperature

- Maximum: **54º C**
- Minimum: **- 36º C**

If fuel temp is below minimum temp limit, change to a warmer altitude.

Operating Fuel Values - Kg

Taxi Fuel per Minute (not included in takeoff weight)	**12**
Minimum for Dispatch (not including taxi fuel)	**3100**
Minimum Hold for Contingencies	**450**
Minimum Alternate Fuel	**550**
Holding Fuel per Hour	**2300**
APU Fuel per Hour	**130**
Approx Fuel Flow per Hour (normal conditions)	**3200**

Example of Fuel Planning - Faro (LPFR) to Lisbon (LPPT)

Trip Information. You must consider:	For example:
• Trip Length – nm	200
• Distance to Alternate – nm // Porto (LPPR)	200
• Route Contingency – min	15
• APU Time – min	45
• Taxi Time – min	30
• Cruise Altitude – ft	16000
• Zero Fuel Weight – Kg	50000
• +H/-T Wind – Knots	+ 15
• TAT – °C	- 4

Fuel Load with example inputs - Kg

Trip Fuel	**2244**
Alternate Fuel	**1906**
Contingency Fuel	**762**
APU Fuel	**98**
Taxi Fuel	**340**
Minimum Desired Landing Fuel	**725**

Total Left Wing Fuel	Total Center Fuel	Total Right Wing Fuel
3039 Kg	**0**	**3039 Kg**
6079 Kg		

- To calculate your fuel, you must know the topics and tables above, for a mental calculation, or simply get a fuel planner software for Airbus A320.

Landing Gear

- Max Landing Gear extension altitude: **25,000 ft**

Flaps/Slats

- Max operating altitude w/ slats or/and flaps extended: **20,000 ft**

Autopilot

- After Takeoff (if SRS is indicated): **100 ft AGL**

Autoland

- Autoland Max headwind: **25 Knots**
- Autoland Max Tailwind: **10 Knots**
- Autoland is permitted using FULL flaps only.

Avionics

- Do not arm ILS APPR mode above 8200 ft AGL.
- Inertial Reference System – In the NAV mode the IRU will not provide valid magnetic heading above 73° North and 60° South. Flights above/below these latitudes are not permitted.

Powerplant

- Airbus A320: CFM 56-53 rated at 27,000lbs. Thrust.

Five Thrust Lever Detents

TOGA	Takeoff go-around
FLX/MCT	Flex Takeoff, Max Continuous
CL	Climb Thrust
IDLE	Idle Thrust for forward and reverse
FULL REV	Maximum reverse Thrust

Normal Start Sequence

Note: Start ENG 2 first to pressurize Yellow Hydraulics for parking brake.

- ENG Mode selector to IGN/START

- ENG Master switch to ON (after amber X's go away)
  At 16 % ignition ON
  At 22% starts fuel flow
  At 50% start valve closes, ignition off
  Engine idle should stabilize at about 58%

- ENG mode selector to NORM

Normal Idle: – 2,4,6,6 –

20% N1 approx;
400 °C EGT;
60% N2;
600 lbs/hr FF. (270 Kg/hr FF)

Manual Start Sequence

- ENG Mode selector to IGN/START
- ENG MAN START pb ON
- At Max Motoring (min. 20% N2) select ENG Master switch ON
  Fuel and ignition will begin when ENG Master selected ON
  At 50% start valve closes, ignition off
- At idle, about 58%, ENG MAN START pb OFF
- ENG mode selector to NORM

Airbus Flight Control Laws

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. Have 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 TOC 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.	
	• 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.

- This table is only a summary of flight control laws, just to give you an idea of each one.

Abbreviations & Acronyms

This is a short list of Airbus abbreviations and Acronyms.

ACM – Air Cycle Machine

ACP – Audio Control Panel, allows pilot to select which radios or interphones to listen to.

ADIRS - Air Data Inertial Reference System, now replaced by GNADIRS

ADIRU - Air Data Inertial Reference Unit

AMU - Audio Management Unit

ASAP – as in LAND ASAP, As Soon As Possible

A/SKID - Anti-skid

BSCU - Brakes Steering Control Unit (computer)

BTC - Bus Tie Contactor

CFDS - Centralized Fault Display System

CRC – Continuous Repetitive Chime, used to be called the fire bell.

DDRMI – Digital Distance and Radio Magnetic Indicator (RMI with DME)

DMC - Display Management Computer

DU - Display Unit (CRT, or "TV screen")

ECAM - Electronic Centralized Aircraft Monitoring

EIU - Engine Interface Unit

ELAC - Elevator Aileron Computer

EO - Engine Out

E/WD - Engine/Warning Display, upper display for aircraft systems.

FAC - Flight Augmentation Computer

FOM – Flight Ops Manual

FCU - Flight Control Unit (auto flight panel)

FMGC - Flight Management Guidance Envelope Computer, what actually performs the computations when you type into the MCDU.

FMGS - Flight Management Guidance Envelope System

F-Plan - Flight Plan

FPA - Flight Path Angle

FWC - Flight Warning Computer

FWS - Flight Warning System

GCU - Generator Control Unit

GLC - Generator Line Contactor

GNADIRS – Global Navigation Air Data Inertial Reference System, GPS, Air Data information and Inertial attitude/guidance all in one.

Green Dot – Best L/D (lift over drag) speed, normally used as the target speed at end of takeoff or for single engine climb out. Technically called VFTO (Final Takeoff Speed). On the Airbus a green dot on the airspeed scale.

IDG – Integrated Drive Generator (the old CSD and generator all in one unit)

INIT – Initialization

L/G - Landing Gear

LGCIU - Landing Gear Control Interface Unit

LSK - Line Select Key (keys used on MCDU screen)

MCDU - Multipurpose Control and Display Unit

MMR – Multi Mode Receiver, the GPS receiver for the GNADIRS, two are installed

ND - Navigation Display

N/W – Nose Wheel

pb – pushbutton

PF – Pilot Flying, the person actually handling the control or autopilot input.

PFD - Primary Flight Display (the display you will look at the most, has airspeed, altitude, attitude, heading and more)

PH – Pilots Handbook

PM – Pilot Monitoring, the non-flying pilot, used to be called PNF (Pilot Not Flying).

PTU – Power Transfer Unit, pump that is able to transfer power (but not fluid) between the green and yellow hydraulic systems

QRH – Quick Reference Handbook

RAT - Ram Air Turbine, an air driven backup pump for blue hydraulic

RMP - Radio Management Panel, allows pilot to select which radio to tune or transmit on.

SD - System Display, lower display for aircraft systems.

SDAC - System Data Acquisition Concentrator

SEC - Spoiler Elevator Computer

SFCC - Slat/Flap Control Computer

SRS - Speed Reference System

THS - Trimmable Horizontal Stabilizer

TLA - Thrust Lever Angle, the TLA indicator is a white “donut” on the N1 gauge.

TOGA – Takeoff Go Around. Highest selectable thrust level. Selected by putting thrust levers in TOGA detent. Also a mode for the Flight Director.

TRU - Transformer Rectifier Unit, also known as TR, transformer rectifier

UTC - Universal Coordinated Time (a politically correct way to say Zulu or GMT)

VFTO – Final Takeoff Speed, normally called "Green Dot", best lift / drag

WHC – Window Heat Computer

WTB – Wing Tip Brake

XFR - Transfer

ZFCG - Zero Fuel Center of Gravity

ZFW – Zero Fuel Weight

Links

- **Airbus A320 Flight Deck:**

http://www.meriweather.com/320/320_main.html

- **Eric Park's Airbus Training Notes:**

http://www.airbusdriver.net/AirbusNotes.doc

Final Comments

This manual does not mean that you don't have to read odder manuals. This is basic information about A320 limitations, procedures and performance. To complete your knowledge about this aircraft you should read much more literature that you can find in the internet, bookstores and in the VA web site.

The A320 fleet wish all pilots to have fun inside our company, always respecting all the intervenients of the Virtual Aviation. Fly efficiently and the most realistic possible.

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Good Flights!