



Preface

Table of Contents

Chapter PT

Section 0

FCTM

Preface	PT
Model Identification	PT.1
Introduction	PT.2
Abbreviations	PT.3
Revision Record	PT.4
List of Effective Pages	PT.5
General Information	1
Ground Operations	2
Takeoff and Initial Climb	3
Climb, Cruise, Descent and Holding	4
Approach and Missed Approach	5
Landing	6
Maneuvers	7
Non-Normal Operations	8
Human Factors	9
Selected References	10
Index	Index



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A319/320/321
Flight Crew Training Manual
FCTM
Delta Air Lines, Inc.

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General

The airplane models listed in the table below are covered in the operations manual. The numbers are used to distinguish data peculiar to one or more, but not all of the airplanes. Where data applies to all airplanes listed, no reference is made to individual airplane numbers.

The table permits flight crew correlation of configuration differences by Registry Number in alpha/numeric order within an operator's fleet for airplanes covered in this manual. Configuration data reflects the airplane as delivered configuration and is updated for service bulletin incorporations in conformance with the policy stated in the introduction section of this chapter.

Airplane number is supplied by the operator. Registry number is supplied by the national regulatory agency. Serial and Model numbers are supplied by Airbus.

A319

Ship Number	Registry Number	Serial Number	Model
3101	N301NB	1058	A319-114
3102	N302NB	1062	A319-114
3114	N314NB	1191	A319-114
3115	N315NB	1230	A319-114
3116	N316NB	1249	A319-114
3117	N317NB	1324	A319-114
3118	N318NB	1325	A319-114
3119	N319NB	1346	A319-114
3120	N320NB	1392	A319-114
3121	N321NB	1414	A319-114
3122	N322NB	1434	A319-114
3123	N323NB	1453	A319-114
3124	N324NB	1456	A319-114
3125	N325NB	1483	A319-114
3126	N326NB	1498	A319-114

A319/320/321 Flight Crew Training Manual

Ship Number	Registry Number	Serial Number	Model
3127	N327NB	1501	A319-114
3128	N328NB	1520	A319-114
3129	N329NB	1543	A319-114
3130	N330NB	1549	A319-114
3131	N331NB	1567	A319-114
3132	N332NB	1570	A319-114
3133	N333NB	1582	A319-114
3134	N334NB	1659	A319-114
3135	N335NB	1662	A319-114
3136	N336NB	1683	A319-114
3137	N337NB	1685	A319-114
3138	N338NB	1693	A319-114
3139	N339NB	1709	A319-114
3140	N340NB	1714	A319-114
3141	N341NB	1738	A319-114
3142	N442NB	1746	A319-114
3143	N343NB	1752	A319-114
3144	N344NB	1766	A319-114
3145	N345NB	1774	A319-114
3146	N346NB	1796	A319-114
3147	N347NB	1800	A319-114
3148	N348NB	1810	A319-114
3149	N348NB	1815	A319-114
3150	N350NB	1819	A319-114
3151	N351NB	1820	A319-114
3152	N352NB	1824	A319-114
3153	N353NB	1828	A319-114

A319/320/321 Flight Crew Training Manual

Ship Number	Registry Number	Serial Number	Model
3154	N354NB	1833	A319-114
3155	N355NB	1839	A319-114
3156	N356NB	1870	A319-114
3157	N357NB	1875	A319-114
3158	N358NB	1897	A319-114
3159	N359NB	1923	A319-114
3160	N360NB	1959	A319-114
3161	N361NB	1976	A319-114
3162	N362NB	1982	A319-114
3163	N363NB	1990	A319-114
3164	N364NB	2002	A319-114
3165	N365NB	2013	A319-114
3166	N366NB	2026	A319-114
3167	N367NB	2028	A319-114
3168	N368NB	2039	A319-114
3169	N369NB	2047	A319-114
3170	N370NB	2087	A319-114
3171	N371NB	2095	A319-114
3172	N372NB	2369	A319-114
3173	N373NB	2373	A319-114
3174	N374NB	2464	A319-114
3175	N375NB	2474	A319-114
3176	N376NB	2618	A319-114
3177	N377NB	2641	A319-114

A320

Ship Number	Registry Number	Serial Number	Tabulation Number
3209	N209US	0118	A-320-211
3210	N310NW	0121	A-320-211
3211	N311US	0125	A320-211
3212	N312US	0152	A-320-211
3213	N313US	0153	A-320-211
3214	N314US	0160	A-320-211
3215	N315US	0171	A-320-211
3216	N316US	0192	A-320-211
3217	N317US	0197	A-320-211
3218	N318US	0206	A-320-211
3219	N319US	0208	A-320-211
3220	N320US	0213	A-320-211
3221	N321US	0262	A-320-211
3222	N322US	0263	A-320-211
3223	N323US	0272	A-320-211
3224	N324US	0273	A-320-211
3225	N325US	0281	A-320-211
3226	N326US	0282	A-320-211
3227	N327NW	0297	A-320-211
3228	N328NW	0298	A-320-211
3229	N329NW	0306	A-320-211
3230	N330NW	0307	A-320-211
3231	N331NW	0318	A-320-211
3232	N332NW	0319	A-320-211
3233	N333NW	0329	A-320-211
3234	N334NW	0339	A-320-212



A319/320/321 Flight Crew Training Manual

Ship Number	Registry Number	Serial Number	Tabulation Number
3235	N335NW	0340	A-320-212
3236	N336NW	0355	A-320-212
3237	N337NW	0358	A-320-212
3238	N338NW	0360	A-320-212
3239	N339NW	0367	A-320-212
3240	N340NW	0372	A-320-212
3241	N341NW	0380	A-320-212
3242	N342NW	0381	A-320-212
3243	N343NW	0387	A-320-212
3244	N344NW	0388	A-320-212
3245	N345NW	0399	A-320-212
3247	N347NW	0408	A-320-212
3248	N348NW	0410	A-320-212
3249	N349NW	0417	A-320-212
3250	N350NA	0418	A-320-212
3251	N351NW	0766	A-320-212
3252	N352NW	0778	A-320-212
3253	N353NW	0786	A-320-212
3254	N354NW	0801	A-320-212
3255	N355NW	0807	A-320-212
3256	N356NW	0818	A-320-212
3257	N357NW	0830	A-320-212
3258	N358NW	0832	A-320-212
3259	N359NW	0832	A-320-212
3260	N360NW	0903	A-320-212
3261	N361NW	0907	A-320-212
3262	N362NW	0911	A-320-212



A319/320/321 Flight Crew Training Manual

Ship Number	Registry Number	Serial Number	Tabulation Number
3263	N363NW	0923	A-320-212
3264	N364NW	0962	A-320-212
3265	N365NW	0964	A-320-212
3266	N366NW	0981	A-320-212
3267	N367NW	0988	A-320-212
3268	N368NW	0996	A-320-212
3269	N369NW	1011	A-320-212
3270	N369NW	1037	A-320-212
3271	N371NW	1535	A-320-212
3272	N372NW	1633	A-320-212
3273	N373NW	1641	A-320-212
3274	N374NW	1646	A-320-212
3275	N375NC	1789	A-320-212
3276	N376NW	1812	A-320-212
3277	N377NW	2082	A-320-211
3278	N378NW	2092	A-320-211

A321

Ship Number	Registry Number	Serial Number	Tabulation Number
3001	N301DN	6923	A-321-211
3002	N302DN	7031	A-321-211
3003	N303DN	7061	A321-211
3004	N304DN	7112	A-321-211
3005	N305DN	7149	A-321-211
3006	N306DN	7165	A-321-211

Preface

Introduction

Chapter PT

Section 2

General

The Flight Crew Training Manual provides information and recommendations on maneuvers and techniques, and is divided into ten chapters. General Information covers procedures and techniques not associated with a particular maneuver or phase of flight. Ground Operations covers information associated with aircraft preflight, engine starting and taxi operations including taxi operations in adverse weather conditions. Chapters 3 through 6 are titled by phase-of-flight and contain information about aircraft operations in each phase. The Maneuvers chapter covers maneuvers associated with climb, cruise, and descent, i.e., stall recovery and emergency descent. The Non-Normal Procedures chapter covers non-normal situations that may occur during any phase of flight. The Human Factors chapter covers Crew Resource Management and Threat Management Tools. The Selected References chapter covers engine out, high elevation and performance considerations, turbulence and windshear avoidance, hydroplaning and Delta maneuver training.

Flight crews are expected to do the non-normal maneuvers, described in the FCTM, from memory.

Flight profiles show procedures for some all-engine and engine-inoperative situations.

Flight profiles do not include all procedural items but show required/recommended:

- configuration changes
- thrust changes
- Flight Control Unit (FCU) changes
- Flight Mode Annunciator (FMA) changes
- pitch mode and roll mode changes
- checklist completions.

Note: In the event of a conflict, the procedures and restrictions published in the Vol. 1, Vol. 2, QRH, MEL, Fleet Bulletin or ODM take precedence over the information, techniques, and recommendations in the FCTM.

Note: Figures in this manual are to be used for training purposes only except where noted. This data is not suitable as a basis for performance calculations or other engineering purposes.

Regulatory Agencies

Regulatory information in this manual is based upon FAA regulations and requirements unless otherwise indicated. Examples of regulations and requirements include, but are not limited to, FAR takeoff field requirements, aircraft approach categories, and low visibility approach criteria.

Aircraft Configuration

The Flight Crew Training Manual (FCTM) is intended to provide information in support of procedures listed in the Vol. 1 and QRH and techniques to help the pilot accomplish these procedure safely and efficiently. The FCTM is written in a format that is more general than the Vol. 1 and QRH. The FCTM does not account for aircraft configuration differences, unless these differences have an impact on the procedure or technique being discussed. For example, the FCTM states, “When the flaps are retracted and the airspeed approaches maneuver speed, ensure CLB thrust is set.” This statement is not intended to tell the crew how to set climb thrust, only to emphasize that the flight crew must ensure that CLB thrust is set. It is recognized that crew actions required to set climb thrust are different in different models. Reference to the Vol. 1 is required for information on how to set climb thrust.

In cases where a procedure or technique is applicable only to an aircraft with a specific configuration, the annotation “as installed” is used. Aircraft configuration differences are found in the Vol. 1.

Manual Rights

The A319/320/321 Operations Manual has been prepared for the exclusive use of Delta Air Lines, Inc., Flight Operations personnel under the direction and authority of Delta and shall, at all times, remain the property of Delta. The holder hereof acknowledges and agrees that this manual contains or may contain trade secrets, copyrighted material and commercial and proprietary information, privileged and confidential, to the interest of Delta, and the holder hereof further agrees that this manual may not be reproduced, distributed or copied, in whole or in part, without the express prior written consent of Delta.

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Corrections to the Manual

Log on to the Delta Flight Operations Portal, <http://dlnet.delta.com> and submit a Publications Change Request (PCR) to correct any errors or discrepancies discovered in this manual, or to submit a suggested change to any Aircraft Operating Manual, Volume 1, Volume 2, Quick Reference Handbook (QRH), Flight Crew Training Manual (FCTM), Normal Checklist, Airway Manual (AM), Flight Operations Manual (FOM), Operating Experience (OE/TOE) Guide, Fleet Bulletin (FB), or All Pilot Bulletin (APB).

There are links to the PCR form on each fleet page and also on the Flight Ops Manuals/Library Services page. Once submitted, the PCR is automatically routed to the applicable Fleet Technical Manager and Technical Writer for that manual.

Organization

The operations manual is organized in the following manner.

Volume 1

- Preface - Contains general information regarding the manual's purpose, structure, and content. It also contains lists of abbreviations, a record of revisions and a list of effective pages.
- Limitations - Covers operational limitations.
- Normal Procedures - Covers all amplified normal operating procedures and are based on a thorough analysis of crew activity required to operate the aircraft, and reflect the latest knowledge and experience available.
- Normal Operational Information - Contains reference material used to support normal procedures.
- Supplementary Procedures is organized by system and covers:
 - any procedure that is non-routine in nature
 - any first-flight-of-the-day test or other systems test
 - guidance on lengthy operating procedures
 - adverse weather procedures and guidance
- Differences - Notes differences between aircraft models and variants.

Volume 2

- Preface - Contains general information regarding the manual's purpose, structure, and content. It also contains lists of abbreviations, a record of revisions and a list of effective pages.
- Contains general aircraft and systems information. These chapters are generally subdivided into sections covering controls and indicators and systems descriptions.

QRH

- Non-normal checklists - Contains checklists used to manage non-normal situations.
- Non-Normal Operational Information - Contains reference material used to support non-normal procedures.
- Non-Normal Checklist Instructions - Contains non-normal checklist instructions; evacuation flow/philosophy.
- Revision Record - Contains general information regarding the manual's purpose, structure, and content. It also contains lists of abbreviations, a record of revisions and a list of effective pages.

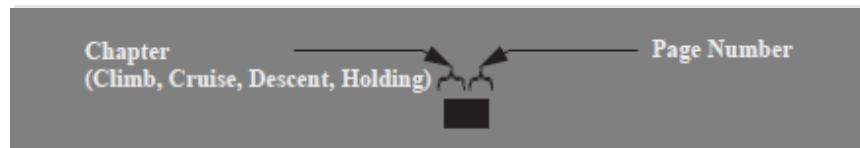
FCTM

- Preface - Contains general information regarding the manual's purpose, structure, and content. It also contains lists of abbreviations, a record of revisions and a list of effective pages.
- Provides information and recommendations on aircraft operations, maneuvers, and techniques, and human factors.

Page Numbering

This manual uses a decimal page numbering system. The page number is divided into three fields; chapter, section, and page. An example of a page number for the Normal Procedures chapter follows:

Example Page Number



Warnings, Cautions, and Notes

The following levels of written advisories are used throughout the manual and are not to be confused with ECAM messages, which are identified in separate text.

Warning - A warning is an instruction about a hazard that if ignored could result in injury, loss of aircraft control, or loss of life. A warning will appear prior to the applicable step or item.

WARNING: Do not pressurize any hydraulic or pneumatic system until clearance is obtained from Maintenance.

Caution - A caution is an instruction concerning a hazard that if ignored could result in damage to equipment. A caution will appear prior to the applicable step or item.

A319/320/321 Flight Crew Training Manual

CAUTION: Do not set takeoff thrust until oil temperature is above 50°C.

Note - A note provides amplified information, instruction, or emphasis. A note will appear after the applicable step or item.

Note: The checklist must not be modified in any way.

Aircraft Effectivities

Differences in aircraft configuration are shown by use of aircraft effectivities throughout Volumes 1 and 2, QRH, and the FCTM. The following rules are used to express aircraft effectivities:

- Aircraft effectivities are listed by model and/or ship number. A range of aircraft is defined by a dash, e.g. 9901- 9910. A comma in the effectivity range indicates a break in the range, e.g. 9901 - 9910, 9912 - 9925; aircraft 9911 is excluded from the range. Aircraft introduced to the fleet following manual publication are effective as subsequent ships, e.g. 9901 & Subsequent.
- Aircraft effectivities are listed in bold text throughout the manual, except in the Limitations chapter. In the Limitations chapter, aircraft effectivities are listed in bold when the effectivity applies to the entire section or subsection. When the effectivity applies only to a step within a section, it is listed in normal text.
- Aircraft effectivities apply only to the paragraph, illustration, operational note, procedural step, etc. and to subordinate items (if any). Refer to the examples below.

Example (with subordinate items):

9951 – 9961

CTR TK PUMP (affected).....OFF
Do not open the WING X FEED valve.

OUTR TK XFR.....ON

In this example, the effectivity 9951 - 9961 applies to the first procedural step (CTR TK PUMP.....) and the further indented/subordinate step (Do not...). The effectivity does not apply to the next equivalently indented step (OUTR TK XFR.....).



Example (without subordinate items):

Using ship number:

9951 – 9961

CTR TK PUMP (affected).....ON

OUTR TK XFR.....OFF

In this example, the effectivity 9951 - 9961 applies to the first procedural step (CTR TK PUMP) only. The effectivity does not apply to the next procedural step (OUTR TK XFR).

Using model number:

767-300

EQUIPMENT COOLING mode selector.....AUTO

In this example, the 767-300 will have the selector in the AUTO position.

When airplane effectivities are centered immediately below a checklist title, the entire checklist applies to the listed airplanes. In the following example, the FUEL L + R CTR PUMPS LO PR checklist is applicable to 9951-9961 only:

FUEL L + R CTR PUMPS LO PR
9951-9961



Preface

Abbreviations

Chapter PT

Section 3

General

The following abbreviations may be found throughout the manual. Some abbreviations may also appear in lowercase letters. Abbreviations having very limited use are explained in the chapter where they are used. Since this list is compiled across several fleets, there may be some abbreviations that do not apply to the A319/320.

A	
A/BRK	Autobrake
ABV	Above
AC	Alternating Current or Aircraft
ACARS	Aircraft Communications Addressing and Reporting System
ACMS	Aircraft Condition Monitoring System
ACP	Audio Control Panel
ACT	Active
ADC	Air Data Computer
ADF	Automatic Direction Finder
ADI	Attitude Director Indicator
ADIRS	Air Data Inertial Reference System
ADIRU	Air Data Inertial Reference Unit
ADM	Air Data Module
ADR	Air Data Reference
ADS	Automatic Dependent Surveillance

ADV	Advisory
AED	Automated External Defibrillator
AFB	Alternate Fuel Burn
AFE	Above Field Elevation
AFM	Airplane Flight Manual (FAA approved)
AFM - DPI	Airplane Flight Manual - Digital Performance Information
AFS	Automatic Flight System (Autopilot or Autothrust)
A/G	Air/Ground
AGL	Above Ground Level
AH	Alert Height
AI	Anti-Ice
AIL	Aileron
ALT	Altitude
ALT HOLD	Altitude Hold
ALTN	Alternate
AM	Amplitude Modulation
ANP	Actual Navigational Performance
ANT	Antenna

AOA	Angle of Attack
AOC	Airline Operational Communication Data Link
A/P	Autopilot
APB	All Pilot Bulletin
APL	Airplane
APP or APPR	Approach
APU	Auxiliary Power Unit
AR	Authorization Required
ARINC	Aeronautical Radio, Incorporated
ARM	Aircraft Restrictions Manual
ARPT	Airport
ARR	Arrival
ASI	Airspeed Indicator
A/SKID	Anti-Skid
ASR	Airport Surveillance Radar
ASYM	Asymmetry
ATA	Actual Time of Arrival
ATC	Air Traffic Control
A/THR	Autothrust
ATIS	Automated Terminal Information Service
ATM	Assumed Temperature Method
ATT	Attitude
AUTO	Automatic
AUX	Auxiliary
AVAIL	Available

AWABS	Automated Weight and Balance System
B	
BARO	Barometric
BAT	Battery
B/C or B/CRS or BAC or BCS	Back Course
BCL	Battery Charge Limiter
BCM	Backup Control Module
BITE	Built-In Test Equipment
BKR	Breaker
BLD	Bleed
BLW	Below
BMC	Bleed Monitoring Computer
BRG	Bearing
BRK	Brake
BRT	Bright
BSCU	Brake Steering Control Unit
BTC	Bus Tie Contactor
BTL	Bottle
BTL DISCH	Bottle Discharge (fire extinguisher)
C	
C	Captain or Celsius or Center or Cool
CAA	Civil Aviation Authority
CADC	Central Air Data Computer

A319/320/321 Flight Crew Training Manual

CAP	Capture
CAPT	Captain
CB	Circuit Breaker
CDL	Configuration Deviation List
CDU	Control Display Unit
CFDS	Centralized Fault Display System
CFIT	Controlled Flight Into Terrain
CG	Center of Gravity
CHKL or C/L	Checklist
CHR	Chronograph
CIDS	Cabin Intercommunication Data System
CKD	Checked
CKT	Circuit
CL	Close
CLB	Climb
CLR	Clear
CMD	Command
CO	Company
COMM	Communication
COMPT	Compartment
CON	Continuous
CONFIG	Configuration
CONT	Control or Continuous
COOL	Cooling
CO RTE	Company Route
CPCU	Cabin Pressure Controller Unit

CPDLC	Controller/Pilot Data Link Communications
CRC	Continuous Repetitive Chime
CRM	Crew Resource Management
CRS	Course
CRT	Cathode Ray Tube
CRZ	Cruise
CSM/G	Constant Speed Motor/Generator
CSTR	Constraint
CTL	Control
CTR	Center
CVR	Cockpit Voice Recorder
D	
DA(H)	Decision Altitude (Height)
DC	Direct Current
DCDU	Datalink Control and Display Unit
DDA(H)	Derived Decision Altitude (Height)
DDG	Dispatch Deviations Guide
DDRMI	Digital Distance & Radio Magnetic Indicator
DEL	Delete
DEP	Departure
DEP ARR	Departure Arrival
DEPR	Depressurize
DES	Descent
DEST	Destination

DFDR	Digital Flight Data Recorder
DH	Decision Height
DIFF	Differential
DIR	Direct
DIR TO	Direct To
DISC	Disconnect
DISCH	Discharge
DK	Deck
DMC	Display Management Computer
DME	Distance Measuring Equipment
DN	Down
DSPL	Display
DTG	Distance to Go
DTW	Distance to Waypoint
DU	Display Unit
E	
ECAM	Electronic Centralized Aircraft Monitor
ECB	Electronic Control Box
ECON	Economic
EDP	Engine Driven Pump
E/D	End of Descent
E/E	Electrical/Electronic
EEC	Electronic Engine Control
EFIS	Electronic Flight Instrument System
EFOB	Estimated Fuel On Board

EGPWS	Enhanced Ground Proximity Warning System
EGT	Exhaust Gas Temperature
EIS	Electronic Instrument System
EIU	Engine Interface Unit
ELAC	Elevator Aileron Computer
ELEC	Electrical
ELEV	Elevator
EMER	Emergency
ENG	Engine
ENG OUT	Engine Out
ENT	Entry
EO or E/O	Engine Out
EPR	Engine Pressure Ratio
EQPT or EQUIP	Equipment
ETOPS	Extended Range Operation with Twin Engine Airplanes
ETP	Equal Time Point
EVAC	Evacuation
EVMU	Engine Vibration Monitoring Unit
E/WD	Engine/Warning Display
EXT	Extend or External
F	
F	Fahrenheit or Flap Retraction Speed
FAC	Final Approach Course OR Flight Augmentation Computer

A319/320/321 Flight Crew Training Manual

FAA	Federal Aviation Administration	FMS	Flight Management System
FADEC	Full Authority Digital Engine Control	F/O or F O	First Officer
FAF	Final Approach Fix	FOM	Flight Operations Manual
FAR	Federal Aviation Regulation	FPA	Flight Path Angle
FB	Fleet Bulletin	F-PLN	Flight Plan
FCDC	Flight Control Data Concentrator	FPM	Feet Per Minute
FCMC	Fuel Control and Monitoring Computer	FPV	Flight Path Vector
FCTL	Flight Control	FREQ	Frequency
FCTM	Flight Crew Training Manual	F/S	Fast/Slow
FCU	Flight Control Unit	FT	Feet
FD, F/D or FLT DIR	Flight Director	FWC	Flight Warning Computer
FF	Fuel Flow	FWD	Forward
FILT	Filter	FX	Fix
FIR	Flight Information Region	G	
FLT	Flight	GA	Go-Around
FLT CTRL	Flight Control	GCU	Generator Control Unit
FMA	Flight Mode Annunciator	GEN	Generator
FMC	Flight Management Computer	GLC	Generator Line Contactor
FMGEC	Flight Management Guidance Envelope Computer	GMT	Greenwich Mean Time
FMGC	Flight Management Guidance Computer	GND	Ground
FMGS	Flight Management Guidance System	GP or G/P	Glide Path
		GPS	Global Positioning System
		GPWS	Ground Proximity Warning System
		GS	Ground Speed
		G/S	Glide Slope
		GW	Gross Weight

H	
HAA	Height Above Airport
HAT	Height Above Touchdown
HDG	Heading
HF	High Frequency
HI	High
HLD	Hold
HMU	Hydro-Mechanical Unit
HP	High Pressure
HPA	Hectopascals
HPV	High Pressure Valve
HSI	Horizontal Situation Indicator
HYD	Hydraulic
I	
IAF	Initial Approach Fix
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organization
IDENT	Identification
IDG	Integrated Drive Generator
IFE	In-Flight Entertainment System
IFR	Instrument Flight Rules
IGN	Ignition
ILS	Instrument Landing System
IM	Inner Marker
IMC	Instrument Meteorological Conditions

IN	Inches
INBD	Inboard
IND	Indicator
IND LTS	Indicator Lights
INOP	Inoperative
INIT	Initialization
INSTR	Instrument
INT or INTPH	Interphone
INTC	Intercept
INTC CRS	Intercept Course
IP	Intermediate Pressure or Instructor Pilot
IRS	Inertial Reference System
IRU	Inertial Reference Unit
ISA	International Standard Atmosphere
ISIS	Integrated Standby Instrument System
ISLN	Isolation
J	
JAA	Joint Aviation Authority
K	
K or KTS	Knots
KCAS	Knots Calibrated Airspeed
KGS	Kilograms
KIAS	Knots Indicated Airspeed

A319/320/321 Flight Crew Training Manual

L	
L	Left
LAT	Latitude
LAT REV	Lateral Revision
LAV	Lavatory
LBS	Pounds
LD	Load
LDA	Localizer-type Directional Aid
LDG	Landing
LDG ALT	Landing Altitude
LE	Leading Edge
LGCIU	Landing Gear Control Interface Unit
LIM	Limit
LIM SPD	Limit Speed
LKD or LK	Locked
LOC	Localizer
LOC-BC	Localizer Back Course
LOM	Locator Outer Marker
LON or LONG	Longitude
LP	Low Pressure
LRC	Long Range Cruise
LRU	Line Replaceable Unit
LSK	Line Select Key
LT	Light
M	
M	Mach or Meter
MAC	Mean Aerodynamic Chord

MAG	Magnetic
MAHP	Missed Approach Holding Point
MAN	Manual
MAP	Missed Approach Point
MAX	Maximum
MB	Millibar
MCC	Maintenance Control Center
MCDU	Multi-purpose Control and Display Unit
MCO	Maintenance Carry Over
MCT	Maximum Continuous Thrust
MDA	Minimum Descent Altitude
MDA(H)	Minimum Descent Altitude (Height)
MDM	Mechanical Dispatch Manual
MEA	Minimum Enroute Altitude
MEL	Minimum Equipment List
MHZ	Megahertz
MIC	Microphone
MIN	Minimum or Minute
MKR	Marker
MLA	Maneuver Load Allevia- tion
MLS	Microwave Landing System
MM	Middle Marker
MMO	Maximum Operating Mach

MMR	Multi Mode Receiver
MNPS	Minimum Navigation Performance Specification
MOCA	Minimum Obstruction Clearance Altitude
MOD	Modify
MORA	Minimum Off Route Altitude
MSA	Minimum Safe Altitude
MSG	Message
MSGS RCVD	Messages Received
MSL	Mean Sea Level
MTOW	Maximum Take-Off Weight
MTRS	Meters
MZFW	Maximum Zero Fuel Weight
N	
N	Normal
NADP	Noise Abatement Departure Procedures
NAR	North American Route
NAV	Navigation
NAV RAD	Navigation Radio
ND	Navigation Display
NDB	Non Directional Beacon
NGS	Nitrogen Generation System
NLT	No Later Than
NM	Nautical Mile(s)
NNC	Non-Normal Checklists

NNM	Non-Normal Maneuvers
NORM	Normal
NWS	Nose Wheel Steering
N1	Low Pressure Rotor Speed
N2	High Pressure Rotor Speed
O	
OAT	Outside Air Temperature
OCC	Operations Control Center
ODM	Operational Data Manual
OFST	Offset
OM	Outer Marker
OP	Open
OVHD	Overhead
OVHT	Overheat
OVRD	Override
OVSPD	Overspeed
OXY or O2	Oxygen
P	
PA	Passenger Address
PAPI	Precision Approach Path Indicator
PAR	Precision Approach Radar
PB	Push-Button
PBE	Protective Breathing Equipment
PDC	Pre-Departure Clearance
PERF	Performance

A319/320/321 Flight Crew Training Manual

PERF INIT	Performance Initialization
PES	Passenger Entertainment System
PF	Pilot Flying
PFAF	Precision Final Approach Fix
PFD	Primary Flight Display
PM	Pilot Monitoring
PNL	Panel
POS	Position
PPOS	Present Position
PRES or PRESS	Pressure
PRED	Prediction
PREV	Previous
PRI	Primary
PRIM	Flight Control Primary Computer
PROC T	Procedure Turn
PROG	Progress
PROX	Proximity
PRV	Pressure Regulating Valve
PSI	Pounds Per Square Inch
PTH	Path
PTT	Push To Talk
PTU	Power Transfer Unit
PWR	Power
PWS	Predictive Windshear System

Q	
Q	Quantity
QFE	Field Elevation Atmosphere Pressure
QNH	Sea Level Atmosphere Pressure
QRH	Quick Reference Handbook
QT	Quart
QTY	Quantity
R	
R	Right
RA	Radio Altitude or Resolution Advisory
RAD	Radio
RAIM	Receiver Autonomous Integrity Monitoring
RAT	Ram Air Temperature or Ram Air Turbine
RCL	Recall
REC or RCDR	Recorder
RECIR or RECIRC	Recirculation
REF	Reference
RET	Retract
REV	Reverse
RF	Radius-to-Fix (RF) Legs or Refill
RMI	Radio Magnetic Indicator
RMP	Radio Management Panel
RNAV	Area Navigation

RNP	Required Navigational Performance
RPM	Revolutions Per Minute
RST	Reset
RSV	Reserves
RSVR	Reservoir
R/T	Receive/Transmit
RTA	Required Time of Arrival
RTE	Route
RTO	Rejected Takeoff
RTOW	Runway Takeoff Weight
RUD	Rudder
RVR	Runway Visual Range
RVSM	Reduced Vertical Separation Minimum
S	
SAAAR	Special Aircraft and Aircrew Authorization Required
SAT	Static Air Temperature or Satellite
SB	Service Bulletin
S/B	Speedbrake
SC	Single Chime
S/C	Step Climb
SD	System Display
SDAC	System Data Acquisition Concentrator
SDCU	Smoke Detection Control Unit

SDF	Simplified Directional Facility
SEC	Flight Control Secondary Computer
SEL	Select
SELCAL	Selective Calling
SENS	Sensitivity
SERV	Service
SFCC	Slat/Flap Control Computer
SMGCS	Surface Movement and Guidance Control System
SID	Standard Instrument Departure
SPD	Speed
SPDBRK	Speedbrake
SPLR	Spoiler
SRS	Speed Reference System
STA	Station
STAB	Stabilizer
STAR	Standard Terminal Arrival Route
STAT or STS	Status
STAT INV	Static Inverter
STBY	Standby
STD	Standard
SW	Switch
SWTG	Switching
SYS	System

A319/320/321 Flight Crew Training Manual

T	
T or TRU	True
T or TK or TRK	Track (to a Navaid)
TA	Traffic Advisory
TAA	Terminal Arrival Area
TACAN	Tactical Air Navigation
TAS	True Airspeed
TAT	Total Air Temperature
T/C	Top of Climb
TCA	Terminal Control Area
TCAS	Traffic Alert and Collision Avoidance System
T/D	Top of Descent
TDZ	Touch Down Zone
TDZE	Touch Down Zone Elevation
TE	Trailing Edge
TEMP	Temperature
TERR	Terrain
TFC	Traffic
TFR	Transfer
THR	Thrust
THS	Trimable Horizontal Stabilizer
TLA	Throttle Lever Angle
TMI	Track Message Identifier
TO or T/O	Takeoff
TOC	Top of Climb
TOD	Top of Descent
TOGA	Takeoff/Go-Around

TOGW	Takeoff Gross Weight
TOPR	Takeoff Performance Request
T-P	Turn Point
TRK	Track
TRU	Transformer Rectifier Unit
TURB	Turbine or Turbulence
U	
UNLK	Unlocked
UNSCHD or UNSCHED	Unscheduled
U.S.	United States
UTC	Universal Time Coordinated
UTIL	Utility
V	
VA	Design maneuvering speed
VAL	Valve
VANP	Vertical Actual Navigational Performance
VAPP	Approach speed
VASI	Visual Approach Slope Indicator
VDP	Visual Descent Point
VEF	Speed at Engine Failure
VERT	Vertical
VFE	Maximum speed flaps extended
VFR	Visual Flight Rules

VG	Vertical Gyro
VHF	Very High Frequency
VIB	Vibration
VLS	Lowest Selectable speed
VLE	Maximum speed with gear extended.
VLV	Valve
VMAX	Maximum speed for current configuration.
VMC	Visual Meteorological Conditions
VMCA	Minimum Control Airspeed or Single Engine Minimum Control Airspeed
VMCG	Minimum Control Speed Ground
VMO	Maximum Operating Speed
VOR	VHF Omnidirectional Range
VR	Rotation Speed
VREF	Reference Speed
VRNP	Vertical Required Navigation Performance
V/S	Vertical Speed
VSCF	Variable Speed Constant Frequency
VSI	Vertical Speed Indicator
VTK	Vertical Track
V1	Critical engine failure speed
V1 (MCG)	Minimum V1 for Control on the Ground
V2	Takeoff safety speed

W	
WATRS	Western Atlantic Route System
WDR	Weight Data Record
WGS-84	World Geodetic System of 1984
WHC	Window Heat Computer
WHL	Wheel
WPT	Waypoint
WT	Weight
WTB	Wing Tip Brake
WXR	Weather Radar
X	
X-FEED	Crossfeed
XFR	Transfer
XPDR or XPNDR	Transponder
XTK	Cross Track
Z	
ZFCG	Zero Fuel Weight Center of Gravity
ZFW	Zero Fuel Weight

Preface

Revision Record

Chapter PT

Section 4

Revision Notification Transmittal Letter

To: All holders of Delta Air Lines, Inc. A319/320/321 Flight Crew Training Manual.

Subject: FCTM Revision.

This revision reflects the most current information available to Delta Air Lines, Inc., through the revision date. The following revision highlights explain changes in this revision. General information below explains the use of revision bars to identify new or revised information.

Revision Record

No.	Revision Date	Date Filed	No.	Revision Date	Date Filed
0	April 22, 2014		1	April 8, 2016	

General

Delta Air Lines issues operations manual revisions to provide new or revised procedures and information. Formal revisions also incorporate appropriate information from previously issued Fleet Bulletins.

The revision date is the approximate date the manual is distributed and considered current. The revision should be incorporated on the revision date, but may be incorporated as much as 21 days after the revision date.

Formal revisions include a Transmittal Letter, a new Revision Record, Revision Highlights, and a current List of Effective Pages. Use the information on the new Revision Record and List of Effective Pages to verify the operations manual content.

The Revision Record should be completed by the person incorporating the revision into the manual.

Filing Instructions

This revision is a complete reprint of the FCTM as indicated on the List of Effective Pages (0.5).

Revision Highlights

This section (PT.4) replaces the existing section PT.4 in your manual.

Chapter PT - Preface

Section 1 - Model Identification

PT.1.6 - Added A321 to model identification chart.

Section 2 - Introduction

General

PT.2.1 - Revised General section for the addition of Human Factors chapter.

PT.2.1 - Second note was revised to align with other fleets.

Manual Rights

PT.2.2 - Added Preface material to align with other manuals.

PT.2.2 - Added 321

Corrections to the Manual

PT.2.3 - Added Preface material to align with other manuals.

Organization

PT.2.3 - Added Preface material to align with other manuals.

Page Numbering

PT.2.4 - Added Preface material to align with other manuals.

Warnings, Cautions, and Notes

PT.2.4 - Added Preface material to align with other manuals.

Aircraft Effectivities

PT.2.5 - Added Preface material to align with other manuals.

Section 3 - Abbreviations

PT.3.1 - Corrected abbreviation.

PT.3.11 - Added new Abbreviation, TOPR (Takeoff Performance Request).

PT.3.12 - Added new abbreviation, VLE (Maximum speed with gear extended).

PT.3.12 - Revised description of VMAX to (Maximum speed for current configuration).

Section 4 - Revision Record

PT.4.1 - Added 321.

Chapter 1 - General Information

Section -

Pushback

- 1.2 - Updated Pushback flow for Captain and First Officer.
- 1.2 - Added Vol. 1 trigger statement.

After Start

- 1.3 - Updated After Start Flow for First Officer.
- 1.3 - Added Vol. 1 trigger statement.

Prior to Taxi

- 1.4 - Prior to Taxi Flow Captain Items updated.
- 1.4 - Added Vol. 1 trigger statement.

Delayed Start

- 1.6 - Delayed Start Flow First Officer Items updated.
- 1.6 - Added Vol. 1 trigger statement.

After Delayed Start

- 1.7 - After Delayed Start Flow First Officer Items updated.

Before Takeoff

- 1.8 - Before Takeoff Flow Captain and First Officer Items updated.
- 1.8 - Added Vol. 1 trigger statement.

After Flaps Selected Up

- 1.9 - Title revised to "After Flaps Selected Up."

Climb

- 1.10 - Added Vol. 1 trigger statement.

Descent

- 1.11 - Added Vol. 1 trigger statement.

Approach

- 1.12 - Added Vol. 1 trigger statement.

Landing

- 1.13 - Added Vol. 1 trigger statement.

After Landing

- 1.14 - Added Vol. 1 trigger statement.

Shutdown - After Engine Cool Down

- 1.15 - Added Vol. 1 trigger statement.

Flap Maneuver Speeds

- 1.18 - revised 2nd and 3rd bullet for clarification.

Minimum Maneuver Speed

- 1.19 - Revised Lowest Selectable Airspeed section.

Wind Component

- 1.21 - Changed to VLS (FULL).

Basic RNP Concept

- 1.27-28 - Revised Lateral and Vertical Deviation sub-section.
- 1.28 - Revised EPE Alerts sub-section.
- 1.28 - Added statement to require autopilot for RNP approaches.
- 1.29 - Revised Radius-to-Fix description.

Chapter 2 - Ground Operations

Section -

Taxi General

- 2.5 - Second bullet under Prior to Taxi was revised.
- 2.5 - 5th Bullet under Prior to Taxi was revised to "Complex taxi clearances should be written down or entered into the MCDU scratchpad."
- 2.5 - Added information to During Taxi.
- 2.6 - Added Prior to Takeoff information.
- 2.6 - Revised second bullet under Prior to Takeoff.
- 2.6 - Added TOPR update request to ACARS bullet under Prior to Takeoff.
- 2.6 - Added information to After Landing section.

Using Runways as Taxiways

- 2.7 - Added Using Runways as Taxiways section.

Taxi Speed and Braking

- 2.10 - Added new section describing A321 brake fans.

Turning Radius and Gear Tracking

- 2.13 - Added A321 wingtip arc.
- 2.13 - Added Caution for A321 wingspan.
- 2.16 - Added A321 Turn Radius Graphic.

Visual Cues and Techniques for Turning while Taxiing

- 2.17 - Revised wording to allow for oversteering in the A321.
- 2.17 - Added A321 information to chart.
- 2.19 - Added 321.

Best Vantage Point

- 2.27 - Removed reference to black triangles.

Chapter 3 - Takeoff and Initial Climb

Section -

Takeoff - General

- 3.1 - Revised for clarity.

Initiating Takeoff Roll

- 3.1 - Note added to explain that FLEX and ATM are synonymous.
- 3.2 - Revised “verify” to “verbalize” to align with new automation policy outlined in FB 16-01 Automation Policy Changes.
- 3.3 - ATM was revised to FLEX.

Rotation Liftoff - All Engines

- 3.5 - Added A321 info to chart.

Effect of Rotation Speed and Pitch Rate on Liftoff

- 3.6 - Added A321.

Crosswind Takeoff

- 3.8 - Revised to align with manufacturer information.

Takeoff Crosswind Guidelines

- 3.8 - Added "crosswind guidance," to Vol. 1 reference.

Gusty Wind and Strong Crosswind Conditions

- 3.9 - Wording was revised to allow for a higher thrust setting in gusty conditions.

Low Visibility Takeoff

- 3.11 - Updated Airway Manual reference.

Adverse Runway Conditions

- 3.12 - Revised wording to match other fleets.

Takeoff Performance Limit Weights

- 3.13 - Reworded to define balanced field length.

Rejected Takeoff Decision

- 3.15 - Added Predictive windshear “caution or warning” to reject chart.
- 3.15 - Added "or ambient temp equals [or exceeds] FLEX temp."
- 3.15 - Windshear prior to V1 deleted, information is in Chapter 7.

Go/Stop Decision Near V1

- 3.19 - Deleted reference to RTO Execution Operational margins diagrams, no longer in FCTM.

Takeoff Risk Factors

- 3.20 - Revised Improper Use of the Flight Director Section.

Immediate Turn after Takeoff - All Engines

- 3.21 - Caution was relocated to Immediate Turn after Takeoff - All Engines

Flap Retraction Schedule

- 3.22 - Deleted statement that minimum altitude for flap retraction is 400 feet.

Departure Speed Restrictions

- 3.29-30 - Added Departure Speed Restrictions section.

Immediate Turn after Takeoff - One Engine Inoperative

- 3.33 - Updated Airway Manual reference.

Autopilot Engagement - One Engine Inoperative

- 3.33 - Revised AFE to AGL.

Flap Retraction - One Engine Inoperative

- 3.33 - Added "after selected the flap handle up."

Flaps Up - One Engine Inoperative

- 3.34 - Revised wording for clarity.

Takeoff Profile - Engine Failure

- 3.35 - Changed initial climb speed line to not indicate a climb.

Chapter 4 - Climb, Cruise, Descent and Holding

Section -

Climb Modes

- 4.1 - Changed VNAV to managed climb.
- 4.1 - Last sentence in first paragraph under Managed Climb was revised for clarity.

Low Altitude Level Off

4.2 - Note under Low Altitude Level Off was revised for clarity.

Cruise Speed Determination

4.7 - Revised last paragraph for clarity.

Engine Inoperative Cruise/Driftdown

4.16 - Deleted extraneous note.

Descent Constraints

4.24 - Revised note under Autotrust Interaction.

4.25 - Revised first paragraph under Autothrust Interaction.

4.25 - Revised autothrust Interaction - Flight Path Angle.

Approaching Top-of-Descent (TOD)

4.26 - Paragraph under Approaching Top-of-Descent (TOD) was revised.

Speedbrakes

4.28 - Added flap positions that speedbrakes may be used for the A319.

4.28 - Added flap positions that speedbrakes may be used for the A320.

4.28 - Added A321 speedbrake section.

Flaps and Landing Gear

4.29 - Deleted note regarding using landing gear for increased drag and passenger comfort.

Holding

4.30 - Wording was revised to take out reference to PF.

Holding Airspeeds

4.31 - Updated Airway Manual reference.

Chapter 5 - Approach and Missed Approach

Section -

Approach Category

5.1 - Updated Airway Manual reference.

Procedure Turn

5.2 - Updated Airway Manual Reference.

Sidestep

5.3 - Updated Airway Manual Reference.

Quick Reference Landing Length

5.4 - Updated landing distances for 319/320/321.

Flap Configurations for Approach and Landing

5.5 - Revised Flaps 3 Landing description.

Flap Extension

5.5 - Revised to read (V Lowest Selectable Speed).

Approach

5.8 - Revised to 2,000 feet.

5.11 - Updated Airway Manual Reference.

5.12 - Removed statue and added (3200m).

5.13 - Revised first sentence under Transition to Manual Approach or Landing to align with other fleets.

ILS PRM Approach

5.16 - Revised PRM Breakout Maneuvers section.

5.17 - Added PRM Breakout Maneuver table.

Non - ILS Instrument Approaches - General

5.25 - Added RNAV(RNP).

5.25 - Updated Airway Manual Reference.

RNAV (GPS) Approaches

5.27 - Changed RNAV to RNAV (GPS).

5.28 - Added RNAV (GPS).

5.29 - Added RNAV (GPS).

Instrument Approach Using APP NAV

5.31 - Second paragraph reworded for clarity.

5.33-36 - Added RNAV (RNP) Approach section.

Circling Maneuver - General

5.40 - Added statement to minimize challenges of cross-cockpit flying.

Obstruction Clearance

5.41 - Added (Cat C) per request of the FAA.

5.41 - Added (Cat D) per request of the FAA.

5.41 - Added Expanded Circling Area Radius (r) from Threshold.

5.41 - Added Note referring to circling radius.

Visual Approach Profile

5.43 - Visual Approach Profile updated.

Downwind and Base Leg

5.45 - Revised AGL to AFE.

5.45 - Added APPR pb.

High Energy Approach

5.46 - Added 321.

5.46 - Added (flaps 2 A321).

5.46 - Revised third bullet for setting target altitude.

5.46 - Added A321 leave flaps 2.

5.46 - Added (1/2) on A320.

5.46 - Revised to 'Disconnect A/P.'

5.46 - Revised second bullet for clarity.

5.46-47 - Upon intercepting the vertical path steps were revised.

Go-Around and Missed Approach - All Engines Operating

5.65 - Updated Airway Manual Reference.

5.66 - Added Go-Around Maneuver Chart.

Chapter 6 - Landing

Section -

VASI Landing Geometry

6.5 - Added A321 chart.

Flare and Touchdown

6.12 - Added A321 section.

Pitch and Roll Limit Conditions

6.16 - Added A321 chart.

Wheel Brakes

6.23 - Added note which describes A321 brake fan operation.

Reverse Thrust Operation

6.25 - Revised full down to forward idle thrust.

Overweight - General

6.29 - Added A321 Note.

Overweight Autolands

6.30 - Revised to align with FCOM revision.

Chapter 7 - Maneuvers

Section -

Abnormal Alpha Protection

7.1-2 - Added Abnormal Alpha Protection from FB-14-06

Erroneous Radio Altimeter Indications

7.9 - Added Erroneous Radio Altimeter Indications section from FB-10-12 and FB-10-15.

Low Energy Warning

7.16-17 - Changed title from SPEED, SPEED, SPEED to Low Energy Warning, and revised description.

TCAS Maneuver

7.23 - Revised wording of first warning to include new phraseology when informing ATC of a TCAS RA.

Traffic Advisory

7.25 - Added "when directed by flight plan remark."

Resolution Advisory

7.25 - Added note which states, "Pilots are authorized to deviate from their current ATC clearance to the extent necessary to comply with a TCAS resolution advisory."

Precautions

7.33 - Added flaps 3 consideration to Approach and Landing.

Windshear Encounter Recognition

7.34 - Added "unusual thrust setting position for a significant period of time" to align with other fleets.

Windshear Escape Maneuver

7.35 - Revised third Pilot Monitoring step.

Windshear During Takeoff Roll

7.35 - Added Prior to V1 for the A321.

7.36 - Added "Once airborne, perform the Windshear Escape Maneuver."

Windshear In Flight

7.36 - Revised section to include A321.

Chapter 8 - Non-Normal Operations

Section -

Non-Normal Approach Speeds.

8.3 - Added VLS (FULL).

EGT OVERLIMIT (Exceedance) During Takeoff

8.12 - Revised to match training standards.

Flight Crew Duties Summary For Emergency Landing/ Ditching Evacuation

8.15 - Added Take portable ELT (Ditching).

Single Hydraulic System Failure

8.24 - Revised Single Hydraulic System Failure Section for A321.

Brake Malfunctions

8.26 - Revised Brake Malfunctions description to match QRH.

Landing with Abnormal Landing Gear

8.28 - Added statement referring to recycling landing gear.

Chapter 9 - Human Factors

9.1- Added Human Factors chapter from FOM.

Chapter 10 - Selected References

10.1 - Added Selected References Chapter from FOM.

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Preface

Chapter PT

List of Effective Pages - FAA Approved

Section 5

Page	Date
FCTM	
* Title Page.1-2	April 8, 2016
* PT.TOC.0.1-2	April 8, 2016
* PT.1.1-6	April 8, 2016
* PT.2.1-6	April 8, 2016
* PT.3.1-12	April 8, 2016
* PT.4.1-12	April 8, 2016
* PT.5.1-2	April 8, 2016
General Information (tab)	
* 1.TOC.1-4	April 8, 2016
* 1.1-38	April 8, 2016
Ground Operations (tab)	
* 2.TOC.1-2	April 8, 2016
* 2.1-44	April 8, 2016
Takeoff, Initial Climb (tab)	
* 3.TOC.1-2	April 8, 2016
* 3.1-38	April 8, 2016
Climb, Cruise, Descent, Holding (tab)	
* 4.TOC.1-2	April 8, 2016
* 4.1-32	April 8, 2016
Approach, Missed Approach (tab)	
* 5.TOC.1-4	April 8, 2016
* 5.1-70	April 8, 2016
Landing (tab)	
* 6.TOC.1-2	April 8, 2016
* 6.1-30	April 8, 2016

Page	Date
Maneuvers (tab)	
* 7.TOC.1-4	April 8, 2016
* 7.1-38	April 8, 2016
Non-Normal Operations (tab)	
* 8.TOC.1-4	April 8, 2016
* 8.1-38	April 8, 2016
Human Factors (tab)	
* 9.TOC.1-2	April 8, 2016
* 10.1-20	April 8, 2016
Selected References (tab)	
* 10.TOC.1-2	April 8, 2016
* 10.1-36	April 8, 2016
Index (tab)	
* Index.1-8	April 8, 2016

* = Revised, Added, or Deleted

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General Information

Chapter 1

Table of Contents

Section TOC

Crew Resource Management.....	1.1
Flow Pattern Diagrams	1.1
Pushback	1.2
After Start	1.3
Prior to Taxi	1.4
Taxi	1.5
Delayed Start.....	1.6
After Delayed Start.....	1.7
Before Takeoff.....	1.8
After Flaps Selected Up	1.9
Climb	1.10
Descent.....	1.11
Approach.....	1.12
Landing	1.13
After Landing	1.14
Shutdown - After Engine Cool Down	1.15
Shutdown - Approximately One Aircraft Length from the Gate	1.16
Shutdown - After Stopping at Gate.....	1.17
Maneuver Speeds and Margins.....	1.18
Flap Maneuver Speeds	1.18
Minimum Maneuver Speed.....	1.19

Maneuver Margins	1.19
Managed Target Speeds	1.20
Takeoff	1.20
Climb, Cruise and Descent	1.20
Approach	1.20
Landing	1.21
Non-Normal Conditions	1.21
Reference Speeds	1.22
Reference Speed	1.22
Thrust Management	1.23
Setting Thrust	1.23
Maximum Thrust	1.23
Track - Flight Path Angle Mode	1.24
RNAV Operations	1.25
RNP and EPE Definitions	1.25
Basic RNP Concept	1.27
Autoflight Guidelines	1.30
Automatic Flight	1.30
FCU Guidelines	1.33
Flight in Moderate to Heavy Rain, Hail, or Sleet	1.33
Turbulent Air Penetration	1.34
Ice Crystal Icing	1.35
Recognizing Ice Crystal Icing Weather	1.35
Avoiding Ice Crystal Icing Weather	1.36
Suspected Ice Crystal Icing	1.36
Wing Anti-Ice Operation - In Flight	1.36



A319/320/321 Flight Crew Training Manual

Fly-By-Wire Flight Controls	1.37
Fly-By-Wire	1.37
Pitch Control	1.37
Roll Control	1.37

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Crew Resource Management

The nature of training requires that pilots have a clear understanding of human factors in FOM chapter 12 prior to training.

The “train the way you fly” philosophy requires that pilots have a good understanding of CRM and Delta Air Lines’ Threat and Error Management (TEM) model. TEM is integrated into every training program at Delta Air Lines. Pilots are expected to perform the following TEM actions during training:

- conduct effective briefings to deal with expected threats,
- proactively identify threats and ways to manage them,
- identify errors and ways to manage them as they are detected, and
- mitigate the consequences of an error after detection.

In addition to TEM strategies, pilots will use the following CRM tools during training:

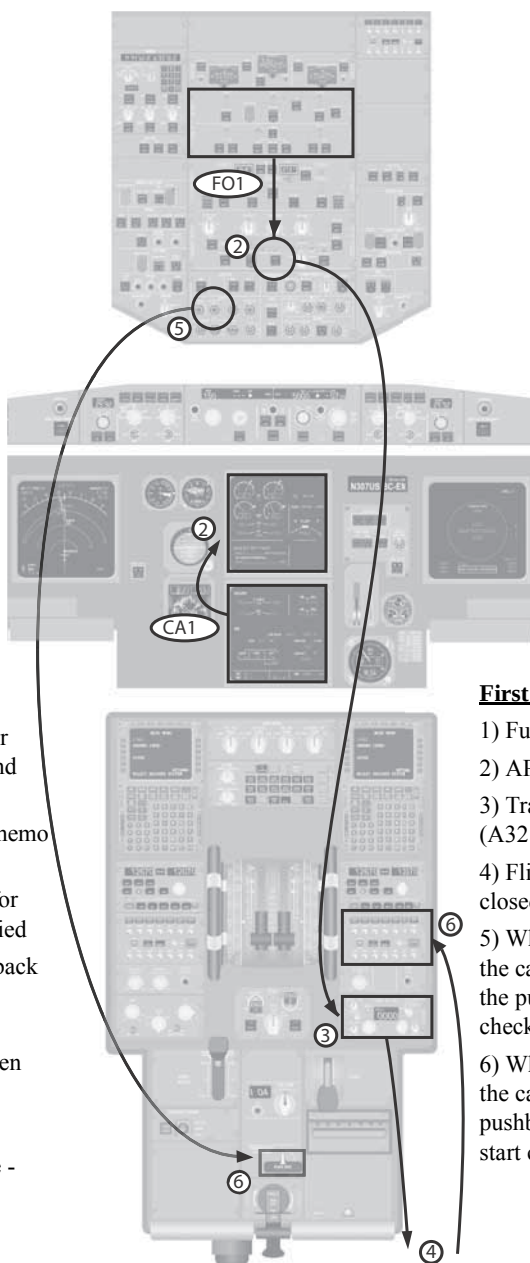
- situational awareness,
- decision making,
- planning,
- communication,
- workload management, and
- professional management.

Flow Pattern Diagrams

Flow patterns are based on their respective procedure and follow the order of the aircraft-specific tasks listed in the procedure. Flow pattern diagrams are a visual training aid used to facilitate accomplishing the steps listed in the respective procedure.

Pushback

When all exterior doors are closed and the cabin is ready for pushback:



Captain Items

- 1) Verify exterior doors - closed and slides armed
- 2) N/WS DISC memo - displayed
- 3) Cabin ready for pushback - verified
- 4) Call for pushback checklist

When pushback clearance has been received:

- 5) Beacon - ON
- 6) Parking brake - OFF

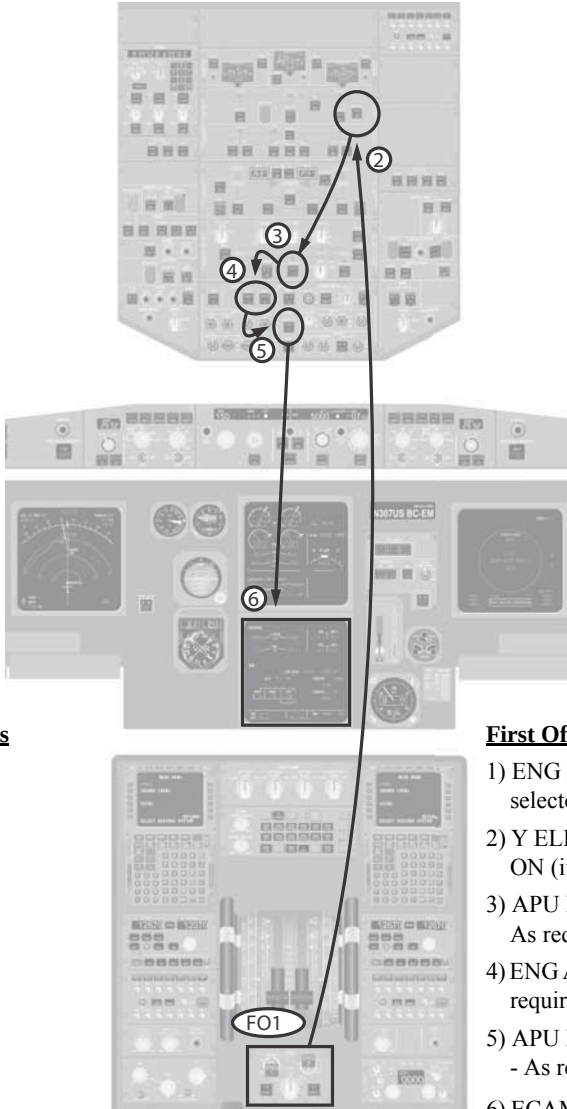
First Officer Items

- 1) Fuel Panel - Set
- 2) APU BLEED - ON
- 3) Transponder - ON, (A321 AUTO)
- 4) Flight deck door - closed and locked
- 5) When requested by the captain, complete the pushback checklist.
- 6) When requested by the captain, call for pushback or engine start clearance.

A319/320/321 Flight Crew Training Manual

After Start

After starting engine(s):



Captain Items

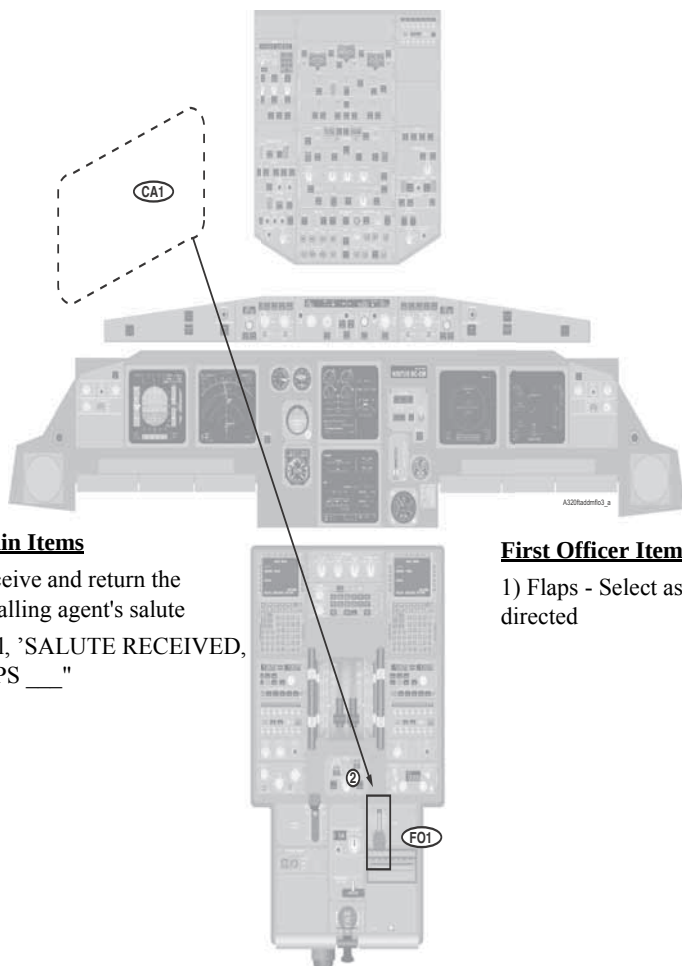
N/A

First Officer Items

- 1) ENG MODE selector - NORM
- 2) Y ELEC PUMP pb - ON (if S/E taxi)
- 3) APU BLEED pb - As required
- 4) ENG ANTI-ICE - As required
- 5) APU MASTER SW - As required
- 6) ECAM Status page - Check

Prior to Taxi

Prior to aircraft movement:



Captain Items

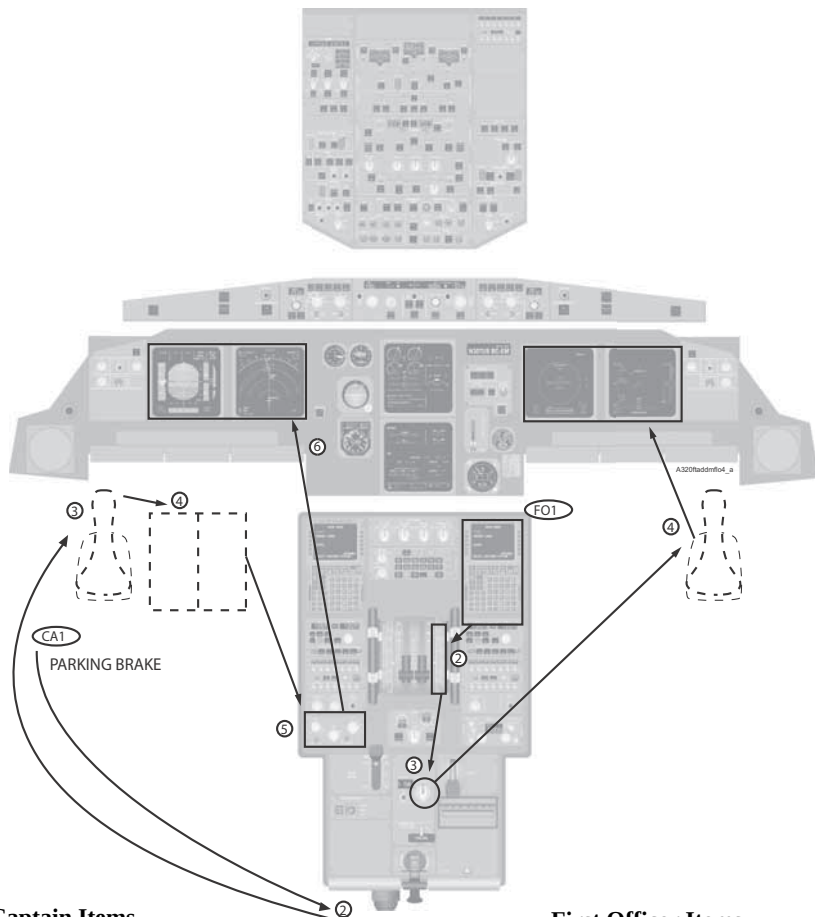
- 1) Receive and return the marshalling agent's salute
- 2) Call, "SALUTE RECEIVED, "FLAPS ____"

First Officer Items

- 1) Flaps - Select as directed

A319/320/321 Flight Crew Training Manual

Taxi



Captain Items

- 1) Brake Check - Accomplish
- 2) Analyze WDR
- 3) *Aileron, Elevator flight controls - Check
- 4) *Rudder control - Check
- 5) Radar - Test
- 6) Flight Instruments - Check

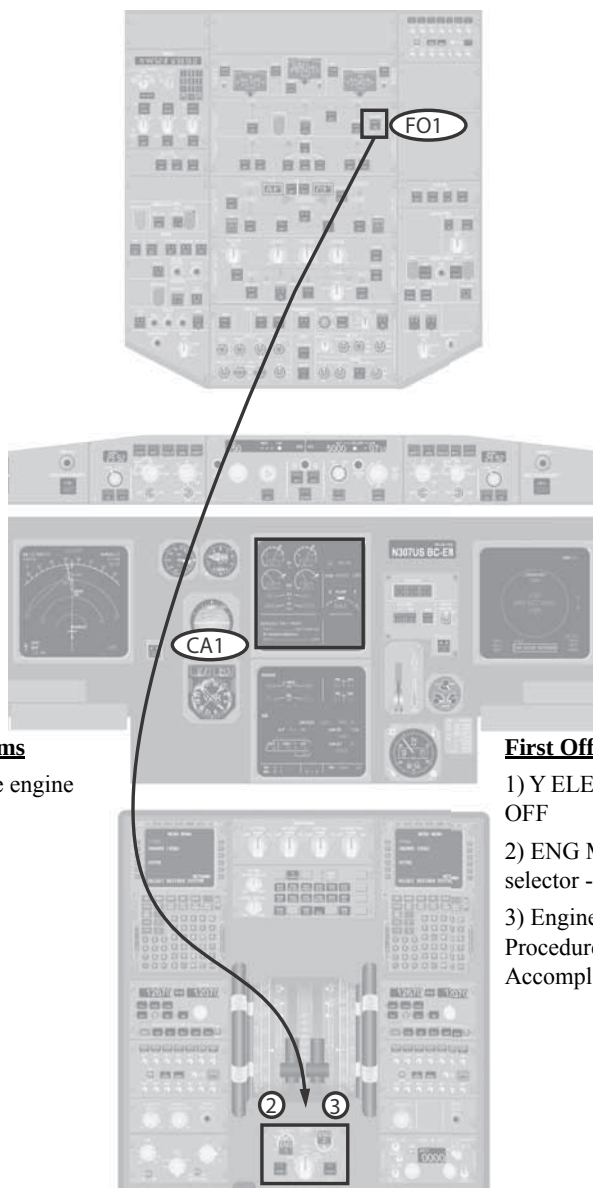
First Officer Items

- 1) Referencing the analyzed WDR data - Perform FMS entries
- 2) Pitch Trim - Set (after engine start)
- 3) RUD TRIM RESET - Push
- 4) *Aileron and Elevator Flight controls - Check
- 5) Flight Instruments - Check

* If two-engine taxi

Delayed Start

When ready to start:



Captain Items

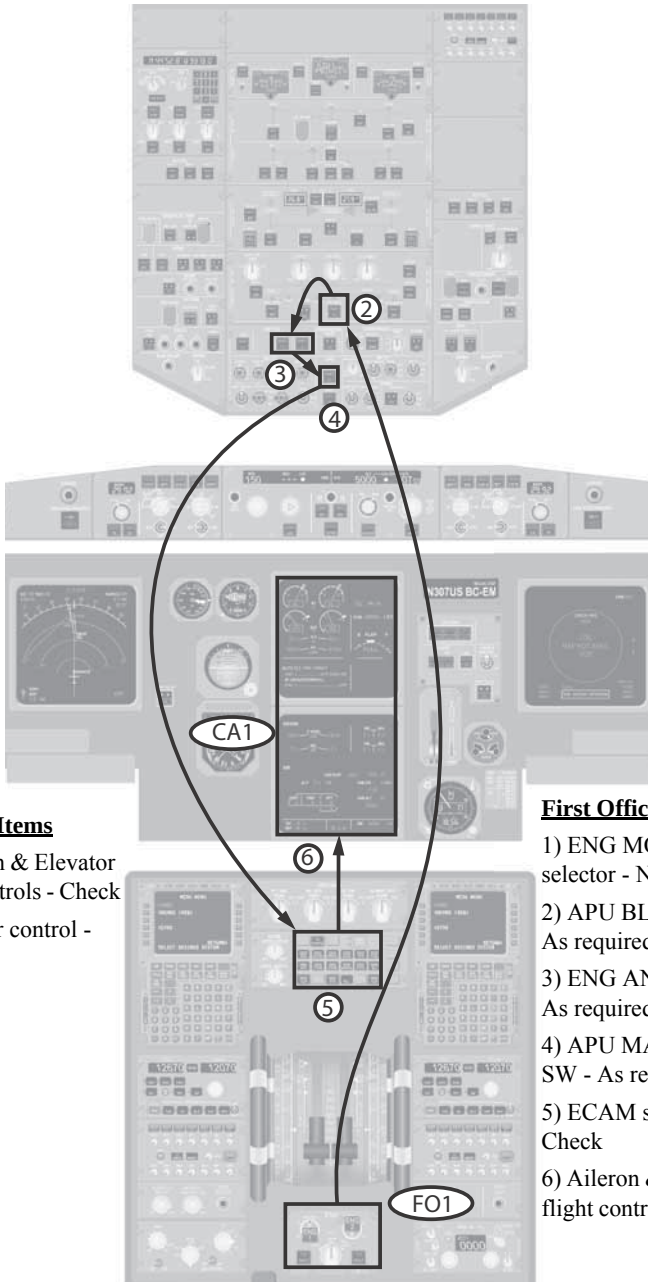
- 1) Announce engine start

First Officer Items

- 1) Y ELEC PUMP pb - OFF
- 2) ENG MODE selector - IGN/START
- 3) Engine Start Procedure - Accomplish

A319/320/321 Flight Crew Training Manual

After Delayed Start



Captain Items

- 1) Aileron & Elevator flight controls - Check
- 2) Rudder control - Check

First Officer Items

- 1) ENG MODE selector - NORM
- 2) APU BLEED pb - As required
- 3) ENG ANTI ICE - As required
- 4) APU MASTER SW - As required
- 5) ECAM status - Check
- 6) Aileron & Elevator flight controls - Check

Before Takeoff

When in proximity to departure runway:

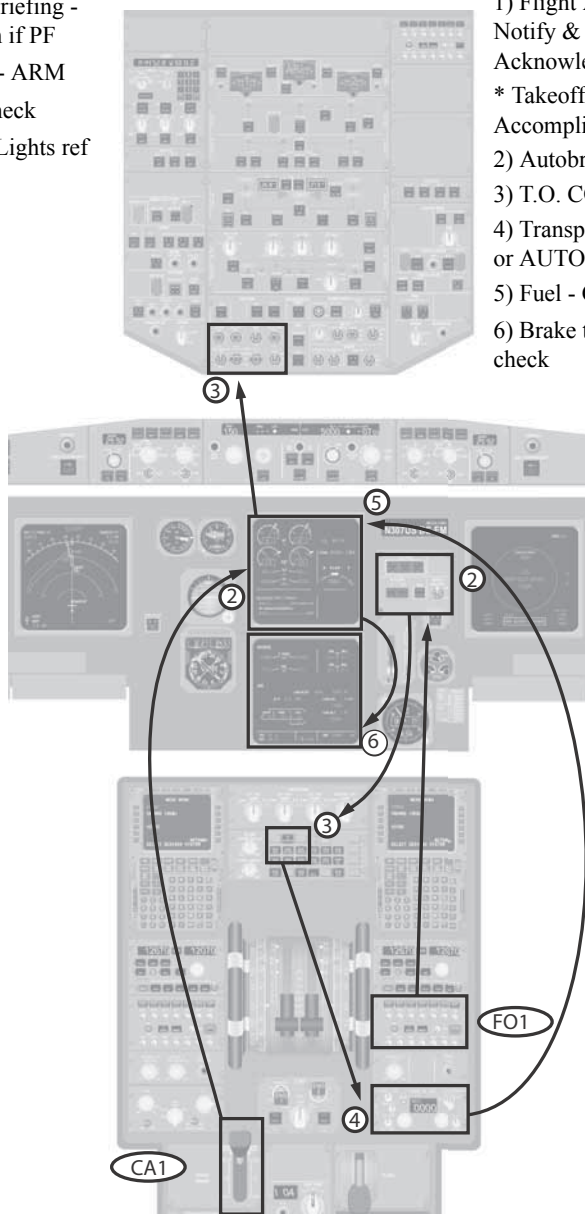
Captain Items

* Takeoff Briefing - Accomplish if PF

- 1) Spoilers - ARM
- 2) Fuel - Check
- 3) Set Ext. Lights ref NP.12

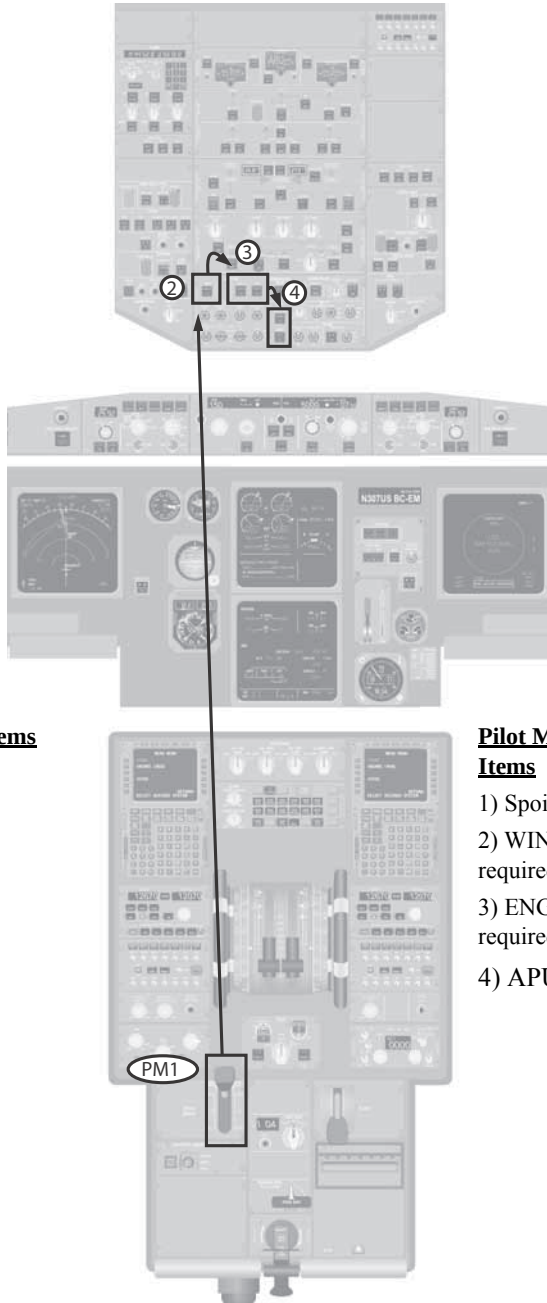
First Officer Items

- 1) Flight Attendants - Notify & Receive Acknowledgment
- * Takeoff Briefing - Accomplish if PF
- 2) Autobrakes - MAX
- 3) T.O. CONFIG - Push
- 4) Transponder - RA/TA or AUTO (A321)
- 5) Fuel - Check
- 6) Brake temperatures check



A319/320/321 Flight Crew Training Manual

After Flaps Selected Up



Pilot Flying Items

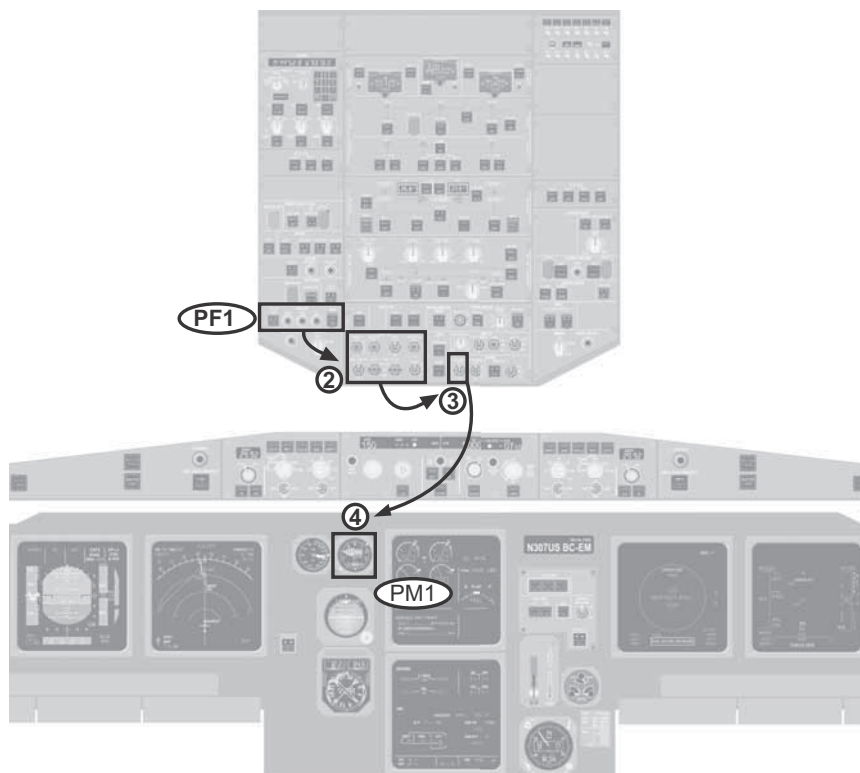
N/A

Pilot Monitoring Items

- 1) Spoilers - Disarm
- 2) WING anti-ice - As required
- 3) ENG anti-ice - As required
- 4) APU - verify off

Climb

| After climbing through approximately 10,000 feet AFE:

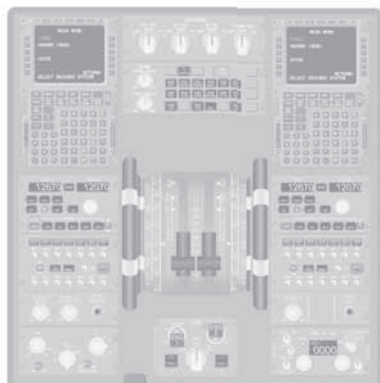


Pilot Flying Items

- 1) (C) SEAT BELTS switch - Cycle OFF-ON to sound cabin chime twice
- 2) (C) Set ext. lights ref NP.12
- 3) (C) SEAT BELTS sign - OFF
- 4) (C) Altimeters - STD at Transition Altitude

Pilot Monitoring Items

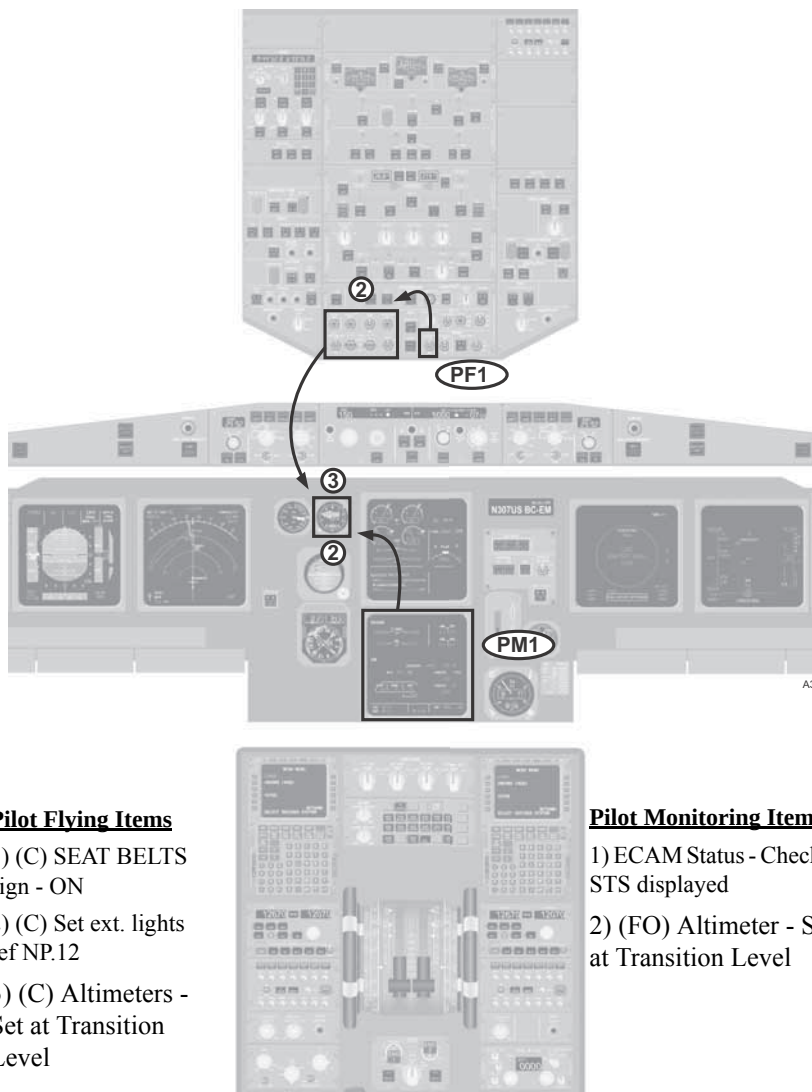
- 1) (FO) Altimeter - STD at Transition Altitude



A319/320/321 Flight Crew Training Manual

Descent

At top of descent or approximately 20 minutes prior to landing:



Pilot Flying Items

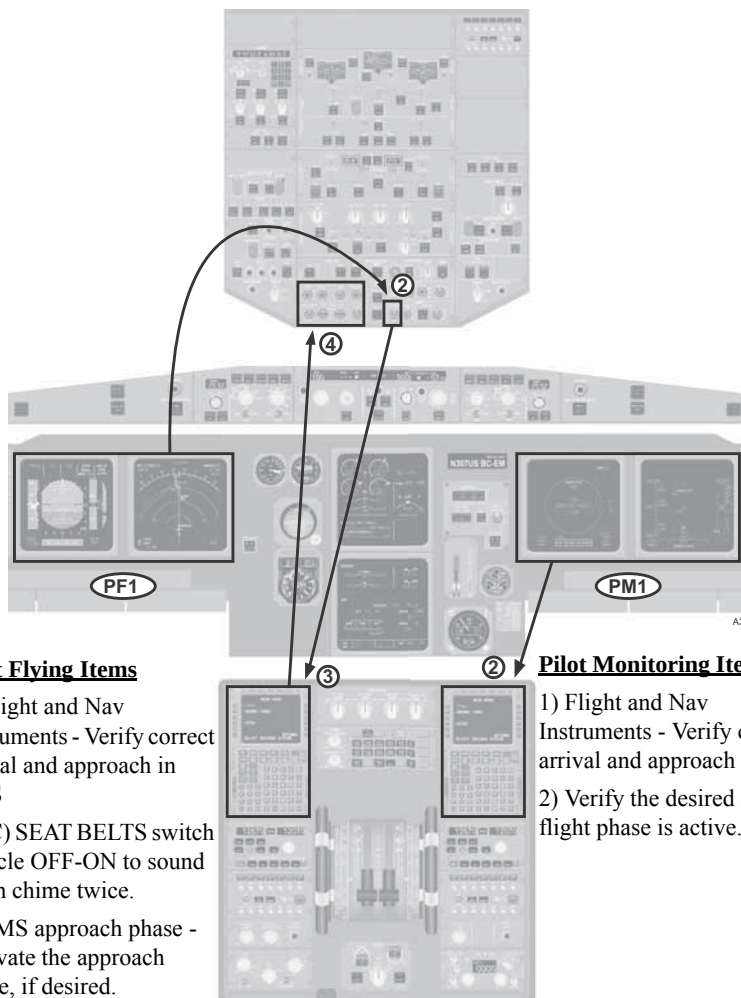
- 1) (C) SEAT BELTS sign - ON
- 2) (C) Set ext. lights ref NP.12
- 3) (C) Altimeters - Set at Transition Level

Pilot Monitoring Items

- 1) ECAM Status - Check if STS displayed
- 2) (FO) Altimeter - Set at Transition Level

Approach

Before descending through approximately 10,000 AFE:



Pilot Flying Items

- 1) Flight and Nav Instruments - Verify correct arrival and approach in FMS
- 2) (C) SEAT BELTS switch - Cycle OFF-ON to sound cabin chime twice.
- 3) FMS approach phase - Activate the approach phase, if desired.
- 4) (C) Set ext. lights ref NP.12

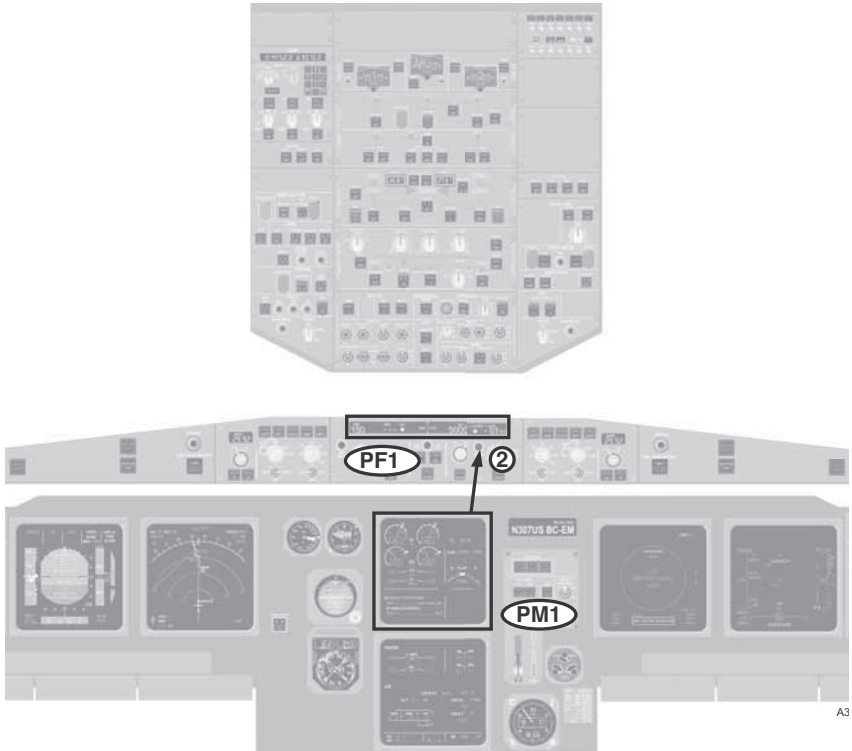
Pilot Monitoring Items

- 1) Flight and Nav Instruments - Verify correct arrival and approach in FMS
- 2) Verify the desired FMS flight phase is active.

A319/320/321 Flight Crew Training Manual

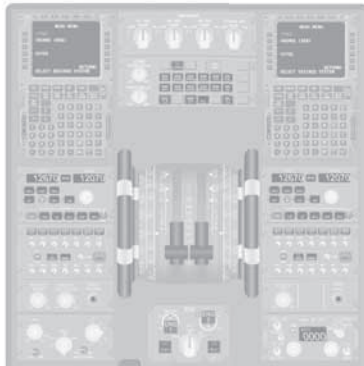
Landing

No later than 1,000 feet AFE:



Pilot Flying Items

- 1) Missed Approach Altitude - Verify Set



Pilot Monitoring Items

- 1) LDG MEMO - Verify all green
- 2) Missed Approach Altitude - Verify Set

After Landing

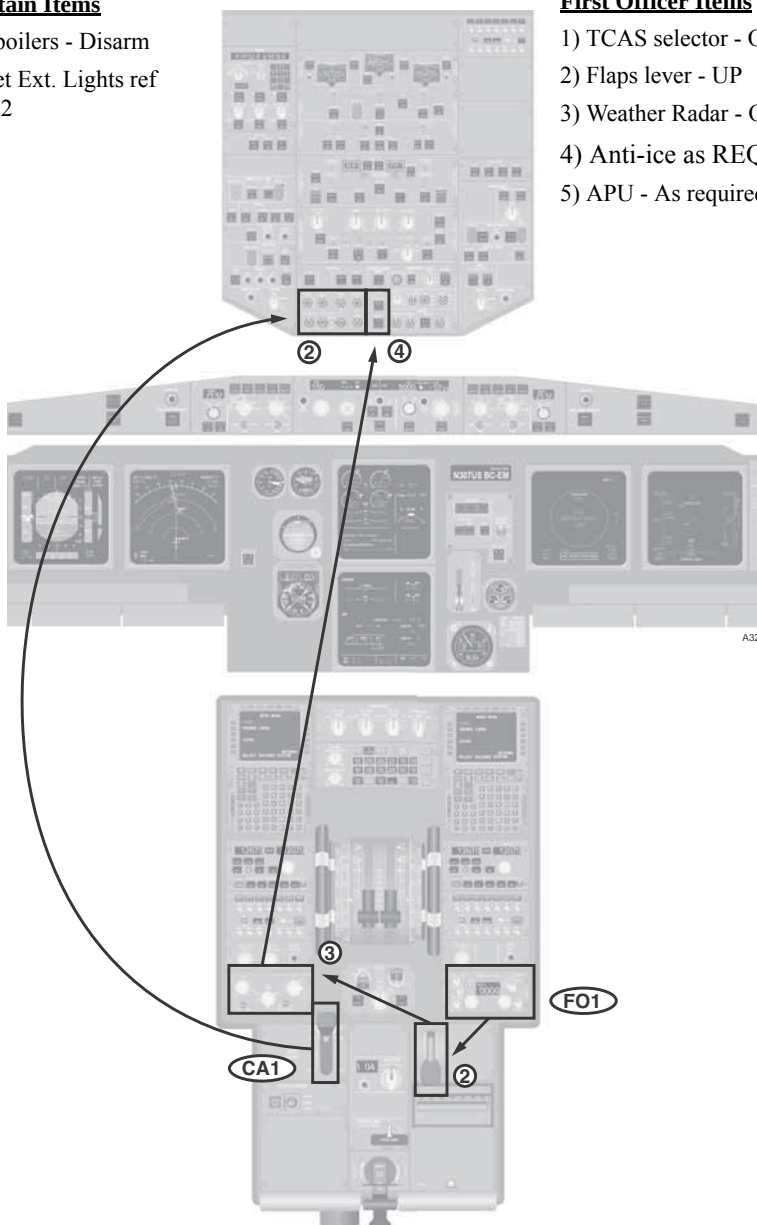
When clear of the active runway and workload permits:

Captain Items

- 1) Spoilers - Disarm
- 2) Set Ext. Lights ref NP.12

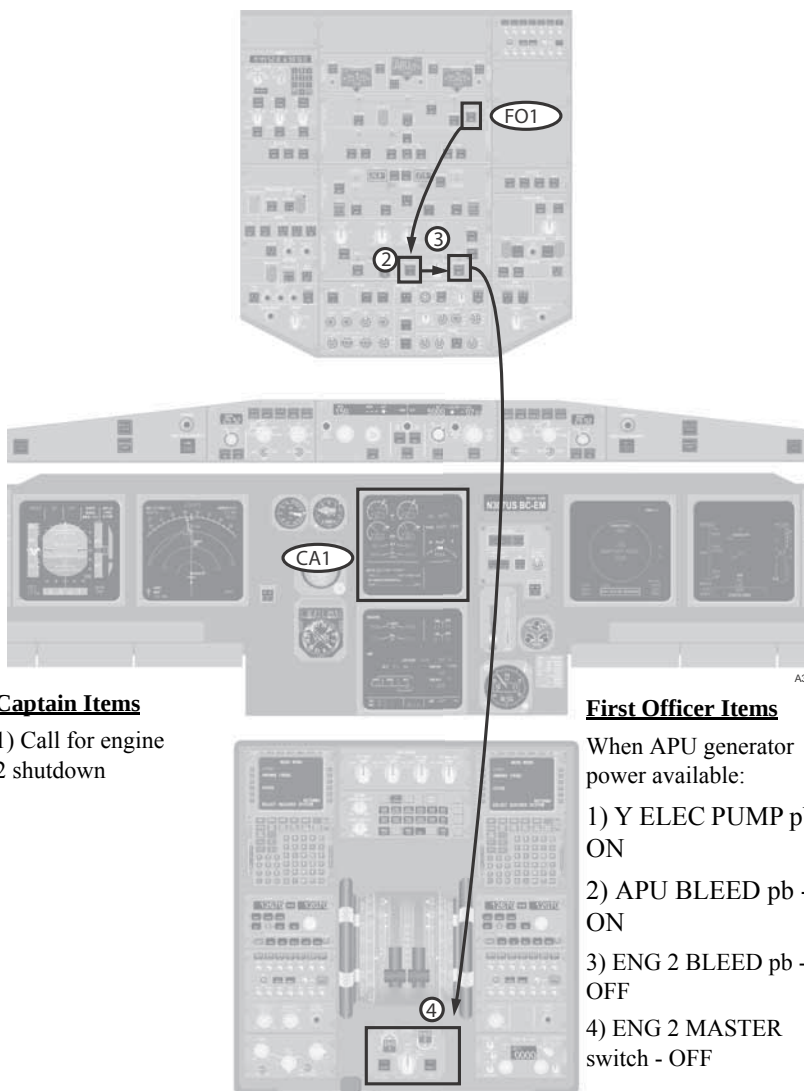
First Officer Items

- 1) TCAS selector - ON
- 2) Flaps lever - UP
- 3) Weather Radar - OFF
- 4) Anti-ice as REQ'D
- 5) APU - As required



Shutdown - After Engine Cool Down

After engine cool down recommendations have been met and single engine taxi is desired:



Captain Items

- 1) Call for engine
- 2 shutdown

First Officer Items

When APU generator power available:

- 1) Y ELEC PUMP pb - ON
- 2) APU BLEED pb - ON
- 3) ENG 2 BLEED pb - OFF
- 4) ENG 2 MASTER switch - OFF



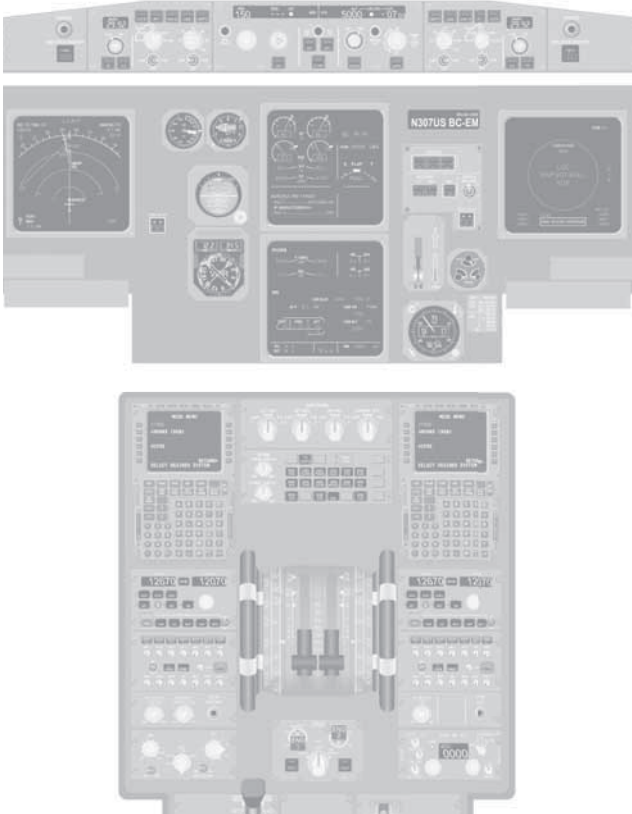
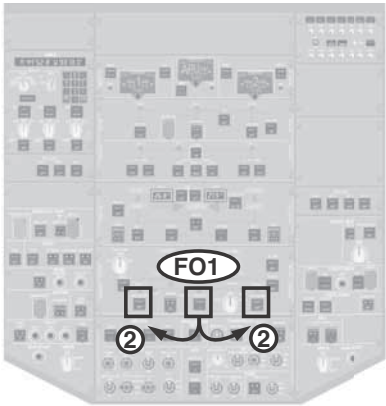
Shutdown - Approximately One Aircraft Length from the Gate

Captain Items

N/A

First Officer Items

- 1) APU BLEED - ON
- 2) ENG BLEED(s) - OFF
- 3) Brake fans-as required (A321)



A319/320/321 Flight Crew Training Manual

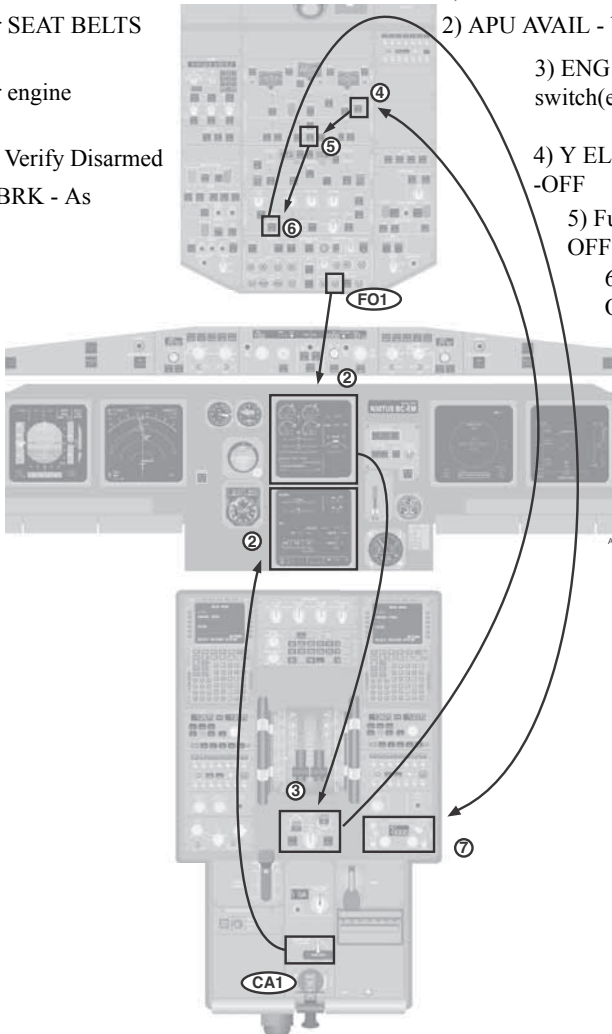
Shutdown - After Stopping at Gate

Captain Items

- 1) PARK BRK - ON
- 2) Call for SEAT BELTS sign OFF
- 3) Call for engine shutdown
- 4) Doors - Verify Disarmed
- 5) PARK BRK - As required

First Officer Items

- 1) SEAT BELTS switch - OFF
- 2) APU AVAIL - Verify
- 3) ENG MASTER switch(es) - OFF
- 4) Y ELEC PUMP pb - OFF
- 5) Fuel pump pbs - OFF
- 6) BEACON - OFF
- 7) Transponder - STBY



Maneuver Speeds and Margins

This section explains flap maneuver speeds and minimum maneuver speeds. It also describes maneuver capability during both a flap extension and flap retraction scenario.

Flap Maneuver Speeds

Flap retraction and extension schedules are indicated by S, F, and green dot speeds. They are displayed on the PFD and on the MCDU PERF TAKEOFF and APPR pages. V1 and V2 are displayed on the PFD. They reflect the speed inserted by the pilot into the MCDU. Lowest selectable speed (VLS) and VAPP are also displayed on the PFD and PERF APPR page. The aircraft has the same maneuver margin that a conventional aircraft would have at its reference speeds. It also has a low-speed protection feature (alpha limit) that the flight crew cannot override.

These speeds are displayed on the PFD as follows:

S and F Speed Indications

The minimum recommended airspeed for retracting the slats/flaps is displayed as a green S or F:

- S is displayed when the flap handle is in position 1.
- F is displayed when the flap handle is in position 2 or 3.

S or F represents the best lift/drag speeds for the current configuration.

Green Dot Airspeed

The best lift/drag speed in the clean configuration is shown by a green circle on the airspeed display (referred to as “green dot”). Green dot speed is also:

- the minimum angle of descent speed (maximum glide distance in still air),
- the slowest speed the autothrust will maintain in managed speed in the clean configuration during the FMS approach (APPR) phase.
- the managed speed in the go-around phase (refer to Vol. 2, chapter 34, Navigation).
- the clean managed speed following an engine failure (when the aircraft is climbing), and
- the best rate of climb speed (single engine conditions).

VFE NEXT is displayed as an amber = sign on the PFD airspeed display and represents the maximum speed for the next flap position.

Minimum Maneuver Speed

Lowest Selectable Airspeed

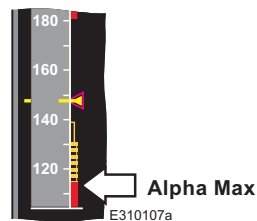
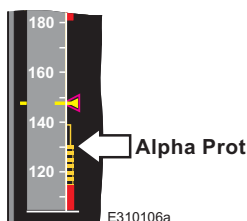
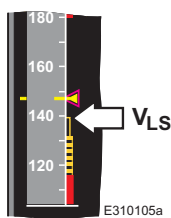
V Lowest Selectable (VLS) is the minimum selectable speed that the autothrust system will maintain with the autopilot on or following the flight director. VLS is calculated dynamically and varies with configuration, load factor (e. g. bank angle), and speed brake extension. It provides margins against stalls, VMC, and is corrected for Mach effect to maintain a 0.3 g buffet margin.

VLS is represented by the top of the amber hook on the PFD airspeed indicator.

VLS is also calculated independent by the FMS for landing performance and displayed on the PERF APPR page. This calculation uses the computed landing weight and CG, selected landing configuration, and landing airport elevation. VLS (FULL) is the same speed as VREF (ECAM uses VREF for speed additives).

VLS is equal to:

- 1.13 VS, at takeoff,
- 1.23 VS, with slats extended, flaps retracted, and
- 1.28 VS, when in clean configuration. (It remains at this value until landing).



Maneuver Margins

Flight control laws determine the handling characteristics, level of automation, and flight envelope protection carried out by the flight control computers.

Normal law contains built-in protections that prevent the aircraft from exceeding defined limits. The limits built into normal law also allow a pilot to execute maximum performance maneuvers without over stressing the aircraft. Refer to Vol. 2, 27.10, Normal Law Protections.

Managed Target Speeds

Target speed may be set by the pilot through the FCU or managed by the FMS and is displayed by a blue (selected) or magenta (managed) triangle on the PFD airspeed indicator if within the display range. If the target speed is outside the airspeed display range, a digital indication of the target airspeed appears at the top or bottom of the airspeed display as appropriate. A target speed can always be selected by the pilot through the FCU. The following discussion focuses on managed speed by phase of flight.

Takeoff

The Speed Reference System (SRS) sets a managed target speed of $V_2 + 10$ with both engines operating. During single engine operations, SRS uses V_2 or the current speed if higher.

As the acceleration height is passed, SRS changes to the Open or Managed climb mode and the target speed to the managed climb speed (normally 250 knots). This change also occurs if the FCU altitude is acquired or a change is made to the vertical mode on the FCU.

Climb, Cruise and Descent

The FMS changes the managed speed to the appropriate ECON CLB speed when above 10,000 feet MSL. ECON CRZ speed is used at the cruise altitude. ECON DES speed is used during the descent. At or below 10,000 feet MSL, the managed target speed is 250 knots.

Approach

Once the approach phase is activated, the FMS sets managed speed to the final approach speed for the landing flap configuration (normally FLAPS 3 or FULL), regardless of the current flap setting. However, the autothrust or pitch flight guidance will not command a slower speed than the minimum maneuvering speed for the existing flap setting when in managed speed.

VAPP is computed by the FMGC using the winds inserted into the MCDU PERF APPR page. During the approach, the FMGC factors in the current ADIRS winds and varies the VAPP Target to maintain the minimum energy level.

Landing

Ground Speed Mini

If the actual headwind is greater than the steady state wind entered into the PERF APPR page, the aircraft's target speed is increased above VAPP ensuring the aircraft energy level remains at a safe margin above stall in the event of a sudden loss of headwind. As the aircraft nears touchdown, actual winds are progressively considered and the target speed is computed to avoid large thrust inputs on short final. GSMINI is only available in managed speed and is not directly displayed on the PFD. Refer to Vol. 2, 22.10, Speed Guidance.

Wind Component

Maximum gust velocity and least favorable direction will be used to compute the crosswind component.

Steady state wind velocity will be used to compute the headwind or tailwind component.

Non-Normal Conditions

Occasionally, a non-normal checklist instructs the flight crew to use a speed additive for the approach. To apply the additive, the crew must apply the additive to the VLS (FULL) displayed on the MCDU PERF APPR page:

$$VAPP = VLS (FULL) + \text{non-normal speed additive (from the ECAM or QRH)}.$$

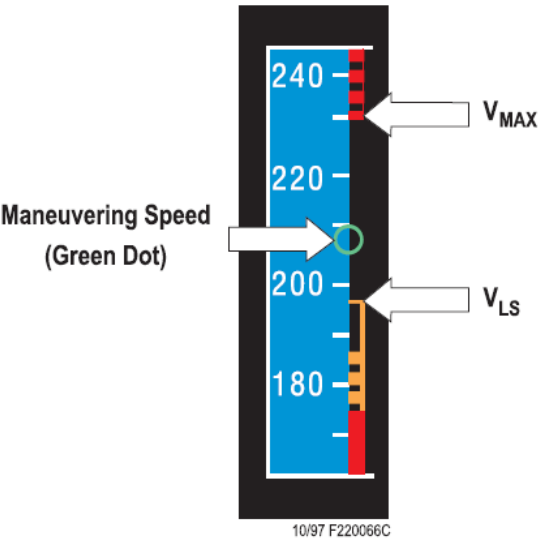
Note: It is important to understand that the speed additive is always applied to the VAPP with FULL as the selected landing flap configuration. This is true even if the ECAM/QRH guidance indicates that a FLAPS 3 landing is to be performed.



Reference Speeds

Reference Speed

The following figure shows the positioning of the target speeds displayed on the airspeed indicator for takeoff and approach.



Thrust Management

Setting Thrust

Thrust can be either set manually by the position of the thrust levers or controlled automatically by the A/THR system. Refer to Vol. 2, 10.22 for a full discussion of the A/THR system.

Maximum Thrust

The maximum thrust available is TOGA thrust.

It is important for crews to understand that TOGA thrust is always available by advancing the thrust levers fully forward, regardless of the level and status of automation.

Track - Flight Path Angle Mode

When TRK-FPA is selected the Flight Path Vector (FPV) is displayed on both PFDs. The FPV shows the lateral track (heading adjusted for drift) and the vertical flight path angle (climb or descent in degrees).

The FPV shows actual aircraft performance. Due to inertia, there is some delay between a pitch change and achieving the desired flight path angle. This delay may make flying dynamic maneuvers in relation to the FPV difficult. Conversely, the FPV is well adapted to fairly stable situations such as level flight and approaches.

The flight director with TRK-FPA selected is a single command bar. The flight director simultaneously commands pitch and roll reflecting the current lateral and vertical flight guidance modes.

TRK-FPA display automatically switches to normal two cue (cross bars) mode when TO/GA is selected on a go-around (with Flaps 1 or greater).

The FPV can be used in several ways:

- on non-ILS approaches for a glide path reference;
- as a reference for establishing and maintaining level flight when the F/D is not in use or not available. When maneuvering the aircraft, adjust pitch to place the FPV on the horizon. This results in zero vertical velocity;
- as a cross-check of the vertical flight path angle when established in a climb, descent, or on a visual final approach segment;
- in climbs or descents, radar tilt can be adjusted to an appropriate elevation based on the displayed FPA. Radar tilt, like the FPV, is referenced to the horizon; and
- as a qualitative indication of aircraft lateral drift direction. The FPV moves left or right of the pitch scale to indicate the relative position of the ground track to the present heading. The amount of drift cannot be determined from this display.

A319/320/321 Flight Crew Training Manual

RNAV Operations

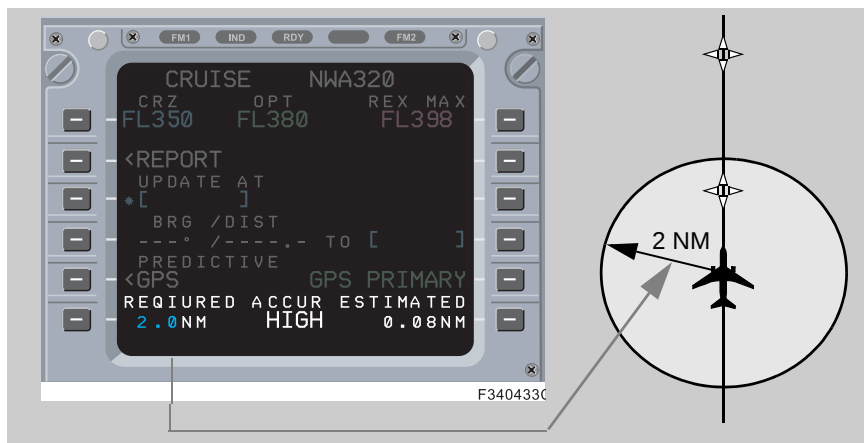
This section provides definitions of terms associated with RNAV and describes basic concepts to include phase of flight navigation for radius-to-fix (RF) legs, terminal (SIDs and STARs), en-route, and approach operations.

RNAV or area navigation is a method of navigation that allows aircraft to fly on any desired flight path within the coverage of GPS, referenced NAVAIDS, or within the capability of self-contained systems, or a combination of these capabilities.

En-route operations can be defined as oceanic and domestic. Oceanic RNAV requirements are described in detail in the applicable MNPS guidance material such as the Pacific or North Atlantic manuals. Specific routes or areas of operation are given RNP levels based on route separation requirements. RNP 10 routes are suitable for all FMSs that are capable of GPS updating and those FMSs that cannot update from GPS but have received the last radio update within the previous six hours.

RNP and EPE Definitions

RNP (Required Navigation Performance) is a specified navigation performance for route, terminal, or approach procedures. It is a measure of the navigation performance accuracy necessary for operations within a defined airspace where the aircraft must be at least 95% of the time. It is shown in nautical miles. All RNP based procedures have an associated RNP level that is published on the procedure chart and displayed on the MCDU PROG page at 6L: REQUIRED.



Oceanic RNP operations are generally 4.0 or higher. Domestic en-route RNAV operations depend on the GPS and are back up with radio updating (DME-DME) sources to support domestic RNP operations. The following domestic RNP operations are fully supported with DME-DME or GPS updating active:

- USA and Canada - RNP 2.0 or higher, RNAV-1, and RNAV-2;
- Europe - B-RNAV (RNP 5.0);
- Asia - As specified for the route or area (e.g. RNP 4 or RNP 10 routes); and
- Africa - As specified for the route or area.

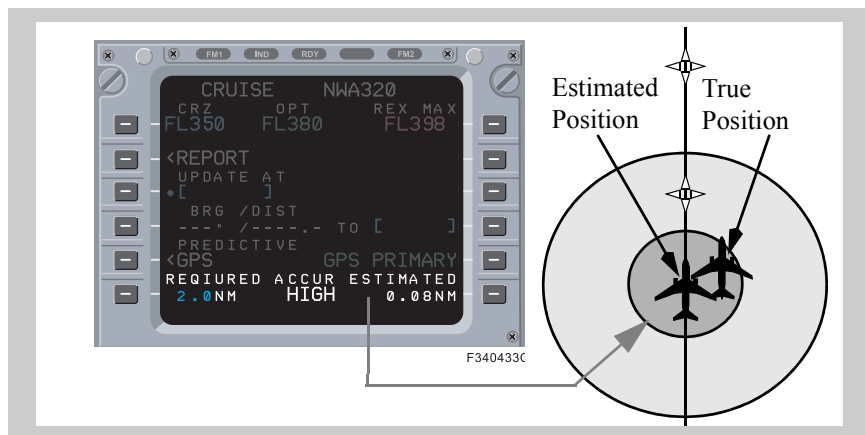
Terminal RNAV operations (SIDs, STARs, and Transitions) are fully compatible with all FMSs with DME-DME or GPS updating active and are defined as:

- USA and Canada - RNP 1.0 SIDs and STARs and
- Europe - P-RNAV (RNP 1.0).

RNAV approaches are compatible with all FMSs provided DME-DME or GPS updating is active at the beginning of the approach and the approach RNP is equal to or greater than the minimum demonstrated RNP in the AFM. Restrictions published on some RNAV approaches may preclude their use without GPS updating active. Approach RNP can be as low as 0.10 NM.

See the Approach section of this manual for further details regarding the techniques for flying RNAV approaches.

EPE (Estimated Position Error) is the FMS calculated certainty of the aircraft's position in nautical miles. It is situation information for the flight crew representing a system estimate of the radius of the area in which the actual position of the aircraft lies. The system uses the best available sensor(s) to minimize positioning error. The flight crew or autoflight system must track the RNAV path using managed nav. There is a 95% probability that the aircraft is within the displayed EPE.



A319/320/321 Flight Crew Training Manual

Basic RNP Concept

RNP is RNAV operations with on-board navigation performance monitoring and alerting. RNP was developed as a method for certifying the navigation capability for RNAV systems that can use multiple sensors for position updating. Navigation performance within the RNP level assures traffic and terrain separation. RNAV (RNP) procedures must be flown as published in the navigation database. Pilot defined routes and lateral or vertical route modifications are not allowed.

The FMS uses one of the following as the displayed RNP:

- Default RNP - FMS default values are set by the FMS and are displayed if no RNP is available from the navigation database or one has not been manually entered.
- Navigation database RNP values (if available) are displayed based on values associated with the procedure. These values may be unique for certain segments or terminal procedures.
- Manually entered RNP - remains until changed or deleted.

The crew may need to make a manual RNP entry if the displayed RNP for the route or procedure is incorrect. Setting an RNP smaller than what is specified for the procedure, airspace, or route may cause nuisance crew alerts. If the RNP is set larger than that specified for a procedure or segment, crew alerting may occur at the incorrect RNP (if the specified RNP is exceeded). The RNP is depicted on the published procedure being flown.

Although today's airspace design has already established certain lateral limits (RNP), no Vertical Required Navigation Performance limits are published. Vertical Required Navigation Performance is available on some FMSs and may be used for certain descent profiles such as Continuous Descent Approaches (CDA), Optimized Profile Descents (OPD), or Tailored Arrivals (TAs).

Lateral and Vertical Deviation

Aircraft performance in staying within the designated RNP containment path is critical. The first indication that the aircraft is having difficulty in following the prescribed path may be displacement of the FD crossbars. While on an RF leg, the first indication might be if the aircraft reaches its maximum bank angle (normally 30°).

For the A321, lateral deviation is displayed on the PFD LDEV display. Each dot of lateral deviation on the LDEV display is equal to 0.1 NM.

For all aircraft, lateral deviation from the path is indicated by the crosstrack (XTK) error displayed on the ND. For the A319/320, this XTK error is displayed to single decimal accuracy. The first XTK indication when deviating from the path is 0.2 NM, while a 0.1 NM deviation can be displayed when returning to the path. For the A321, XTK is indicated to two decimal places. The first indication when deviating is 0.02 NM, with 0.01 NM displayed only when returning to the path.

For all aircraft, vertical deviation is displayed by the PFD VDEV display and numerically on the PROG page. Each dot on the VDEV display is equal to 100 feet.

If vertical deviation approaches the limit as indicated on the VDEV display or PROG page, a missed approach is required.

If lateral deviation approaches the limit as indicated on the LDEV display or XTK error, a missed approach is required.

Note: For the A319/320, a missed approach is required as soon as 0.2 NM XTK error is displayed.

During RNP operations other than approach, anytime the deviation exceeds the limit or an amber GPS PRIMARY LOST message occurs, the crew must return the aircraft to course by selecting an intercept HDG or manually flying the aircraft back to course. If unable to comply, the flight crew must revert to other means of navigation such as conventional ground-based or radar navigation.

During RNP approach operation, any time the deviation exceeds the limit or an amber GPS PRIMARY LOST message occurs the crew must execute a missed approach unless suitable visual reference has been established and the aircraft is aligned with the landing runway. In the event of a missed approach, the crew may consider requesting an alternate clearance.

EPE Alerts

When EPE exceeds RNP, a NAV ACCUR DOWNGRAD RNP alert is displayed. If this occurs during RNP operations other than approach, the crew should verify position, confirm updating is enabled, and consider requesting an alternate clearance. This may mean changing to a non-RNP procedure or route or changing to a procedure or route with a RNP higher than the displayed EPE value.

If the alert occurs during RNP approach operations, the crew must execute a missed approach unless suitable visual reference has been established and the aircraft is aligned with the landing runway. In the event of a missed approach, the crew may consider requesting an alternate non-RNP clearance.

Autoflight Use During RNP

Normally, a route segment or procedural leg is defined by its required width. For RNP operations, route width is normally equal to at least $2.0 \times \text{RNP}$ from either side of the RNAV course. Required width is determined by minimum terrain or traffic clearance requirements. The probability of exceeding this maximum deviation after FINAL has engaged with the autopilot engaged is very small.

RNP operations require appropriate path tracking consistent with the RNP level. Use of the autopilot is required for all RNP approaches in IMC conditions and is required in VMC conditions for approaches that include an RF leg segment until arrival at the DA.

A319/320/321 Flight Crew Training Manual
Radius-to-Fix (RF) Legs

RF legs are waypoints connected by a constant radius course similar to a DME arc. These may be identified in some terminal procedures by 'Arc' displayed on the profile view (e.g. "RT Arc" or "LT Arc"). They can also be identified on the FMS F-Plan page by the label line 'xxARC' (in small white font) between waypoints (xs replaced by a number representing the radius of the arc).

Some considerations regarding the use of RF legs:

- There may be a maximum speed shown on some straight legs or some RF legs of smaller radius. This limitation is critical for the crew to observe since the ability of the aircraft to track the RF leg is determined by ground speed and maximum available bank angle. In high tailwinds, the resulting ground speed may cause the maximum bank angle to be reached. In this situation, excessive course deviation may occur if the maximum RF speed is exceeded.
- Do not begin a procedure by proceeding direct to an RF leg or by intercepting the course on an RF leg segment. This may cause excessive deviation when the aircraft maneuvers to join the RF leg. Normally there is a track-to-fix leg prior to an RF leg to ensure proper RF leg tracking.
- The second waypoint of an RF leg can be inadvertently deleted by entering an intercept course or proceeding Direct to the waypoint.
- If a go-around is executed while on an RF leg, it is important to immediately verify Managed NAV engagement to avoid excessive course deviation.

Autoflight Guidelines

Automatic Flight

Autoflight systems can enhance operational capability, improve safety, and reduce workload. Automatic approach and landing, Category III operations, and fuel-efficient flight profiles are examples of some of the enhanced operational capabilities provided by autoflight systems. LNAV, VNAV, and instrument approaches using VNAV are some of the reduced workload features. Varied levels of automation are available. The pilot decides what level of automation to use to achieve these goals by selecting the level that provides the best increase in safety and reduced workload.

Automatic systems give excellent results in the vast majority of situations. Deviations from expected performance are normally due to an incomplete understanding by the flight crew. The FMA indicates the status of the AP, FD, and A/THR, and their corresponding operating modes. The PF must monitor the FMA. The flight crew uses the FCU and MCDU to give orders to the AP/FD. When the automatic systems do not perform as expected, the pilot should reduce the level of automation until proper control of path and performance is achieved. For example, if the pilot failed to select the exit holding feature when cleared for an ILS or Localizer approach, the aircraft will intercept and fly the approach, but would not fly the missed approach because the holding fix, now behind the aircraft, is still the TO waypoint. If this occurs the PF may direct the PM to delete the holding fix waypoint and continue the ILS or Localizer approach. A second example, if the aircraft levels off unexpectedly during an ILS due to ALT* engagement prior to GS capture, the PF may reestablish a descent by selecting a new altitude in the FCU and continuing the descent using OP DES or V/S. Note that the minimum altitude selected in this case should be 1,000 feet above field elevation to ensure that stabilized approach criteria are met.

Early intervention prevents unsatisfactory aircraft performance or a degraded flight path. Reducing the level of automation as far as manual flight may be necessary to ensure proper control of the aircraft is maintained. The pilot should attempt to restore higher levels of automation only after aircraft control is assured. For example, if an immediate level-off in climb or descent is required, it may not be possible to comply quickly enough using the AFS. The PF should disengage the autopilot and level off the aircraft manually at the desired altitude.

Note: Regardless of the level of automation selected by the pilot, flight control laws will remain in effect. Pilots must understand the effect of flight control laws on pitch, roll, and thrust.

A319/320/321 Flight Crew Training Manual

Recommended Pitch and Roll Modes**Roll Modes**

The Lateral Guidance Modes provide flight guidance along a selected lateral path controlled via the FCU (HDG or TRK), or managed guidance following a previously entered flight plan. During an approach, lateral flight guidance can be automatically provided by coupling either:

- the lateral flight guidance to a localizer signal (LOC, LDA, SDF) or
- the FMS along a flight plan non-precision approach.

Note: In instrument conditions the approach must be selected from the database. It is not possible to couple the lateral flight guidance to a VOR or NDB signal.

Pitch Modes

Climbs or descents can be directly controlled by selecting modes and altitudes via the FCU. Managed climbs and descents can also be accomplished by programming altitude constraints (crossing restrictions) at flight plan waypoints and allowing the FMS to comply with them as the flight plan sequences.

Two actions must occur to make an altitude (level) change using the altitude knob:

- Select a new altitude with the FCU ALT knob (the new altitude remains in the FCU altitude window indefinitely).
- Pull or push the altitude knob.

Pulling on the altitude knob selects an open climb or descent (OP CLB or OP DES).

Pushing on the altitude knob activates a managed climb or descent (CLB or DES).

Selected vertical modes are available any time a FD or AP is engaged. Managed vertical modes are only available when managed lateral NAV (or LOC) is engaged because the managed vertical modes consider speed and altitude crossing restrictions (constraints) located at waypoints along the FMS flight plan. Managed vertical nav is not available in HDG.

An altitude change or level off may also be made with the vertical speed knob. Use of the vertical speed knob does not require setting the FCU altitude first. Vertical speed may also be selected in a direction away from the FCU altitude (e.g., selecting a vertical speed descent with the FCU altitude selected at or above the current), in which case no altitude capture will occur.

Autopilot Engagement

The autopilot is FAA certified to allow engagement at 100 feet AGL and at least 5 seconds after liftoff. The aircraft should be in trim, and the flight director commands should be satisfied before autopilot engagement. This prevents unwanted changes from the desired flight path during autopilot engagement.

Disengaging Automation

AP Disengage

The preferable means of disengaging the AP is with the red AP DISC push button on the sidestick.

Note: It is common practice to announce “Autopilot OFF” just prior to disengaging the AP to let the other pilot know that disengagement is intentional.

Disengaging the AP by pushing the illuminated AP push button on the FCU panel results in the ECAM failure message, AUTO FLT AP OFF appears, which must then be cleared with the ECAM CLR key.

Flight Directors OFF

When turning off the Flight Directors ensure BOTH are turned OFF. The PF should therefore clearly state, “Flight directors OFF” when wanting them off. Additionally, it is imperative that both pilots verify that column five of the FMA does not have any FD indications in line 2.

If a fixed thrust mode is engaged (OP CLB or OP DES) and the PF's FD is off while the PM's FD is on, the PF's PFD will not display pitch guidance. The autothrust will continue to follow the commands of the only engaged FD, either idle thrust (OP DES) or climb thrust (OP CLB). Failure to follow the commanded vertical guidance will result in a speed greater than or less than the target speed.

There is no scenario in which it is desirable or acceptable to have only one FD engaged.

A commonly used configuration is to select the autopilot and both flight directors off leaving the autothrust engaged. This configuration automatically places the autothrust in speed mode, and allows maneuvering with the autothrust maintaining the current selected or managed speed. This greatly reduces pilot workload allowing the pilot to concentrate on flight path, while the autothrust automatically takes care of the airspeed. For this reason, “flight directors off” is used when flying a TCAS maneuver, and as a technique for visual approaches.

Autothrust OFF

The recommended method of disconnecting the A/THR is to match the thrust levers to the actual thrust value (use the TLA “donuts”) then press either red instinctive disconnect push buttons on the thrust levers. The A/THR may also be disconnected by retarding both thrust levers fully to the idle thrust setting.

A319/320/321 Flight Crew Training Manual

FCU Guidelines

Crewmembers must coordinate their actions so that the aircraft is operated safely and efficiently.

Autothrottle Use

Use of A/THR is recommended during the entire flight. It may be used in most failures cases, including:

- engine failure, even during autoland, and
- abnormal configurations.

Airbus recommends the use of A/THR when the autotrim function is lost (i.e., direct law) to reduce pilot workload. However, if the use of A/THR aggravates pitch oscillations, manual thrust may be preferable.

A/THR should be monitored via the:

- FMA – SPEED / SPEED TREND on the PFD, and
- N1 and Thrust Limit Mode displayed on the ECAM E/WD.

Manual Flight

The PM should make FCU mode selections at the request of the PF. Heading and altitude changes from ATC clearances and speed selections associated with flap position changes may be made without specific directions. However, these selections should be announced, such as, “HEADING 170 SET”. The PF must be aware such changes are being made. This enhances overall safety by requiring that both pilots are aware of all selections, while still allowing one pilot to concentrate on flight path control.

Ensure the proper flight director modes are selected for the desired maneuver by referencing the FMA. If the flight director commands are not to be followed, both flight directors should be turned off.

Flight in Moderate to Heavy Rain, Hail, or Sleet

The aircraft is designed to operate satisfactorily when the maximum rates of precipitation expected in service are encountered. However, flight into moderate to heavy rain, hail, or sleet could adversely effect engine operations and should be avoided whenever possible. If moderate to heavy rain, hail, or sleet is encountered, reducing airspeed can reduce overall precipitation intake. Also, maintaining an increased minimum thrust setting can improve engine tolerance to precipitation intake, provide additional stall margin, and reduce the possibility of engine instability or thrust loss.

Turbulent Air Penetration

It is Delta Air Lines' policy to avoid severe turbulence if at all possible. When the aircraft is operated at its optimum altitude, margins available to the buffet boundary will normally be greater than 0.5g. Because of this, buffet and control margins will be adequate for most conditions. However, if moderate or greater turbulence is anticipated or encountered, a descent of 4,000 feet, or more is advisable. Other recommendations for operating in turbulent conditions include:

- Maintain a turbulent air penetration speed. These speeds provide the best structural protection during gusts while maintaining an adequate margin above VLS.
- If the autopilot is engaged, leave it engaged unless airspeed, altitude, or attitude deviations require the use of manual control. Maneuver in turbulence at bank angles below those normally used. In moderate turbulence, use the autothrust unless thrust changes are extreme. In severe turbulence, disconnect the autothrust.
- During manual flight allow airspeed to vary and maintain attitude. Avoid large thrust changes.
- Do not allow the airspeed to decrease and remain below the turbulence penetration speed as buffet margins will be reduced and considerable time will be required to regain speed. Sacrifice altitude if necessary and advise ATC. Keep the wings level or bank less than 15° if a turn is necessary.
- Rely primarily on the PFD for attitude reference. In severe vertical drafts, do not attempt to control the aircraft by reference to the air data instruments.
- At high altitude, you may experience momentary Mach buffet. It cannot persist and should not be confused with low speed buffet.

CAUTION: The reset of flight control computers is not allowed while in severe turbulence.

Other factors to consider in anticipation of turbulent air are:

- Use the shoulder harnesses.
- Ensure that the SEAT BELTS sign is ON.
- Place the ENG MODE selector to IGN/START.
- Notify the cabin crew of the expectation of turbulence.

Refer to Vol. 1, SP.16, Turbulence for additional information on turbulent air penetration.

Ice Crystal Icing

Ice crystals at high altitude are often not considered a threat to jet transport airplanes because they don't lead to airframe icing. However, a condition exists where solid ice particles can cool interior engine surfaces through melting and ice buildup can occur. When the ice breaks off, it can result in engine power loss or damage. Symptoms can include surge, flameout, or high vibration.

Typically, the engine power loss has occurred at high altitude, in clouds, as the airplane is flying above an area of convective weather where little or no airplane weather radar returns were observed at the flight altitude. In other cases, flight altitude radar returns were observed and pilots conducted the flight to avoid these areas. Despite pilot avoidance of reflected weather, engine power losses have occurred. Avoidance of ice crystals is a challenge because they are not easily identified.

At temperatures below freezing near convective weather, the airplane can encounter visible moisture made up of high concentrations of small ice crystals. Ice crystals can accumulate aft of the engine fan, in the engine core. Ice shedding can cause engine vibration, engine power loss, and engine damage.

These weather conditions are difficult to detect because ice crystals do not cause significant weather radar returns. They are often found in high concentrations above and near regions of heavy precipitation. Ice crystals do not stick to cold aircraft surfaces.

Flight in clouds containing ice crystals has been associated with engine vibration, engine power-loss, engine damage and airplane Total Air Temperature (TAT) probe icing.

Recognizing Ice Crystal Icing Weather

Ice crystals are most frequently found in areas of visible moisture and above altitudes normally associated with icing conditions. Their presence can be indicated by one or more of the following:

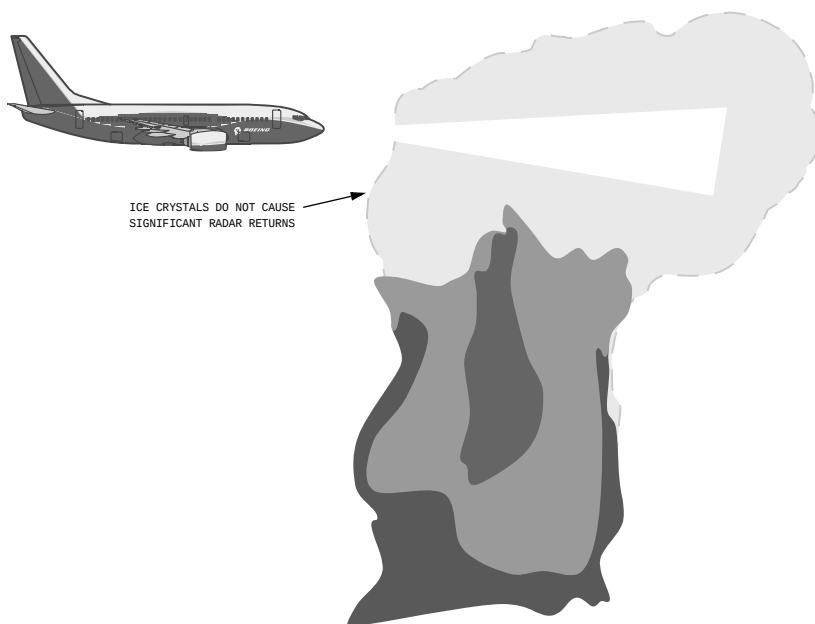
- appearance of rain on the windshield at temperatures too cold for liquid water to exist. This is due to ice crystals melting on the heated windows (sounds different than rain).
- areas of light to moderate turbulence
- In IMC with:
 - no significant radar returns at airplane altitude and
 - heavy precipitation below the airplane, identified by amber and red radar returns on weather radar
- cloud tops above typical cruise levels (above the tropopause)

Note: There is no significant airframe icing.

Avoiding Ice Crystal Icing Weather

During flight in IMC, avoid flying directly over significant amber or red radar returns, even if there are no returns at airplane altitude.

Use the weather radar controls to assess weather radar reflectivity below the airplane flight path. Refer to weather radar operating instructions for additional information.



Suspected Ice Crystal Icing

Exit the ice crystal icing conditions. Request a route change to minimize the time above red and amber radar returns.

Wing Anti-Ice Operation - In Flight

The wing anti-ice system may be used as a de-icer or anti-icer in flight only. The primary method is to use it as a de-icer by allowing ice to accumulate before turning wing anti-ice on. This procedure provides the cleanest airfoil surface, the least possible runback ice formation, and the least thrust and fuel penalty. Normally it is not necessary to shed ice periodically unless extended flight through icing conditions is necessary (holding).

The secondary method is to select the WING ANTI-ICE pb ON when wing icing is possible and use the system as an anti-icer.

Fly-By-Wire Flight Controls

The flight control design consists of a fly-by-wire system with its control laws and protections, commanded through the side stick, and an integrated Auto Flight System (AFS) comprising:

- the FMS interfaced through the MCDU,
- the AP/FD interfaced through the FCU,
- the A/THR interfaced through stationary thrust levers, and
- the FMA, providing Guidance targets and Information, to monitor the AFS.

Fly-By-Wire

The fly-by-wire system is used in the operation of all flight control surfaces, including flaps and slats. Pilot or autopilot demands are sent electronically to flight control computers. The demands are processed by the computers which send electronic commands to the appropriate flight control surface's hydraulic servos, which in turn move the control surfaces. Position signals from the control surface and feedback from aircraft sensors (e.g., g load) report the resulting performance back to the computer. Whereas some manufacturers build in “soft protections,” Airbus has chosen to incorporate “hard protections” to stop the aircraft from exceeding the design envelope. The computers contain factory preset instructions and limitations (flight control laws).

Pitch Control

In normal law, throughout most of the normal flight envelope, pitch is controlled by demanding changes in g load (load factor demand). Normal law provides automatic pitch trimming and flight envelope protections. Forward or aft sidestick displacement controls pitch by demanding a change in g load. The g load demanded determines the rate of pitch change. Returning the sidestick to neutral maintains the current pitch attitude and a 1 g load.

Roll Control

In normal law, throughout most of the normal flight envelope, roll control is roll rate demand. Left and right sidestick displacement demands a roll rate proportional to the sidestick displacement, independent of speed. Returning the sidestick to neutral maintains the current bank angle and zero roll rate.



Intentionally
Blank



Ground Operations
Table of Contents

Chapter 2
Section TOC

Preflight	2.1
FMS Uplinks	2.1
FMS Alternate	2.1
Pushback and Towing	2.3
Engine Start	2.4
Normal	2.4
Anomalies	2.4
Taxi	2.5
Taxi General	2.5
Using Runways as Taxiways	2.7
Thrust Use	2.7
Single Engine Taxi	2.9
Taxi Speed and Braking	2.9
Antiskid Inoperative	2.11
Tiller/Rudder Pedal Steering	2.11
Flight Deck Perspective	2.11
Turning Radius and Gear Tracking	2.13
Visual Cues and Techniques for Turning while Taxiing	2.17
Taxi - Adverse Weather	2.24
Ground De/Anti-Icing	2.25
Definitions and Concepts	2.25
Delta De/Anti-icing Program	2.28
Aircraft or Ground Emergency Communications	2.31
De/Anti-icing Fluids	2.32
Forced Air Deicing	2.34
Engine Running De/Anti-Icing	2.34



A319/320/321 Flight Crew Training Manual

De/Anti-icing Checks	2.35
Communication Procedures.....	2.39
Holdover Times	2.39
Configuring the Aircraft for De/Anti-icing	2.44

Preflight FMS Uplinks

The onboard communication systems facilitate two-way datalink communications between the FMS and Delta operations. Information can be uplinked at the discretion of the dispatcher or in response to a downlink request from the FMS. The uplink of data to the FMS is designed to reduce the data input crew workload. Data that can be uplinked includes, but is not limited to, flight plan routing, waypoint winds, descent forecast data, and performance initialization data. Data is uplinked to the aircraft via VHF ACARS.

Receipt of uplinked data is indicated by FMS scratch pad message(s). Refer to Vol. 1, NP.20, Preflight Procedure - Pilot Flying and Taxi Procedure.

FMS Alternate

Refer to the FLIGHT PLAN FUEL block of the Flight Dispatch Release:

FLIGHT PLAN FUEL	REQUIRED TIME/BURN	DISCRETIONARY TIME/BURN
TAXI		15/ 363
TRIP MSP/KMSP-ATL/KATL	237/ 16396	
ALTN SAV/KSAV FL270	41/ 4531	
RESERVE FUEL	45/ 3500	
CONTINGENCY FUEL	18/ 1206	18/ 1205

MIN FUEL FOR T/O	* 25633 *	*****
BLOCK FUEL		* 27200 *

- If **no destination alternate** airport is specified, insert the RESERVE FUEL value in the FINAL/TIME field on INIT page B.
- If a **single destination alternate** is specified:
 - The flight plan uplink system will automatically uplink the alternate airport into INIT A.
 - Insert the ALTN fuel value (4.5) into the ALTN field on INIT page B. (This action overwrites the FMS calculated value.)
 - Insert the RESERVE FUEL value (3.5) in the FINAL/TIME field on INIT page B.
- When **two destination alternates** are specified, the farthest is uplinked into the FMS. Insert the fuel value associated with this alternate.

**A319/320/321 Flight Crew Training Manual**

- **International Flights:** Most A-319/320 international flights are actually dispatched using Domestic Fuel Requirements and the above procedures are appropriate. If a flight is dispatched using International Fuel Requirements:
 - Verify the alternate airport on INIT page A.
 - Enter the ALTN fuel in the ALTN field on INIT page B.
 - Add the INTL FLAG RES and 30 MIN HOLD AT ALTN values and enter into the FINAL/TIME field on INIT page B.

Once the alternate is inserted in INIT A, the alternate airport appears (in blue) after the destination airport. The ALTN F-PLN section can be accessed either by scrolling to the end of the F-PLN or by pressing the AIRPORT p/b twice. If desired, the Alternate F-PLN can then be modified to include routing between the destination and alternate airports.

Pushback and Towing

Pushback and towing present serious hazards to ground personnel. Many accidents have occurred where personnel were run over by the aircraft wheels. Good communication between the flight deck and ground personnel is essential for a safe operation.

Pushback and towing involve three phases:

- positioning and connecting the tug and tow bar,
- moving the aircraft, and
- disconnecting the tow bar.

The marshaller, who is walking in the vicinity of the nose wheels, is usually the person injured or killed in the majority of the accidents.

Note: Pushback or tow out is normally accomplished with no hydraulic systems pressurized and the nose wheel steering locked out.

Note: The aircraft should not be taxied away from a gate, or pushback position, unless the marshaller indicates the aircraft is clear to taxi.

Engine Start

Normal

Approximate Idle Indications

Standard day, sea level, approximate stabilized idle indications are:

- N1 - approximately 20%,
- EGT - approximately 400°C,
- N2 - approximately 60%, and
- fuel flow - approximately 600 lbs/hr.

Normal Engine Start Considerations

- The ENG START selector must be placed in NORM to reset normal control of the ignition system.

Anomalies

There are two abnormal conditions that the ECAM cannot detect: a hung start and a tailpipe fire (refer to the QRH for non-normal procedures).

Taxi

Taxi General

Loss of situational awareness and not following ATC instructions result in runway incursions. The threat of incursions and collisions is a persistent problem. Planning, active monitoring/crosschecking, and vigilance help prevent ground incidents. If unsure of ATC instructions or obstruction clearance, stop the aircraft.

Use lights in accordance with Vol. 1, NP.12, Lights Usage.

The following guidelines are intended to enhance situational awareness and safety during ground operations:

Prior to Taxi

- Review NOTAMS and current ATIS for any taxiway or runway closures, construction activity, or other airport risks that could affect the taxi route.
- Both pilots verify that the correct aircraft position is in the FMS entries.
- Brief applicable items from airport diagrams and related charts to include the location of hold short lines.
- Ensure both crewmembers understand the expected taxi route.
- Complex taxi clearances should be written down or entered into the MCDU scratchpad when received.
- An airport diagram should be readily available to each crewmember during taxi.
- Be aware that hold short lines may be located as far as 400 feet from a runway edge.

During Taxi

- Exercise increased awareness when taxiing between parallel runways.
- Reference the heading indicator to ensure turns are being made in the correct direction and are following the assigned taxi route.
- Approaching a clearance limit, verbalize the hold short clearance limit.
- Keep other crewmembers in the loop by announcing when going heads down, and report when back up.
- Progressively follow taxi position on the airport diagram.
- During low visibility conditions, call out all pertinent signs to verify position.
- If unfamiliar with the airport consider requesting a FOLLOW ME vehicle or progressive taxi instructions.
- Use standard radio phraseology.
- Read back all clearances. If any crewmember is in doubt regarding the clearance, verify taxi routing with the assigned clearance or request clarification. Stop the aircraft if the clearance is in doubt.
- If ground/obstruction clearance is in doubt, stop the aircraft and verify clearance or obtain a wing-walker.

- Avoid distractions during critical taxi phases; plan ahead for checklist accomplishment and company communications.
- Consider delaying checklist accomplishment until stopped during low visibility operations.
- Do not allow ATC or anyone else to rush you.
- Be constantly aware of the equipment, structures, and aircraft behind you when the engines are above idle thrust.

Prior to Takeoff

- If you have been holding in position on the runway for more than 90 seconds, or upon seeing a potential conflict, contact the tower.
- When assigned a departure at an intersection, state the intersection departure during the clearance and read back.

If extended taxi time will result in fuel below min fuel for takeoff:

- Contact Dispatch to coordinate and adjust designation of some Required Additional Fuel to Discretionary Additional Fuel. This lowers the Minimum Fuel for Takeoff (desirable).
- Return to the gate (last resort).

At the runway if you are overweight for any reason (e.g., did not burn sufficient taxi fuel):

- use a lower assumed temperature setting to increase performance,
- Manually apply Flight Plan Addendum adjustments to WDR RATOW,
- delay takeoff until fuel has been burned, or
- request a TOPR/WDR update via ACARS.

Runway Safety

- Verify the runway is clear (both directions) and clearance is received prior to entering a runway.
- Confirm aircraft location utilizing an outside source such as runway signage, painted runway number markings, and/or aircraft heading.

Prior to Landing

- Plan/brief the expected taxiway exit and route to parking.

After Landing

- Ensure taxi instructions are clearly understood, especially when crossing closely spaced parallel runways.
- Delay non-essential radio or cabin communications until clear of all runways.
- Wait until you have exited the runway and you are sure of your taxi clearance prior to beginning an after landing checklist, or non-essential communications.

A319/320/321 Flight Crew Training Manual

Using Runways as Taxiways

- Minimize distractions, such as heads down time, discretionary company and cabin communications, engine starts and checklists when on any runway.
- Runways are typically wider than taxiways. As a result of field of vision, signs located at the edge of a runway may be more difficult for the pilot to see and identify than on the edge of a taxiway.
- While taxiing on a runway that crosses an active runway, the runway intersections points are frequently missing signs, markings, and lighting typically found on a taxiway.

Thrust Use

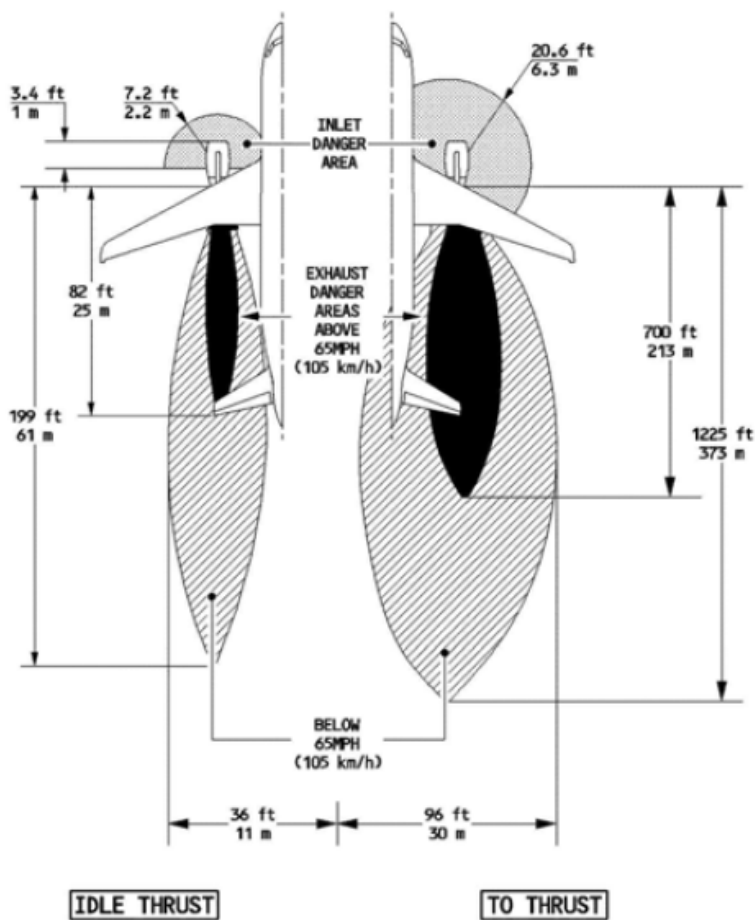
Thrust use during ground operation demands sound judgment and technique. Even at relatively low thrust the air blast effects from the large, high bypass engines can be destructive and cause injury. Aircraft response to thrust lever movement is slow, particularly at high gross weights. Engine noise level in the flight deck is low and not indicative of thrust output.

Excess thrust while taxiing may cause foreign objects to deflect into the lower aft fuselage, stabilizer, or elevators, especially when the engines are over an unimproved surface. Run-ups and taxi operations should only be conducted over well maintained paved surfaces and runways.

In some cases simply releasing the brakes is sufficient to begin moving, while other conditions will require greater thrust. Allow time for engine spool-up and aircraft movement before increasing thrust further. If more than 40% N1 is necessary, ensure area behind aircraft is clear or consider starting the other engine.

 DELTA

A319/320/321 Flight Crew Training Manual



A319/320/321 Flight Crew Training Manual

Single Engine Taxi

If a two-engine taxi is initiated but it is decided to use a single-engine taxi, ensure the APU generator is operating and place the yellow system electric hydraulic pump ON prior to shutting down engine #2.

High bypass engines require warm up prior to applying takeoff thrust and cool down prior to shutting down. If the engine has been shut down for several hours, it is desirable to operate the engine at as low a thrust setting as practical for several minutes prior to takeoff.

If taxiing with an engine shut down, the crew must be aware of systems requirements; i.e., hydraulics, brakes, electrical, particularly any degraded system operation due to enroute failures. When making a minimum radius turn, consider turning in a direction that puts the operating engine on the outside of the turn. In operational environments such as uphill slopes, soft asphalt, high gross weights, congested ramp areas, high density altitude airports, and wet/slippery ramps and taxiways; consider taxiing with both engines operating.

Taxi Speed and Braking

To begin taxi, release brakes, smoothly increase thrust to minimum required for the aircraft to roll forward, and then reduce thrust as required to maintain normal taxi speed. A turn should normally not be started until sufficient forward speed has been attained to carry the aircraft through the turn at idle thrust.

The aircraft may appear to be moving slower than it actually is due to the flight deck height above the ground. Consequently, the tendency may be to taxi faster than desired. This is especially true during runway turnoff after landing. The ground speed display on the ND may be used to determine actual taxi speed. The appropriate taxi speed depends on turn radius and surface condition.

Note: Passengers seated in the midsection of the cabin will hear the brake shuttle valve "clunk" every time the brakes are applied and released. Although passengers have expressed concern to the flight attendants in the past, the sound is normal.

Taxi speed should be closely monitored during taxi out, particularly when the active runway is some distance from the departure gate. Normal taxi speed is approximately 20 knots, adjusted for conditions. On long straight taxi routes, speeds up to 30 knots are acceptable, however at speeds greater than 20 knots use caution when using the nose wheel steering wheel to avoid overcontrolling the nose wheels. When approaching a turn, speed should be slowed to an appropriate speed for conditions. On a dry surface, use approximately 10 knots for turn angles greater than those typically required for high speed runway turnoffs.

Under normal conditions, differential braking and braking while turning should be avoided. Allow for decreased braking effectiveness on slippery surfaces.

Avoid following other aircraft too closely. Jet blast is a major cause of foreign object damage.

The use of reverse thrust to control taxi speed is not authorized except in emergencies.

Note: High taxi speed combined with heavy gross weight and a long taxi distance can result in tire sidewall overheating.

Note: Taxiing long distances with continuous light brake pressure can cause the wheel fuse plugs to melt and deflate the tires.

These braking technique recommendations are intended as general taxi guidelines only. Safety and passenger comfort should remain the primary considerations.

Note: Unlike other aircraft, the brake pedals do not have to be pressed before setting the PARK BRK - the parking brake will activate regardless of aircraft speed. Parking brake activation must be verified on the ACCU-PRESS BRAKES indicator. Handle position alone does not ensure brake activation.

Carbon Brakes

Carbon brake wear is primarily dependent on the total number of brake applications. One firm brake application causes less wear than several light applications. Maximum carbon brake life can be achieved during taxi by using a small number of long, moderately firm brake applications instead of numerous light brake applications. This can be achieved by allowing taxi speed to increase from below desired speed to above target speed. Then use a single moderately firm brake application to reduce speed below that desired and repeat as necessary. Carbon brake wear is much less sensitive to aircraft weight and speed than steel brake wear.

A321 Brake Fans

Brake fans cool the brakes and the brake sensor. Therefore, when the brake fans are running, the indicated brake temperature will be significantly lower than the indicated brake temperature when the brake fans are off. The brake temperature decreases almost instantaneously when the brake fans are turned on. On the other hand, when the brake fans are switched off, it will take several minutes for the indicated brake temperature to increase and match the actual brake temperature. When the fans are running, the difference between the indicated and actual brake temperature can range from 50°C (when the actual brake temperature is 100°C) to 150°C (when the actual temperature is 300°C). Therefore, before takeoff, if the fans are running, the flight crew should refer to the indicated brake temperature and delay takeoff when the indicated temperature is above 150°C. Brake fans should not be used during takeoff, in order to avoid Foreign Object Damage to fans and brakes.

Antiskid Inoperative

With antiskid inoperative, tire damage or blowouts can occur if moderate to heavy braking is used. With this condition, it is recommended that taxi speed be adjusted to allow for very light braking.

Tiller/Rudder Pedal Steering

The captain's and first officer's positions are equipped with a nose wheel steering tiller. The nose wheel steering tiller is used to turn the nose wheels through the full range of travel at low taxi speeds. Maintain positive pressure on the nose wheel steering tiller at all times during a turn to prevent the nose wheels from abruptly returning to center. Rudder pedal steering turns the nose wheels through a limited range of travel. Straight ahead steering and large radius turns may be accomplished with rudder pedal steering. On straight taxiways, the aircraft is correctly aligned on the centerline when the centerline is lined up between the PFD and ND.

The relationship between tiller deflection and nosewheel angle is not linear and the tiller forces are light. Therefore, the pilot should move the tiller smoothly and maintain the tiller's position. Any correction should be small and smooth, and maintained for enough time to enable the pilot to assess the outcome. Being over-active on the tiller will cause uncomfortable oscillations. Both pilots should not make simultaneous tiller inputs. Do not attempt to transfer control while a steering input is being made.

If nose wheel "scrubbing" occurs while turning, reduce steering angle and/or taxi speed. Avoid stopping the aircraft in a turn as excessive thrust is required to start taxiing again.

Differential thrust may be required at high weights during tight turns. This should only be used as required to maintain the desired speed in the turn. After completing a turn, center the nose wheels and allow the aircraft to roll straight ahead. This relieves stresses in the main and nose gear structure prior to stopping.

Flight Deck Perspective

There is a large area near the aircraft where personnel, obstacles, or guidelines on the ground cannot be seen, particularly in the oblique view across the flight deck. Special care must be exercised in the parking area and while taxiing. When parked, the pilot should rely on ground crew communications to a greater extent to ensure a safe, coordinated operation.

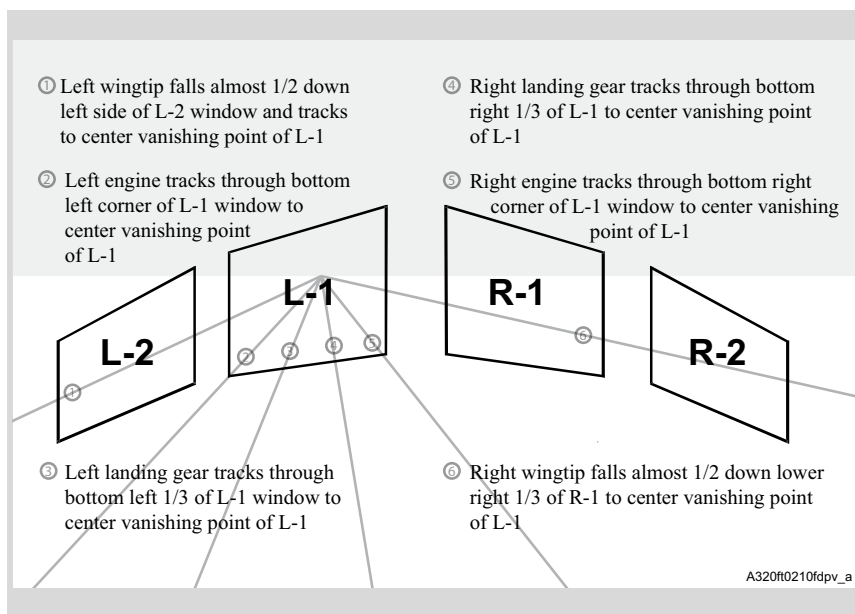
The pilot's seat should be adjusted for optimum eye position. The rudder pedals should be adjusted so that it is possible to apply maximum braking with full rudder deflection.

During taxiing, the pilot's heels should be on the floor, sliding the feet up on the rudder pedals only when required to apply brakes to slow the taxi speed, or when maneuvering in close quarters on the parking ramp.

Flight Deck References During Straight-Line Taxi

Certain flight deck references can be utilized to indicate the track of the main landing gear and wing tips while taxiing in a straight line.

These references are general guidelines only and crews must not rely solely on these to assure wing tip and/or main gear clearance. If ever in doubt to wing tip and/or main gear clearance, stop the aircraft and get wing walkers or have the aircraft towed.

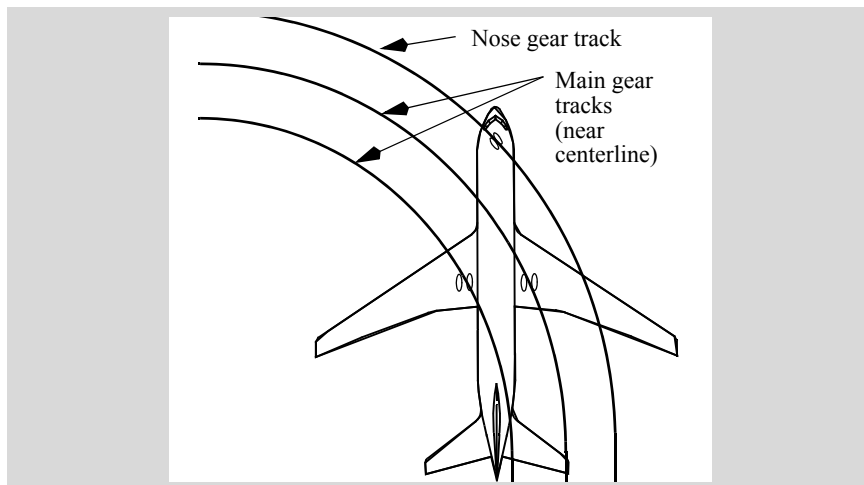


A319/320/321 Flight Crew Training Manual

Turning Radius and Gear Tracking

During all turning maneuvers, crews should be aware of their position relative to the nose and main landing gear. The pilot seat position is forward of the nose wheels and main gear as indicated in the tables in this chapter.

As the following diagram illustrates, while the aircraft is turning, the main gear tracks inside the nose gear. The smaller the radius of the turn, the greater the distance that the main gear tracks inside the nose gear and the greater the need to steer the nose gear outside of the taxi path (oversteer). For the A319/320, as the flight deck is only nine feet ahead of the nose gear, most normal turns require little to no oversteer.



Turning Radius Diagrams

Although the object may appear a comfortable distance from the flight deck, the wingtip scribes a larger arc than the flight deck. The following assumes a maximum effort, 70° turn:

- A319:
The wingtip's arc is approximately 16 feet in front of the flight deck.
- A320:
The wingtip's arc is approximately 12 feet in front of the flight deck.
- A321:
The wingtip's arc is approximately 4 feet in front of the flight deck.

CAUTION: The A321 wingspan is 6-feet wider than the A319/320. Use caution when taxiing or parking.

Pilots should verify that there is at least 20 feet of flight deck clearance before attempting a turn away from an object.

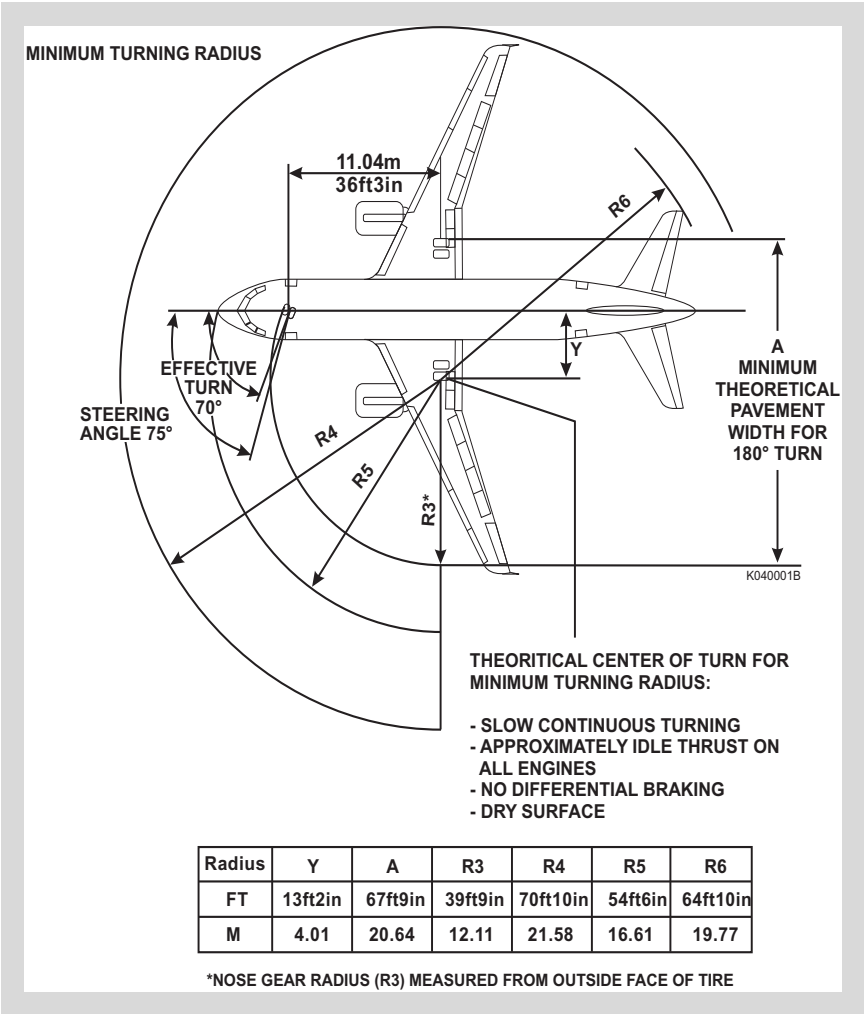


A319/320/321 Flight Crew Training Manual

The following illustration shows the minimum turn radius capability. The wing tip and elevator swings the largest arc while turning and determines the minimum obstruction clearance path. All other portions of the aircraft are within this arc.

Note: Minimum width of pavement for 180° turn A319 is 67 feet 9 inches. A320 is 75 feet 2 inches.

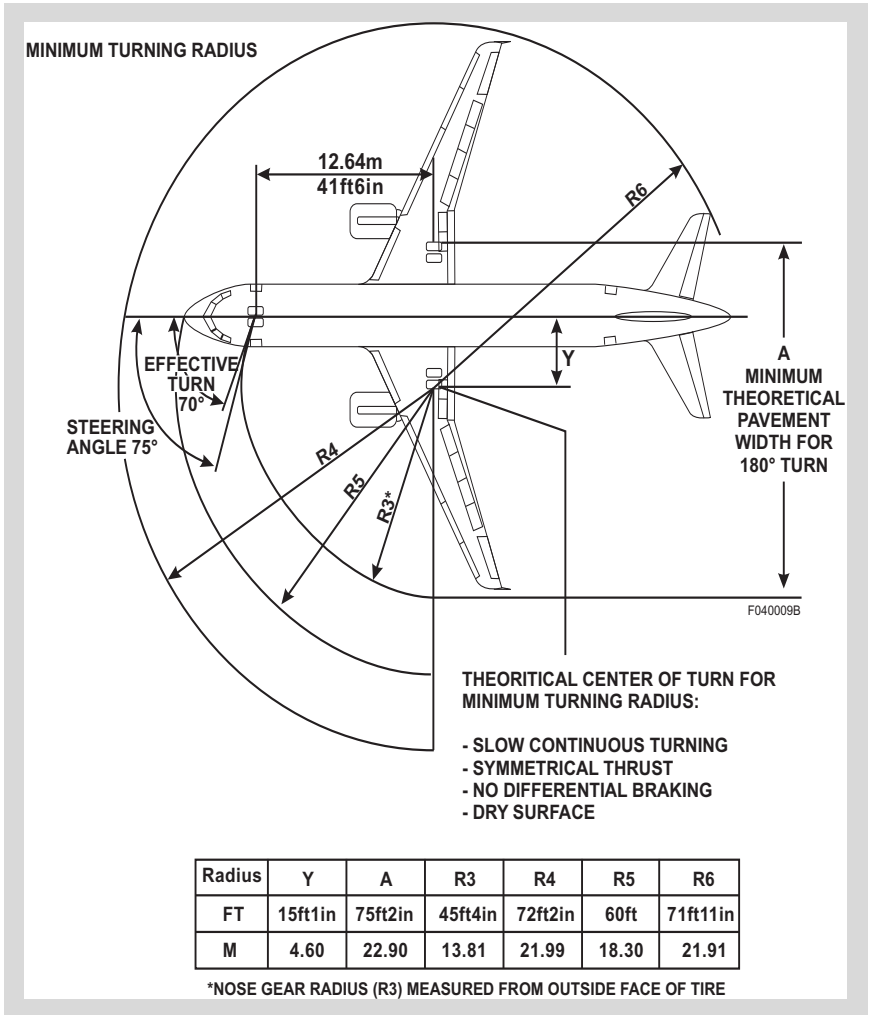
A319



Note: The A319 wingspan is 111 feet 10 inches.

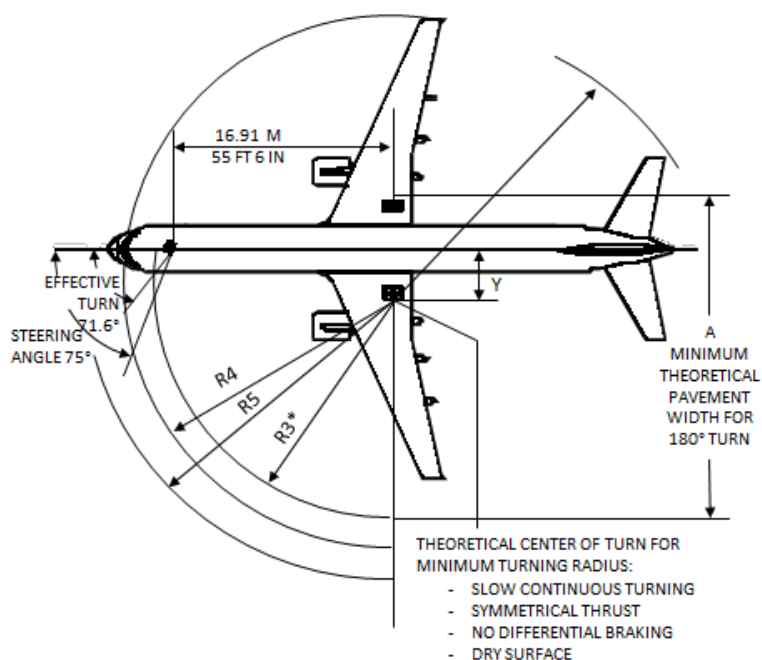
A319/320/321 Flight Crew Training Manual

A320



Note: The A320 wingspan is 111 feet 10 inches.

A321



	Y	A	R3	R4	R5	R6
F	18	93	59	78	74	81
M	5.6	28.3	17.9	23.9	22.7	24.7

* NOSE GEAR RADIUS (R) MEASURED FROM OUTSIDE FACE OF TIRE

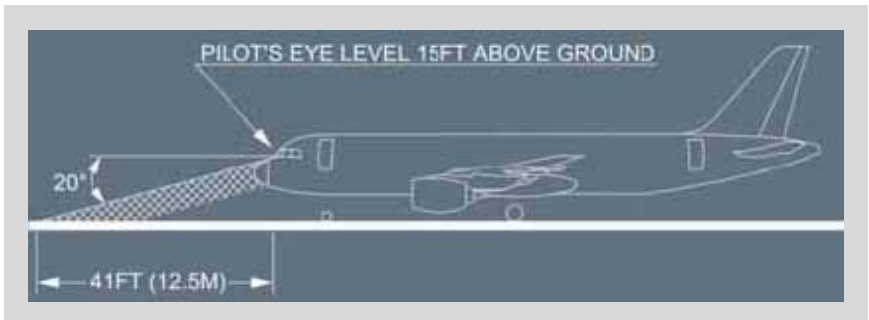
Note: The A321 wingspan is 117 feet 5 inches.

Visual Cues and Techniques for Turning while Taxiing

The following visual cues assume the pilot's seat is adjusted for optimum eye position. The following techniques also assume a typical taxiway width. Since there are many combinations of turn angles, taxiway widths, fillet sizes, and taxiway surface conditions, pilot judgment must dictate the point of turn initiation and the amount of nose wheel steering tiller required for each turn. Except for turns less than approximately 30° , speed should be 10 knots or less prior to turn entry. For all turns, keep in mind the main gear are located behind the nose wheels, which causes them to track inside the nose wheels during turns. The pilot position being forward of the nose wheels and main gear is depicted in the table below.

The oversteering technique may be considered, especially for A321 where main gear is 65 ft behind the pilot. On the A319 and A320 the main gear is located 45 ft and 50 ft behind the pilot, respectively, therefore little oversteer is required for most turns.

Model	Pilot Seat Position (forward of nose gear) feet (meters)	Pilot Seat Position (forward of main gear) feet (meters)
A319	9 (2.7)	45.3 (13.8)
A320	9 (2.7)	50.6 (15.4)
A321	10 (3.0)	65.6 (20.3)



When the seating position is correct, the cut-off angle is 20° , and the visual ground geometry provides an obscured segment of 41 feet (12.5 meters). During taxi, a turn must be initiated before an obstacle approaches the obscured segment. This provides both wing and tail clearance, with symmetric thrust and no differential braking.

Turns less than 90 degrees

During the turn, steer the nose wheels far enough beyond the centerline of the turn to keep the main gear close to the centerline.

Turns of 90 degrees or more

Initially use approximately full nose wheel steering tiller displacement. Adjust the tiller input as the aircraft turns to keep the nosewheel outside of the taxiway centerline, near the outside radius of the turn. Nearing turn completion, when the main gear are clear of the inside radius, gradually release the tiller input as the aircraft lines up with the intersecting taxiway centerline or intended taxi path. To prevent the likelihood of the aircraft stalling during a turn approaching 90° and greater, enter at a speed of approximately 10 knots. If the aircraft “stalls” during the turn, straighten the nose gear, apply sufficient thrust to begin moving the aircraft and reinitiate the turn. Initiate the turn as the intersecting taxiway centerline (or intended exit point) approaches the aft edge of the sliding window. Do not use differential braking as a means to steer the aircraft under routine operations.

Turns of 180 Degrees

If the available taxi surface is narrow, coordination with external observers may be required to complete the operation safely. Reference special airport operating instructions, if available. In some cases (e.g., heavy weight, pilot uncertainty of runway and/or taxiway pavement edge locations and related safety margins, nearby construction, vehicles, potential FOD damage, etc.), towing the aircraft to the desired location may be the safest option.

If a minimum radius 180° turn is necessary, consider using the ground crew to monitor the wheel path and provide relevant information as the turn progresses. The ground crew should be warned of the risk associated with jet blast and position themselves to avoid the hazard. Also ensure that obstacle clearance requirements are met. Since more than idle thrust is required, the flight crew must be aware of buildings or other objects in the area being swept by jet blast during the turn.

Note: Monitor the nose gear track closely, because it leaves the pavement in the turn before the main gear.

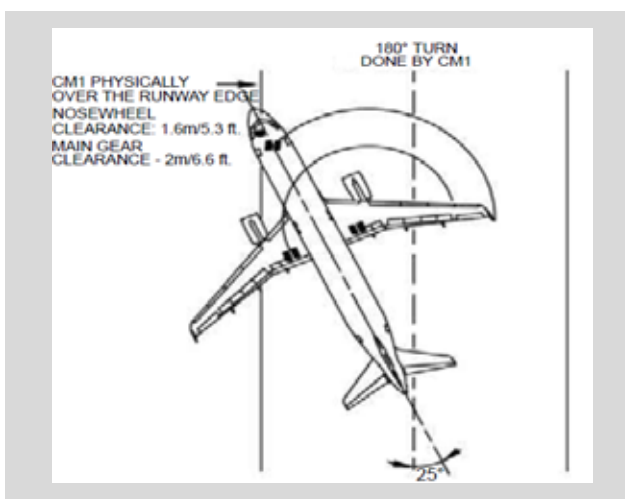
A319/320/321 Flight Crew Training Manual

For a turn of 180° , the following procedure is recommended for making a turn in the most efficient way. Taxi on the right hand side of the runway and turn left to establish a 25° divergence from the runway heading with a ground speed no more than 5 - 8 knots. When the captain assesses to be physically over the runway edge on A320/321, or to be about 6 feet before the runway edge on A319, smoothly initiate a full deflection turn to the right. Asymmetric thrust will be used during the turn. Establish approximately 30 - 35% N1, to maintain a continuous speed of approximately 8 knots throughout the maneuver.

Note: Painted runway markings are slippery when wet and may cause skidding of the nose gear during the turn.

This technique results in a low speed turn and less runway being used. It does not impose undue stress on the landing gear and tires provided the wheel brakes are not locked during the turn. If the nose gear skids, a good technique is to apply the inside wheel brake briefly and keep the aircraft turning with asymmetric thrust as needed. If the turnaround is planned on a surface significantly greater in width than the minimum required, a turn entry could be made, without stopping, at 5-10 knots speed, using intermittent inside wheel braking and thrust as needed. Wind, slope, runway or taxiway surface conditions, and center of gravity may also affect the turning radius.

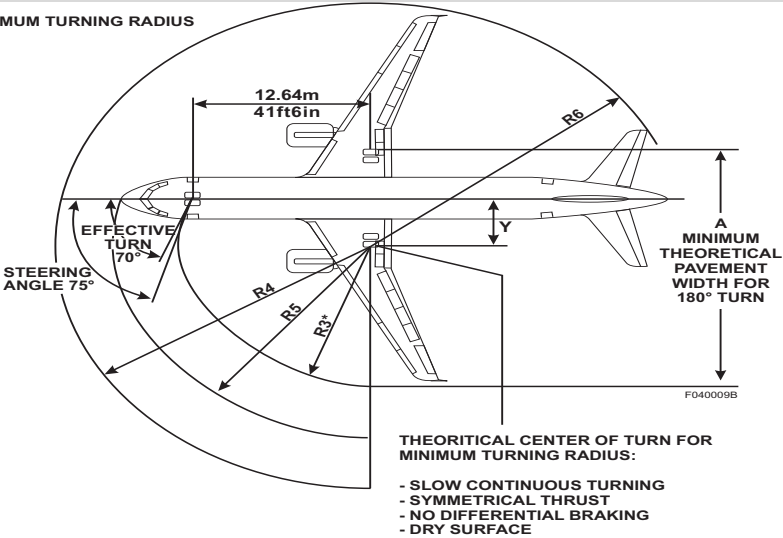
The following diagrams show suggested aircraft ground tracks for minimum radius 180° turns with various runway turnaround configurations. These ground tracks provide the best maneuver capability while providing the maximum runway length available for takeoff at the completion of the turn. However, this type of maneuvering is normally not required unless operating on runways less than 148 feet (45m) in width.





A319/320/321 Flight Crew Training Manual

MINIMUM TURNING RADIUS

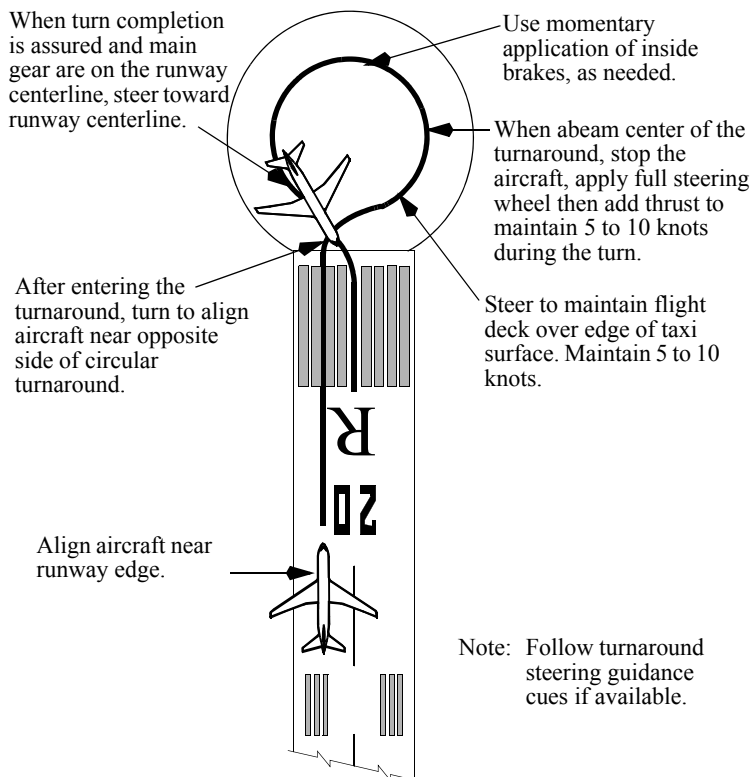


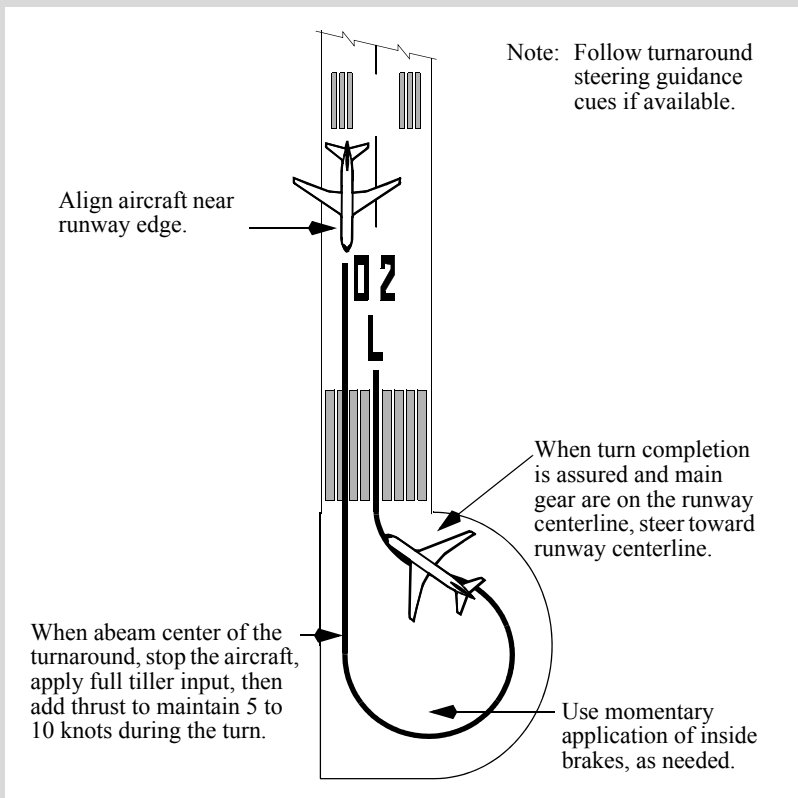
Radius	Y	A	R3	R4	R5	R6
FT	15ft1in	75ft2in	45ft4in	72ft2in	60ft	71ft11in
M	4.60	22.90	13.81	21.99	18.30	21.91

*NOSE GEAR RADIUS (R3) MEASURED FROM OUTSIDE FACE OF TIRE

A319/320/321 Flight Crew Training Manual

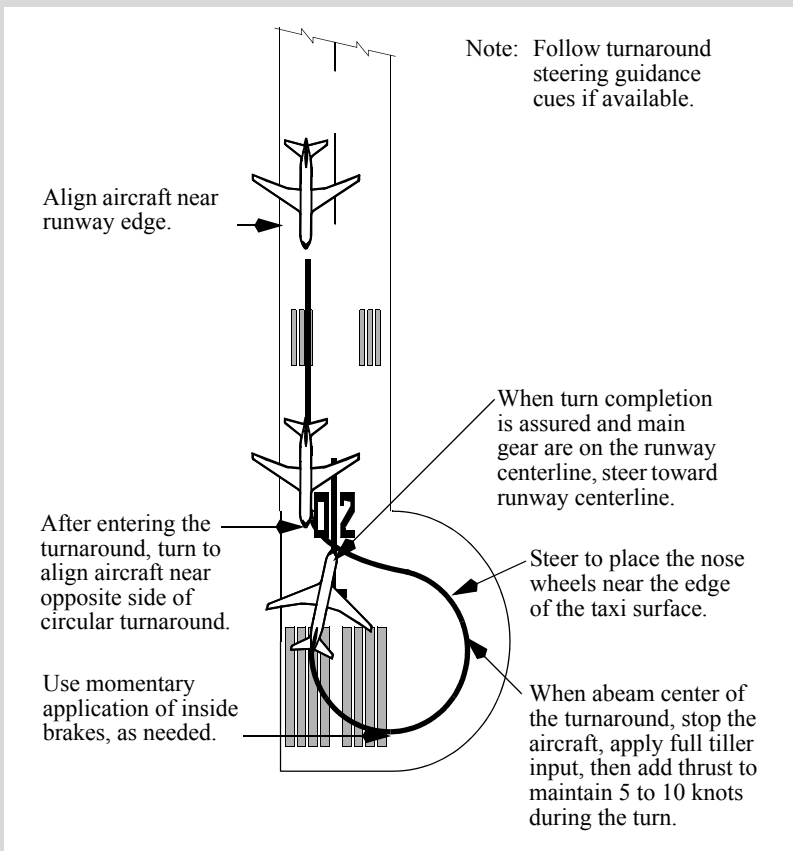
Techniques when using a Circular Turnaround



Techniques when using a Hammerhead Turnaround

A319/320/321 Flight Crew Training Manual

Techniques when using a Hammerhead Turnaround



Taxi - Adverse Weather

Taxi under adverse weather conditions requires more awareness of surface conditions.

When taxiing on a slippery or contaminated surface, particularly with strong crosswinds, use reduced speeds. Use of differential engine thrust assists in maintaining aircraft momentum through the turn. When nearing turn completion, placing both engines to idle thrust reduces the potential for nose gear skidding. Avoid using large nose wheel steering inputs to correct for skidding. Differential braking may be more effective than nose wheel steering on slippery or contaminated surfaces. If speed is excessive, reduce speed prior to initiating a turn.

Note: A slippery surface is any surface where the braking capability is less than that on a dry surface. Therefore, a surface is considered “slippery” when it is wet or contaminated with ice, standing water, slush, snow, or any other deposit that results in reduced braking capability.

Low Visibility

Pilots need a working knowledge of airport surface lighting, markings, and signs for low visibility taxi operations. Understanding the functions and procedures to be used with stop bar lights, ILS critical area markings, holding points, and low visibility taxi routes is essential to conducting safe operations. Many airports have special procedures for low visibility operations. For example, airports operating under FAA criteria with takeoff and landing minimums below 1200 feet (350 meters) RVR are required to have a low visibility taxi plan.

Ground De/Anti-Icing

Definitions and Concepts

Ground de/anti-icing background information and policies are described in this section and the AM, SUP-4WX.2, Icing. Procedures for aircraft specific de/anti-icing are located in Vol. 1, SP.16.

Deicing

Deicing is the procedure of removing frost, ice, slush, or snow from the aircraft in order to provide clean surfaces. On the ground this may be accomplished by:

- Using any mechanical or pneumatic means that will not damage the aircraft.
- Using heated deicing fluid to remove all forms of frozen contamination (including environmental frost). Heated fluids penetrate the frozen contaminants and contact the aircraft skin. The high thermal conductivity of the aircraft skin causes the heat to spread, breaking the bond of the ice and snow, causing it to melt or fall off the aircraft.

Anti-icing

Anti-icing is a precautionary procedure that provides protection against the formation of frost or ice, and accumulation of snow or slush on treated surfaces of the aircraft for a limited period of time (holdover time). Anti-icing fluid is the only protection against airfoil icing prior to getting airborne. Therefore, fluid application should be completed as close to takeoff time as possible.

Additional Anti-icing

If an aircraft which has been de/anti-iced is delayed on the ground long enough that anti-icing protection is no longer effective, or if for any reason the de/anti-icing process is interrupted while freezing/frozen precipitation is falling, the ground de/anti-icing procedure must be reaccomplished in its entirety.

The contaminated anti-icing fluid and all frozen contamination must be completely removed by deicing before making another application of anti-icing fluid. A new holdover time must be determined after completing additional de/anti-icing.

Clean Aircraft Concept

The airline industry, in concert with the FAA, is operating with a clean aircraft concept to minimize the effects of all forms of frozen contamination on aircraft surfaces.

Takeoff is prohibited when frost, ice, snow or slush is adhering to the wings, control surfaces, engine inlets, or other critical surfaces of the aircraft.

- Do not rely on air flow during takeoff roll to remove frozen precipitation that may be adhering to the aircraft.
- A coating of frost up to 1/8 inch thick on the lower wing surface, below the fuel tank area, is permissible provided it is caused by cold soaked fuel.
- It is acceptable to have a thin coating of hoar frost on the fuselage, provided all vents and ports are clear. If the hoar frost extends down to the area of the windows, the fuselage must be deiced.

Cold soaked wings

A cold soaked wing condition can occur when an aircraft lands with a large amount of fuel remaining in the wing tanks. During cruise at high altitude, the aircraft is subjected to extremely cold temperatures for an extended period of time causing the aircraft skin and fuel to become super cooled. If enough super cooled fuel is remaining in the wing tanks to contact the upper wing surface, it will maintain the skin at a temperature below freezing. When this happens, any moisture contacting the upper wing surface may form frozen contamination, even in ambient air temperatures as high as 15°C (59°F).

A cold soaked wing should also be suspected if both of the following conditions are met:

- Frost or ice is observed on the wing's underside during the walk around, and
- A large amount of fuel was remaining in the wing tanks after landing.

If cold soaked wings are suspected, cabin windows may be used during the preflight to visually inspect the upper wing surfaces for frost or ice. The quickest way to alleviate a cold soaked wing condition is to add warm fuel to the wing tanks.

Critical Aircraft Surfaces and Components

Critical aircraft surfaces and components are those surfaces which must be clear of adhering frozen contamination before beginning takeoff roll. Critical aircraft surfaces include, but may not be limited to:

- wings, slats, flaps, ailerons, spoilers;
- horizontal stabilizer and elevator;
- vertical stabilizer and rudder;
- pitot heads, static ports, ram-air intakes, engine and flight instrument probes, other kinds of instrument sensor pickups;
- engine and APU inlets and exhausts; and
- radome.

A319/320/321 Flight Crew Training Manual

Representative Aircraft Surfaces

Representative aircraft surfaces are those which the pilot can readily observe to determine whether or not frost, ice, or snow is accumulating or forming on that surface. By using a representative surface, a pilot can make a reasoned judgment regarding whether or not frost, ice, or snow is adhering to other aircraft surfaces.

Representative aircraft surfaces visible from the flight deck are:

- fuselage, and
- radome.

Representative aircraft surfaces visible from the best vantage point(s) in the cabin are:

- wing area upper surfaces;
- wing leading edges;
- engine inlets.

Best Vantage Point(s)

The best vantage point is the location in the aircraft where a pilot can best check representative aircraft surfaces. This will normally be a passenger window in the over-wing area. It may be necessary in some circumstances to move a few rows to get the best view of the engines. Outside lighting conditions and glare may also affect which specific location is the best vantage point.

Holdover Time

Holdover time is the estimated time that anti-icing fluid will prevent the formation of frozen contaminants on the treated surfaces of the aircraft. Holdover time is determined by the pilot using the Holdover Time Tables.

Holdover time starts when the final application of fluid begins. The final fluid applied will be either:

- de/Anti-icing fluid in the one step procedure; or
- anti-icing fluid in the two step procedure.

Holdover time ends when either:

- the applied fluid loses its effectiveness, or
- the time extracted from the holdover time range expires.

Ground Icing Conditions

Guidance for determining precipitation categories (type) and intensities (light, moderate, and heavy) is located in the AM, SUP-4WX.2, Icing and the associated Ground Precipitation Intensity chart.

WARNING: Do not take off during heavy freezing drizzle, heavy ice pellets, moderate freezing rain, or heavy freezing rain.

Operational Effects of Frozen Contamination

Frost, ice, and/or snow adhering to airfoils, engine inlets, flight controls and flight instrument sensors, even in small amounts, can have a critical effect on aircraft performance. For example, ice formations on the wing's leading edges and upper surfaces creating texture roughness of medium to coarse sandpaper can reduce lift as much as 30 percent and increase drag by 40 percent. Therefore, frozen contamination on the aircraft in any form poses a serious threat to flight safety due to degraded operational performance.

Degraded aerodynamic performance such as:

- Lift decreases - Frozen contamination may destroy the lifting ability of an airfoil, including leading edge devices. The aircraft may not lift off at a normal pitch attitude. Required gaps in leading edge devices may be blocked and further reduce lift on one or both wings.
- Drag/weight increases - An aircraft may fail to reach takeoff speed in the calculated distance.
- Stall speed increases - Buffet or stall may occur before activation of stall warning systems.
- Controllability decreases - Caused by changing the aerodynamic properties of the control surface due to ice. For example, ice on the leading edge of the horizontal stabilizer can affect pitch control, especially during rotation.

Reduction in available engine power caused by:

- icing of engine inlets, guide vanes or compressor blades; or
- ingestion of ice shedding from other parts of the aircraft.

Impairment of flight and engine performance indicators resulting in:

- incorrect power settings due to EPR probe icing;
- incorrect airspeed indication caused by pitot/static probe icing; or
- erroneous stall warning caused by ice on the AOA probe.

Degraded flight control response as ice may interfere with the free movement of the flight controls.

Delta De/Anti-icing Program

Delta Air Lines' Ground De/Anti-icing Program is coordinated among Airport Customer Service, Maintenance, Flight Control, Flight Operations, Fleet Management and Reliability, and Flight Safety. Each Delta deicing station will have designated trained personnel on duty to determine when to initiate ground de/anti-icing operations. At airports where no Delta personnel are permanently assigned, the captain may declare the de/anti-icing program in effect. In this case, the captain shares responsibility for the effectiveness of the effort with the ground crew. The procedures outlined in this section will help guide the captain through this decision making process.

A319/320/321 Flight Crew Training Manual

There are several components to Delta's De/Anti-icing Program. Pilots need to be aware of how key components play an integral part in ensuring safe winter flight operations.

De/Anti-icing Alert Plan

A Deicing Alert Chart will be issued daily by Delta Meteorology to the OCC Duty Director. This chart reflects forecasted freezing/frozen precipitation for specific geographic regions for the next day's flying (24 - 48 hours in advance). Affected stations will be notified, and plans will be made to initiate local de/anti-icing operations. Flight Control will work in conjunction with individual stations to determine possible changes to the flight schedule based on any anticipated decrease in airport air traffic capacity.

Station De/Anti-icing Plans

Each Delta station that conducts de/anti-icing operations is required to have a detailed de/anti-icing plan on file. This plan contains, but is not limited to, the following information:

- persons responsible for implementing/terminating the de/anti-icing plan;
- deicing equipment and fluids;
- location of de/anti-icing areas;
- local procedures including communication with the flight crew and coordination with local ATC.

ATC will be notified whenever the local de/anti-icing plan is in effect. Departure runway queues will be managed by ATC in order to minimize the amount of time an aircraft spends on the ground after being de/anti-iced.

Special procedures for the pilots will be contained in the Airway Manual, airport green pages, or noted in the Airport Remarks section of the flight plan.

De/Anti-Icing/Overnight Protection

If the aircraft is de/anti-iced prior to the arrival of the flight crew, a completed Captain Notification And Overnight Protection Form will be left on the captain's seat or with the flight papers. If the aircraft has been de/anti-iced prior to the arrival of the flight crew, the flaps and slats must be inspected prior to departure.

During forecasted overnight icing conditions, Type IV fluid may be applied to the fuselage, wings and tail. A completed Captain Notification And Overnight Protection Form will be left on the captain's seat or with the flight papers.

CAUTION: All Type IV fluid used for overnight protection must be removed with Type I fluid prior to departure.

Responsibility for De/Anti-icing of Aircraft

The captain has the ultimate responsibility for ensuring the aircraft's critical surfaces are free of frozen contamination and the flight can be operated safely. The ground deicing crew shares in this responsibility by providing an aircraft that complies with the clean aircraft concept.

The flight crew will notify station personnel as soon as possible when deicing is required, and coordinate with Ground Operations prior to deicing/anti-icing operations. The Station Manager (or qualified designee) has authority to direct de/anti-icing before the captain arrives at the airplane.

ACS and/or contractors accomplish aircraft de/anti-icing. As always, pilot vigilance is paramount during any de/anti-icing procedure. If possible, the pilots should evaluate the operation from the flight deck as it is being conducted and:

- If deicing or anti-icing is not being performed properly or safety is jeopardized, stop the operation and attempt to have the problem corrected.
- When possible, provide timely feedback on individual station de/anti-icing performance to the Dispatcher. A telephone report is preferred.
- Document all de/anti-icing problems or accolades on an FCR, ASR, or ASAP as appropriate.

Depending on the circumstances and local station procedures, aircraft de/anti-icing may be accomplished:

- whenever requested by the captain;
- during overnight parking (prior to pilots' arrival);
- at the gate - prior to pushback;
- after pushback - clear of the gate;
- at a remote site.

De/Anti-icing at Offline Stations

When de/anti-icing is required at an offline station, consult with Flight Control. Flight Control will advise the crew if the station has been trained on Delta de/anti-icing procedures.

Stations Trained on Delta De/Anti-Icing Procedures: Follow normal de/anti-icing procedures.

Stations Not Trained on Delta De/Anti-Icing Procedures: A cabin check is always required when de/anti-icing at a station not trained on Delta de/anti-icing procedures. The crew will need to confirm the following with the de/anti-icing ground crew:

- Fluid type
- Time fluid application started

A319/320/321 Flight Crew Training Manual

- Fluid mixture, for type II/IV fluid at non-US locations
- Signal for area clear to start engines/taxi

Charter Flight De/Anti-Icing

In non-company locations, de/anti-icing of company aircraft may be accomplished by an OAL/FBO under supervision of a company employee who has successfully completed company de/anti-icing training. The company employee shall be responsible for ensuring that the de/anti-icing, all flight deck communications and all required inspections have been completed per company standards before the aircraft can be released and/or dispatched. Engine running deicing is NOT allowed in these locations and deicing shall not be performed until the flight crew arrives at the aircraft.

Exempt Stations

Due to geographical location and meteorological history, some stations are not trained in de/anti-icing. These stations are noted in a Flight Plan Remark or Delta Special Page (green page). Delta aircraft are not permitted to be de/anti-iced at an Exempt Station.

Aircraft or Ground Emergency Communications

Note: Both VHF and interphone must be monitored at all times.

During an aircraft or ground emergency, Delta requires that standard terminology be used to communicate specific commands.

When an aircraft or ground emergency is declared, the deicer/ coordinator shall notify all aircraft on the same pad via VHF radio to shut down engines.

When an aircraft or ground emergency is declared, the captain will ensure all engines are shut down.

Aircraft Emergency

In the event of an aircraft emergency, a flight deck crewmember will contact the deicer/coordinator by interphone and VHF radio. The captain will also flash the nose taxi lights and/or any other exterior lights on and off to immediately alert ground personnel. All ground personnel will pull away from the aircraft to allow emergency vehicles to approach. Ground personnel should stand by to assist with passenger evacuation, if required.

Note: The captain will determine when a problem with the aircraft is deemed an aircraft emergency.

Note: When a deicer/coordinator verbally advises the captain of an aircraft fire, the captain will determine the appropriate action to safeguard the passengers and crew.

Ground Emergency

In the event of a ground emergency, the deicer/coordinator will contact the flight crew by interphone or by VHF radio (this may be relayed through the Iceman) and advise the captain of the nature of the ground emergency. All ground personnel will be notified by ground radio. Upon notification they will pull away from the aircraft and stand by to assist with passenger evacuation, if required.

Note: A ground emergency is defined as any problem with a deicing vehicle that affects the safety of ground crews, deicers, flight crews or passengers.

The captain is responsible for assessing if the declared ground emergency requires the declaration of an aircraft emergency. The captain will also determine if the situation requires evacuation of the aircraft.

De/Anti-icing Fluids

Type I Fluid

Type I fluid is a deicing and anti-icing fluid with low viscosity and is considered an unthickened fluid. It forms a very thin wetting film on aircraft surfaces and has excellent deicing properties. Type I fluid can be orange-colored or colorless. Due to its low viscosity, it provides minimal anti-icing protection. Type I fluid is always diluted because adding water ensures fluid freeze point protection and ensures proper aerodynamic flow-off characteristics. Type I fluid is never applied 100 percent. Different dilution ratios of Type I fluids affect the freeze point of the fluid, but do not alter its holdover time significantly. The Type I Holdover Times Table will apply for all concentrations of this fluid.

Type II Fluid

Type II fluid is a deicing and anti-icing fluid of high viscosity and is considered a thickened fluid. It adheres to the aircraft surfaces to provide a protective film. It creates a thicker layer than Type I fluid and thus has improved anti-icing capability. Type II fluid can be straw-colored or colorless. Airflow during takeoff roll causes the fluid to shed so that by rotation the surfaces are aerodynamically clean. Varying concentration levels of Type II fluid affect its holdover time. Delta prefers to use 100 percent concentration of Type II fluid, but other concentration levels may be used at contract or overseas facilities. Not all stations will have Type II available. One of the Type II Holdover Tables will apply when this fluid is used.

Deicing ground crews may communicate a specific brand of Type II fluid, e.g., "Type II, ABAX, ECOWING 26." Flight crews should note the fluid brand information and utilize the correct brand specific Type II Holdover Time table if it is in the De/Anti-icing Guide. If the specific brand of Type II fluid is not in the Delta De/Anti-icing Guide, or the crew is not positive as to the brand name of the fluid, default to the FAA Generic Type II Fluid table.

A319/320/321 Flight Crew Training Manual

Type IV Fluid

Type IV fluid is an enhanced performance deicing and anti-icing fluid with characteristics similar to Type II. Type IV fluid is green colored, except in Japan, where it is colorless. Its anti-icing effectiveness is superior to Type II fluid and holdover time is increased by a significant factor under most conditions. There are separate Holdover Time Tables for Type IV which reflects this improved performance. Additionally, Type IV fluid has some unique visual characteristics. It is pale green in color and considerably thicker than Type II fluid. When applied to the wings, the extra thickness may cause the fluid to appear wavy or bumpy. Varying concentration levels of Type IV fluid affect its holdover time. Delta prefers to use 100 percent concentration of Type IV, but other concentration levels may be used at contract or overseas facilities. Not all stations will have Type IV available. One of the Type IV Holdover Tables will apply when this fluid is used.

Deicing ground crews may communicate a specific brand of Type IV fluid e.g., “Type IV, Octagon, Max-Flight.” Flight crews should note the fluid brand information and utilize the correct brand specific Type IV Holdover Time table if it is in the De/Anti-icing Guide. If the specific brand of Type IV fluid is not in the De/Anti-icing Guide, or the crew is not positive as to the brand name of the fluid, default to the FAA Generic Type IV Fluid table.

Noncertified Fluids

A de/anti-icing fluid that does not meet SAE/ISO certification requirements (including military fluids) is classified as noncertified, Type I, Type II, or Type IV fluid. These fluids may be encountered at certain international stations, or during offline operations at military bases. The use of noncertified Type I fluid is not authorized for takeoff during active icing conditions. Contact the Dispatcher if a noncertified Type I fluid is used. Noncertified Type II or Type IV fluids are not authorized under any circumstances.

Fluid Effects on Braking and Steering

Generally, Type I, Type II, and Type IV fluids are considered to have the same affect on braking and steering as water.

CAUTION: A slippery condition may exist in and around the de/anti-icing ramp and taxi ways, particularly during dry weather conditions or light precipitation.

De/Anti-icing Fluid vs. Hydraulic Fluid

It is very difficult to distinguish between de/anti-icing fluids and hydraulic fluid. In small quantities and thin coatings, both fluids will have similar coloring and feel slippery to the touch. During the exterior inspection, if residual fluids on aircraft surfaces cannot be identified, contact local Maintenance or call the MCC through the Dispatcher for guidance.

Fluid Application Methods

De/anti-icing can be performed using a one or two step procedure.

- One step procedure - This procedure is a combination of deicing and anti-icing performed at the same time with the same fluid (de/anti-icing). The fluid used to deice the aircraft is always heated and remains on the surface to provide anti-icing protection. This procedure can be repeated so as to minimize the time required to complete the final application of fluid.
- Two step procedure - This procedure consists of two distinct fluid applications. The first step, deicing with a heated fluid, is followed by the second step, anti-icing, as a separate fluid application. Normally, Type II or Type IV fluid is used during the second step; however, Type I fluid may be used.

Note: Holdover time starts when the final application begins in either the one step or two step procedure.

Forced Air Deicing

Forced air only and forced air with Type I fluid technology utilizes an air stream to remove accumulations of frozen contaminants from the aircraft. Forced air deicing minimizes the amount of glycol used and as a result provides economic and environmental benefits.

When forced air only or forced air with Type I fluid is used as the final application, no holdover time exists.

Note: If forced air only or forced air with Type I fluid is used as the final application, it must be communicated to the captain in the Pre and Post De/Anti-icing Communication.

Engine Running De/Anti-Icing

Engine running de/anti-icing is authorized at remote locations as noted on the specific Delta Special Pages (Green Pages). At all other stations, engine running de/anti-icing **is not authorized**. The Deicing Coordinator at the remote location is the final authority in deciding if engine running de/anti-icing will be accomplished.

An operative APU is not required for engine running de/anti-icing. During remote de/anti-icing operations at these locations, a Ground Power Unit and air start equipment will be staged at or near the remote locations. If engines need to be shut down at remote locations, immediately notify the remote pad coordinator. Ground equipment will be immediately dispatched to the aircraft to facilitate the recovery.

During light freezing rain or moderate freezing drizzle, engine running de/anti-icing at the remote locations without an operating APU is not allowed because the engines may need to be shut down to inspect the wings during de/anti-icing.

De/Anti-icing Checks

There are four types of de/anti-icing checks: Post De/Anti-icing Check, Flight Deck Check, Cabin Check, and External Check.

Post De/Anti-icing Check

This check is an integral part of the de/anti-icing process. After aircraft de/anti-icing is complete, the deicing ground crew performs a Post De/Anti-icing Check to confirm that the critical surfaces are free of any contamination.

When the Deicer/Coord. states: “De/anti-icing and aircraft inspection complete”, this indicates that the de/anti-icing process has been completed and that all required inspections for the specific aircraft have been completed and the aircraft is contaminant free.

Flight Deck Check (Pre-Takeoff Check)

This check is an integral part of the holdover time and is performed by the pilots. Because of the limitations and cautions associated with the use of the Holdover Time Tables, the pilots must not rely on the use of holdover times as the sole determinant that the aircraft is free of contamination. They must continually assess the current weather, environmental conditions, and the aircraft’s condition. Several Flight Deck Checks are required during the holdover time period to maintain awareness of the aircraft’s condition.

The Flight Deck Check is performed by the pilots just prior to takeoff and is required anytime:

- ground icing conditions exist; and
- the holdover time is still valid.

The Flight Deck Check consists of a check of representative aircraft surfaces which are visible from the flight deck. If desired or if any doubt exists, conduct a Cabin Check.

When circumstances do not permit a satisfactory visual check from inside the aircraft, return to the designated area and:

- have ground de-icing crew perform an External Check; or
- if any doubt exists as to the condition of the aircraft, repeat the Ground De/Anti-icing procedure.

Cabin Check (Pre-Takeoff Contamination Check)

This check is performed by the pilots and is required:

- when doubt exists after conducting the Flight Deck Check;
- anytime the aircraft has been de/anti-iced, and holdover time is exceeded during conditions of frost, freezing fog, or snow;
- during conditions of heavy snow (provided Type IV fluid has been used for anti-icing); or
- within 5 minutes of takeoff anytime a pilot-assessed change in intensity is to be used.

The Cabin Check is not authorized when the holdover time has been exceeded and the following conditions exist:

- Type I fluid has been applied during freezing drizzle, light freezing rain, or rain on cold soaked wings.
- Type II or Type IV fluid has been applied during freezing drizzle, light freezing rain, or rain on cold soaked wings. Additional de/anti-icing or an External Check must be accomplished prior to takeoff.
- Ice pellets have fallen.

The Cabin Check consists of a visual inspection of all representative aircraft surfaces which are visible from the best vantage point(s) in the cabin. Normally, de/anti-icing fluid failure will first occur on the leading or trailing edges of the wing rather than the mid-chord. Therefore, the leading edges and upper surfaces of both wings must be visually checked for evidence of fluid failure. Additionally, engine inlets must be inspected for contamination. Takeoff must occur within five minutes of the most recent check.

The ability to adequately perform this check from inside the aircraft is highly dependent upon several factors. Lighting conditions, cleanliness of cabin/flight deck windows, and outside visibility may severely hinder or prevent the pilot's ability to satisfactorily assess aircraft surfaces for contamination. When circumstances do not permit a satisfactory visual check from inside the aircraft, return to the designated area and:

- have ground de-icing crew perform the External Check.
- if any doubt exists as to the condition of the aircraft, repeat the ground de/anti-icing procedure.

External Check (Alternative Pre-Takeoff Contamination Check)

This check is performed by the de/anti-icing ground crew and is required anytime:

- doubt exists after conducting a Cabin Check; or
- the aircraft has been anti-iced with Type II or Type IV fluid, and holdover time is exceeded during freezing drizzle, light freezing rain, or rain on cold soaked wings.

A319/320/321 Flight Crew Training Manual

This check consists of a close visual inspection of the aircraft's upper wing surfaces and leading edges for frozen contamination. Takeoff must occur within five minutes of the External Check.

If the External Check cannot be accomplished, return for additional de/anti-icing.

CAUTION: An External Check is not authorized when Type I fluid is used during freezing drizzle, light freezing rain, or rain on cold soaked wings.

Contact local operations for specific locations on the airfield to accomplish the External Check. Be aware that some stations may conduct additional de/anti-icing as an alternative to the External Check.

Visual Indications of Loss of Fluid Effectiveness

It is difficult to determine when anti-icing fluid is beginning to fail, however, when any ice or snow, or frost can be seen accumulating on treated surfaces, the fluid has lost its effectiveness. Any ice, frost, or snow on top of deicing or anti-icing fluids must be considered as adhering to the aircraft, and additional de/anti-icing must be accomplished prior to takeoff.

- Normally, de/anti-icing fluid failure will first occur on the leading or trailing edges of the wing rather than the mid-chord. However, when the aircraft is pointing downwind the mid-chord will fail first.
- The leading edges and upper surfaces of both wings must be visually checked for evidence of fluid failure.
- If the leading edges and upper surfaces of both wings cannot be inspected from the cabin, return for an External Check or additional de/anti-icing.

Type I Fluid

When Type I fluid has lost its effectiveness, frozen precipitation will begin to accumulate on the aircraft surface in much the same manner as it would on a nontreated surface.

Type II and Type IV Fluid

When Type II or Type IV fluid has lost its effectiveness and is no longer able to absorb the freezing moisture, look for the following visual indications:

- gray or white appearance and buildup of ice crystals in or on top of the fluid;
- progressive surface freezing;
- snow accumulation;
- dulling of surface reflectiveness caused by the gradual deterioration of the fluid to slush (loss of gloss or orange peel appearance);
- ice buildup on the wing life raft attach points (if installed), adjacent to the over-wing exits.

Communication Procedures

Any airport specific deicing procedures will be contained in the Airway Manual, Delta Special Pages (Green Pages), or noted in the Airport Remarks section of the flight plan.

It is critical to establish communications with the ground crew prior to commencing de/anti-icing. Once the deicing operation commences, any aircraft movement or changes in configuration must be coordinated with the ground crew.

Note: At airports where Delta uses vendors or Other Airlines (OAL) for deicing, variance in Delta's standard communication may occur. This will be noted in the Delta Special Pages.

Note: See the Aircraft Configuration and Communication section.

Post De/Anti-icing Communication

After de/anti-icing is complete, a report will be provided over the interphone or other means of direct communication. The use of visual signals or relayed information through a third party is NOT authorized. This report will include number of minutes since final fluid coating was started, fluid type, and fluid freeze point (Type I fluid only) or water mix ratio (Type II/IV fluid only).

Note: A report is not required when the aircraft is deiced due to frost, prior to the pilot's arrival, and no active frost is forming.

Holdover Times

Use of Holdover Time Tables

Note: If no specific fluid manufacturer and type is identified in the Post De/Anti-Icing Communication, or if there is no specific HOT table for the fluid used, or there is any doubt as to the exact fluid product applied, crewmembers must default to the FAA Generic Type II or Type IV HOT table.

Holdover times provide an operational guideline for departure planning. They must be used in conjunction with the Flight Deck Check.

Holdover times published in the tables are only approximate and must be adjusted after considering all variables. The source of the Holdover Time Tables is the Aerospace Division of the Society of Automotive Engineers (SAE). Time data is derived from an analysis of testing conducted in field and laboratory conditions, as well as airline operational experience. Numerous factors affect the actual time that anti-icing fluid will provide protection against frozen contamination.

A319/320/321 Flight Crew Training Manual

The times specified in the tables represent the approximate holdover times for seven categories of active precipitation.

- Frost.
- Freezing fog.
- Snow/Snow Grains/Snow Pellets.
- Freezing drizzle.
- Freezing rain (light).
- Ice pellets
- Rain on cold soaked wings.

Three precipitation categories specify a time range (snow, freezing drizzle, and rain on cold soaked wings), and four categories specify a single time (freezing fog, frost, light freezing rain and ice pellets).

Whenever a time range is given, the lower time in the range is for moderate precipitation conditions and the upper time is for light conditions.

When a single time is specified in the table, it represents the approximate holdover time limit for that weather condition. However, it may be necessary to adjust the holdover time downward after considering other environmental factors.

Establishing Holdover Time

A holdover time is established using the following five steps.

1. Complete the Post De/Anti-icing Communication. The following data from the communication is used to establish a holdover time:

- Fluid type. When Type II, or Type IV fluids are used, the anti-icing fluid manufacturer's name and product type name will be given. If the specific brand of fluid is not in the Delta De/Anti-Icing Guide, or if the crew is not positive as to the brand name of the fluid, default to the FAA Generic Type II/IV Fluid table.
- Concentration (Non-US stations for Type II and Type IV only). There are no fluid mixture breakouts on the Type I Holdover Time Table because dilution ratios do not significantly affect holdover time for Type I fluids.
- Time since the final anti-icing began. The holdover timing starts when the final (anti-icing) fluid application began.

2. Determine the current weather conditions (OAT, type of precipitation, and intensity of precipitation).

- In snowfall conditions, refer to the De/Anti-Icing guide to determine snowfall intensity.
- OAT is determined by the most current weather report or ATIS.
- The Holdover tables allow pilots to determine holdover times based partly upon the type and intensity of the frozen precipitation that is falling.

- The type and intensity of frozen precipitation (light, moderate, or heavy) is officially determined by the most current official weather report (e.g., from National Weather Service [NWS], NWS-approved automated system, or other agent approved by the NWS).
- If at any time a pilot assesses intensity greater than that being reported, he/she shall use the heavier precipitation when entering the holdover tables for holdover time.
- If, in the pilot's judgment, the intensity is less than that being reported, the pilot shall request (e.g., to the tower or trained weather observer) a new observation be taken and reported or shall wait long enough for an update to an automated meteorological observation to be taken and reported as applicable.
 - A pilot may act on their own assessment of lesser precipitation intensity only in those cases concerning snowfall or ice pellets where the officially reported (e.g., from NWS, NWS-approved automated system, or other agent approved by the NWS) meteorological precipitation intensity is grossly different from that which is obviously occurring. (For example: precipitation is reported when there is no actual precipitation occurring.)
 - If an adjustment to intensity is pilot-assessed, the pilots shall communicate the newly assessed intensity to Flight Control via ACARS.
 - If a pilot acts based upon their own assessment that precipitation intensity levels are LOWER than the official reported intensity level, a Cabin Check is required within the 5 minutes preceding takeoff.
- Pilot assessment of precipitation intensity levels may only be used when there is enough natural sunlight or artificial lighting available to provide adequate exterior visibility. All windows through which the assessment is made must be adequately transparent so as to not restrict the pilot's visibility under the lighting conditions present.
- The Snowfall Intensities as a Function of Prevailing Visibility chart in the De/Anti-icing Guide, Flight Crew Operations Manual, is based on prevailing visibility and allowances are made for the effects of night light conditions.
- Ice pellet intensity shall be assessed using the following criteria:
 - light - scattered pellets that do not completely cover exposed surfaces regardless of duration;
 - moderate - slow accumulation on the ground;
 - heavy - rapid accumulation on the ground.
- Pilots are not permitted to self-assess intensity in the case of reported freezing drizzle or freezing rain unless no precipitation is actually falling. Freezing drizzle and freezing rain quickly adhere to cold surfaces and can be difficult to see; for this reason, if conditions are reported or anticipated the aircraft shall be de-iced and/or treated with anti-icing fluid as a precaution against encountering these conditions during taxi-out.

A319/320/321 Flight Crew Training Manual

3. Based on all the information obtained in steps 1 and 2, reference the appropriate Holdover Time Table and determine:

- a single time from the frost, freezing fog, light freezing rain or ice pellets column; or
- a time range from the snow, freezing drizzle, or rain on cold soaked wings column.

4. If a single time was extracted from the table, go to step 5. If a time range was extracted, determine a specific holdover time from this range by assessing:

- Intensity of precipitation. As a general rule, holdover time ranges should be interpreted as follows:
 - light conditions = upper end of time range;
 - moderate conditions = lower end of time range;
 - heavy conditions = less than the lower time value.
- When determining intensity, the pilots must consider the rate, density, and moisture content of the precipitation. For example, wet snow is considered more intense than dry/powdery snow and will have a lower holdover time. Wet snow occurs at or near freezing temperatures of -1°C (30°F) or above.

5. Further refine the determined holdover time after considering the following additional factors:

- Environmental factors - Jet blast, high wind velocity, and wind direction may cause anti-icing fluid to flow off aircraft surfaces thus reducing holdover time. Blowing snow due to wind or jet blast could decrease holdover time by increasing the amount of precipitation contacting aircraft surfaces and diluting the fluid. Solar radiation from direct sunlight may increase holdover time by warming aircraft surfaces.
- Aircraft skin temperature - Although this is difficult to determine, pilots need to be aware that aircraft skin temperature lower than OAT may decrease holdover time. One of the best ways to assess wing skin temperature is by referencing the fuel temperature, if available. Fuel temperature significantly lower than OAT may decrease holdover time.
- Operational experience of the pilots - For example, pilots who rarely fly in ground icing conditions may feel more comfortable using more conservative holdover times. Additionally, any background knowledge or experiences can be applied by the pilots.



Adjusting Holdover Time

A continuous assessment of weather and environmental conditions in conjunction with the Flight Deck Check is required during the holdover time period. Changing conditions may increase or decrease fluid effectiveness, necessitating a holdover time adjustment.

- A change in OAT.
- A change in type or intensity (rate or density) of precipitation. Snow changing to light freezing rain, or light snow changing to heavy snow will decrease holdover time. Conversely, moderate snow changing to light snow may increase holdover time. Presence of ice pellets precipitation may necessitate similar adjustment.
- Jet blast, an increase in wind velocity, or a change in wind direction will decrease holdover time.

Exceeding Holdover Time

The captain is responsible for monitoring the status of the aircraft exterior for frozen contamination. The pilot performs periodic Flight Deck Checks to ensure the aircraft is free of contamination during the time between anti-icing and takeoff, whenever the holdover time is still valid.

When holdover time is exceeded, the required course of action will depend upon the type of active precipitation and the type of fluid used to anti-ice. Refer to the current De/Anti-Icing Guide booklet for additional specific guidance.

Required Action When Holdover Time is Exceeded

Fluid Used to Anti-Ice	Active Precipitation					
	Frost	Freezing Fog	Snow, Snow Grains, Snow Pellets	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wings
Type I	Accomplish one of the following actions: A Cabin Check, An External Check, or Additional De/Anti-Icing			Takeoff Not Authorized		
Type II or Type IV				Accomplish one of the following actions: An External Check, or Additional De/Anti-Icing		

Configuring the Aircraft for De/Anti-icing

It is the responsibility of the pilots to ensure the aircraft is properly configured prior to commencing de/anti-icing operations.

Note: Whenever de/anti-icing will occur during overnight parking, the pilots must ensure the aircraft is properly configured prior to leaving for the night. Refer to Vol. 1, SP.16, Cold Weather Operation, Secure Procedure.



Intentionally
Blank



Takeoff and Initial Climb

Chapter 3

Table of Contents

Section TOC

Takeoff	3.1
Takeoff - General	3.1
Initiating Takeoff Roll	3.1
Rotation and Liftoff - All Engines	3.4
Effect of Rotation Speed and Pitch Rate on Liftoff	3.6
Center-Of-Gravity Effects	3.7
Crosswind Takeoff	3.8
Takeoff Crosswind Guidelines	3.8
Directional Control	3.8
Rotation and Takeoff	3.9
Gusty Wind and Strong Crosswind Conditions	3.9
Reduced Takeoff Thrust (Less Than Full Power)	3.10
Assumed Temperature Method (ATM)	3.10
Derated Takeoff Thrust (Fixed Derate)	3.10
Thrust Control	3.11
Low Visibility Takeoff	3.11
Post De/Anti-Icing Takeoff	3.11
Adverse Runway Conditions	3.12
Takeoff Performance Limit Weights	3.13
Rejected Takeoff Decision	3.14
Rejected Takeoff Maneuver	3.16
Go/Stop Decision Near V1	3.18
RTO Execution Operational Margins	3.19
Tail Strike	3.20
Takeoff Risk Factors	3.20

Initial Climb - All Engines	3.21
Immediate Turn after Takeoff - All Engines	3.21
Roll Modes	3.22
Pitch Modes	3.22
Autopilot Engagement	3.22
Flap Retraction Schedule	3.22
Normal Takeoff Profile (Distant/ICAO NADP 2)	3.24
Special Takeoff Profile (Close-In/ICAO NADP 1)	3.27
Noise Abatement Takeoff	3.29
Departure Speed Restrictions	3.29
Takeoff - Engine Failure	3.30
General	3.30
Engine Failure Recognition	3.30
Rotation and Liftoff - One Engine Inoperative	3.31
Initial Climb - One Engine Inoperative	3.32
Immediate Turn after Takeoff - One Engine Inoperative	3.33
Autopilot Engagement - One Engine Inoperative	3.33
Flap Retraction - One Engine Inoperative	3.33
Flaps Up - One Engine Inoperative	3.34
Takeoff Profile - Engine Failure	3.35
Engine Failure During an ATM Takeoff	3.37
Engine Failure During a Derated Thrust (Fixed Derate) Takeoff	3.37
Engine Failure During a Combined ATM and Fixed Derate Takeoff	3.37

Takeoff and Initial Climb

Chapter 3

Takeoff

Normal takeoff procedures (NADP2 profile) satisfy typical noise abatement requirements. Some airports may have special procedures (NADP 1 profile or Green Pages) which require modification of the takeoff profile.

Takeoff - General

Review the TAKEOFF PERF page to ensure the entries are correct. While taxiing, the FMA normally indicates CLB and NAV (blue). However, if there is no managed NAV segment immediately following the runway (on the FPLN page) or if a heading is selected on the FCU, column three will be blank. Consider displaying the radar or terrain on the NDs. Select the ND range and mode most advantageous for departure.

Mode: Display ARC mode on the ND if the takeoff direction is approximately the departure direction, or the ROSE NAV mode if the direction change is to be more than 70 degrees after takeoff.

Range: Set the minimum range to display the first waypoint after departure, or as required for weather radar.

At least one pilot should be on the F-PLN page for departure.

Review the F-PLN page for any climb constraints. Ensure the F-PLN page contains the appropriate altitude and airspeed restrictions consistent with the departure procedure.

Initiating Takeoff Roll

Flight director use is required for all takeoffs. Autothrust will arm automatically when desired thrust is set, TOGA or FLEX.

Note: The technique to reduce engine wear is termed "FLEX," which is synonymous with the Assumed Temperature Method (ATM).

Rolling Takeoff

Before applying thrust for takeoff, the PF will apply forward sidestick pressure to move the sidestick position indicator halfway to the limit (place the PFD '+' symbol halfway between the horizon line and the lower brackets). This will counter the nose-up effect created by takeoff thrust.

A rolling takeoff while setting takeoff thrust is recommended. It expedites the takeoff and reduces the risk of foreign object damage or engine surge/stall due to a tailwind or crosswind. Flight test and analysis prove that the change in takeoff roll distance due to the rolling takeoff procedure is negligible when compared to a standing takeoff.



A rolling takeoff is accomplished by maintaining normal taxi speeds when cleared for takeoff before or while entering the runway. When the aircraft is aligned with the runway centerline ensure the tiller is released and apply takeoff thrust by advancing the thrust levers to approximately 50% N1. Allow the engines to stabilize momentarily then promptly advance the thrust levers to takeoff thrust.

If a rolling takeoff is being made by the CA, request the FO to apply forward sidestick until the sidestick CA announces, "I HAVE THE AIRCRAFT."

Note: The "Dual Input" aircraft callout may be triggered momentarily during the transfer of controls.

Static Takeoff

A static takeoff is accomplished by holding in position on the assigned runway. Ensure the nose wheel steering tiller is released and release brakes, then apply takeoff thrust as described above. This method satisfies the criteria for takeoff minima in low visibility.

Note: Brakes are not normally held with thrust above idle unless a standing takeoff in icing conditions is required.

Standing Takeoff

A standing takeoff is accomplished by holding the brakes until the engines are stabilized at or above 70% N1.

Ensure the nose wheel steering tiller is released, then gently release the brakes and promptly select TOGA or FLEX.

All Takeoffs

Allowing the engines to stabilize momentarily prior to advancing to takeoff thrust provides uniform engine acceleration to takeoff thrust and minimizes directional control problems. This is particularly important if crosswinds exist or the runway surface is slippery.

The PM will announce "MAN FLEX" or "MAN TOGA" after verifying FMA thrust indication.

Ensure FLEX or TOGA thrust is set by 40 knots and actually achieved by 60 knots. At 60 knots, check the upper ECAM to confirm that the N1 achieved is equal to the N1 target and that the thrust limit mode selected agrees with the mode planned.

**A319/320/321 Flight Crew Training Manual**

If the wrong detent is inadvertently selected during takeoff, an ECAM message will appear. Selecting TOGA may clear the ECAM and allow the takeoff to be continued.

Note: If the thrust levers are left in the CL detent, the call out “RETARD, RETARD” will occur at approximately 80 knots.

If full thrust is desired for any reason during a FLEX thrust takeoff, advance the thrust levers to the maximum forward detent (TOGA) and verify TOGA appears in column 1 of the FMA.

Use of the nose wheel steering tiller is not recommended above 30 knots. However, pilots must use caution when using the nose wheel steering tiller above 20 knots to avoid over-controlling the nose wheels resulting in possible loss of directional control.

Light forward pressure is held on the sidestick. Keep the aircraft on centerline with rudder pedal steering and rudder. The rudder becomes effective between 40 and 60 knots. Maximum nose wheel steering effectiveness is available when above taxi speeds by using rudder pedal steering.

Regardless of which pilot is making the takeoff, the captain should keep one hand on the thrust levers until V1 in order to respond quickly to a rejected takeoff condition. After V1, the captain's hand should be removed from the thrust levers.

The PM should monitor the E/WD, SD and airspeed indications during the takeoff roll and announce any abnormalities. The PM should announce passing 80 knots and the PF should verify that his airspeed indicator is in agreement.

A pitot system blocked by protective covers or foreign objects can result in no airspeed indication, or airspeed indications that vary between instruments. It is important that aircrews ensure airspeed indicators are functioning and reasonable at the 80 knot callout. Generally, the Speed Trend Arrow is near the top of the PFD Airspeed Tape. During a heavy weight, high temperature, or high altitude takeoff this may not be the case. If the accuracy of either primary airspeed indication is in question, reference the standby airspeed indicator. Another source of speed information is the ground speed indication. Early recognition of a malfunction is important in making a sound go/stop decision. Refer to the Airspeed Unreliable section in chapter 8 for an expanded discussion of this subject.



Rotation and Liftoff - All Engines

CAUTION: If a takeoff is made with the flight directors off, V2 defaults to 100 knots, and autothrust will not arm.

Takeoff speeds are established based on minimum control speed, stall speed, and tail clearance margins. Shorter-bodied aircraft are normally governed by stall speed margin while longer-bodied aircraft are normally limited by tail clearance margin. When a smooth continuous rotation is initiated at VR, tail clearance margin is assured because computed takeoff speeds depicted in the FMS or ODM are developed to provide adequate tail clearance.

Above 80 knots, relax the forward sidestick pressure so it is neutral by 100 knots. For optimum takeoff and initial climb performance, initiate a smooth continuous rotation at VR toward 17.5° of pitch attitude. However, takeoffs at low thrust setting (low excess energy) will result in a lower initial pitch attitude target to achieve the desired climb speed. After liftoff, use the PFD as the primary pitch reference. The flight director, in conjunction with indicated airspeed and other flight instruments, is used to maintain the proper vertical flight path.

Using the technique above, resultant rotation rates vary from 2.5° to 3°. Liftoff attitude is achieved in approximately 5 - 7 seconds.

Once airborne, smoothly release any rudder input and allow the aircraft to weathervane into the wind. Remove any lateral sidestick input before the aircraft transitions from the ground mode to the flight mode. This transition varies with pitch rate, but generally occurs within the first 50 feet (approximately 5 seconds) after takeoff.

Continue the rotation to the pitch bar, which commands the Speed Reference System (SRS) mode during takeoff.

If the FD is not commanding SRS, rotate the aircraft to a target pitch of 17.5° nose up and then adjust as necessary to achieve V2+10.

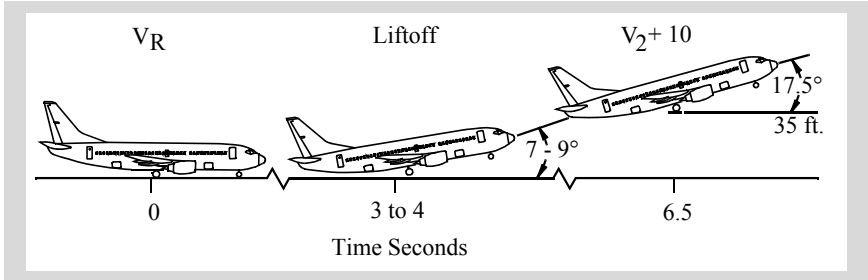
In the flight mode, zero roll rate is achieved when there is no lateral sidestick input.



A319/320/321 Flight Crew Training Manual

Typical Rotation, All Engines

The following figure shows typical rotation with all engines operating.

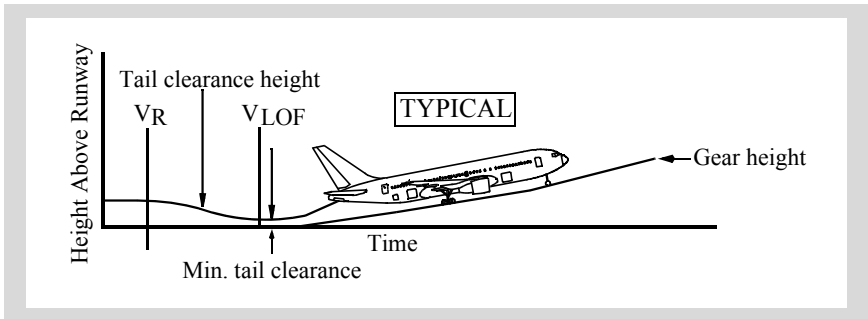


Retract the landing gear after a positive rate of climb is indicated on the altimeter and the IVSI.

Retract flaps in accordance with the technique described in this chapter.

Note: When operating at low gross weights, takeoff with less than full rated thrust will aid in aircraft directional control in the event of an engine failure.

The following diagram and table show the minimum tail clearance during takeoff. Additionally, the last column of the table shows the pitch attitude for tail contact with wheels on the runway and landing gear struts extended and compressed. For a discussion of tail strike procedures see this chapter and the Tail Strike NNC.



Tail strike pitch attitude		
Model	L/G compressed	L/G extended
A319	13.9°	15.5°
A320	11.7°	13.5°
A321	9.7°	11.2°

Effect of Rotation Speed and Pitch Rate on Liftoff

Takeoff and initial climb performance depend on rotating at the correct airspeed and proper rate to the rotation target attitude. Early or rapid rotation may cause a tail strike. Late, slow, or under-rotation increases takeoff ground roll. Any improper rotation decreases initial climb flight path.

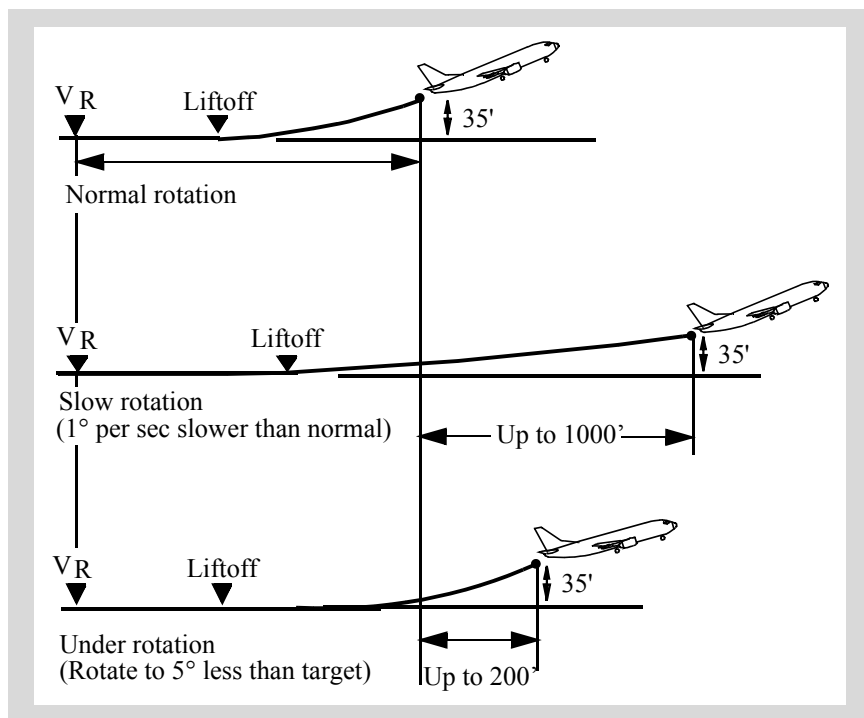
Initiate the rotation with a smooth positive backward sidestick input (typically 2/3 backstick). The initial rotation rate takes time to establish. It is typically 2.5 to 3 °/s. Rotation rates significantly below 2 °/s should be avoided.

If the established pitch rate is not satisfactory, make smooth corrections on the sidestick. If an increase in the rotation rate is made around the time of liftoff, the possibility of tailstrike increases significantly, especially on the A321.

During rotation, do not chase the FD pitch bar, since it might lead to overcorrection. Once airborne, smoothly adjust the pitch attitude using the FD.

The following diagram shows how a slow or under rotation during takeoff increases the distance to a height of 35 feet compared to a normal rotation.

Slow or Under Rotation (Typical)





Center-Of-Gravity Effects

When taking off at light weight and with an aft CG, the combination of full thrust, rapid thrust application, and sudden brake release may tend to pitch the nose up, reducing nosewheel steering effectiveness. Maintain forward pressure on the sidestick until 100 knots to increase nosewheel steering effectiveness. Above 80 knots, relax the forward sidestick pressure so it is neutral by 100 knots. At light weight and aft CG, use of reduced thrust and rolling takeoff technique is recommended whenever possible. The rudder becomes effective between 40 and 60 knots.

Aircraft with an aft CG and trimmed erroneously for “nose up” may cause a premature rotation increasing the possibility of a tail strike.

Note: If the stabilizer trim has been incorrectly set, the aircraft may “feel” different during the rotation. However, if the stabilizer trim is anywhere in the normal range (green band), there should be no major effects on aircraft handling. After liftoff, the THS will trim to the correct setting.

Crosswind Takeoff

When the crosswind component is in excess of 20 knots, modify the thrust application as follows to prevent possible compressor stall of the upwind engine. Advance the thrust levers normally to 50% N1 and ensure symmetric acceleration. Then rapidly advance the thrust levers to 70% N1 and then smoothly forward to the proper takeoff thrust detent.

The use of full forward sidestick is recommended for crosswinds in excess of 20 knots before applying takeoff thrust to increase nosewheel steering effectiveness during the initial takeoff roll.

Engine stress and possible engine surge can occur with a strong crosswind or tailwind component if takeoff thrust is set before brake release. Therefore, the rolling takeoff procedure is strongly advised when crosswinds exceed 20 knots.

Takeoff Crosswind Guidelines

Takeoff crosswind guidelines are based on the most adverse aircraft loading (light weight and aft center of gravity) and assume an engine out RTO and proper pilot technique.

For contaminated runways, refer to Vol. 1, SP.16, Guidelines for Contaminated Runways, Crosswind Guidance.

Directional Control

Initial runway alignment and smooth symmetrical thrust application result in good crosswind control capability during takeoff. Forward pressure on the sidestick during the initial phase of the takeoff roll (below approximately 100 knots) increases nose wheel steering effectiveness. Any deviation from the centerline during thrust application should be countered with immediate, smooth, and positive control inputs. Smooth rudder control inputs result in a normal takeoff with no overcontrolling. Large sidestick inputs (more than 1/3 lateral displacement of the sidestick) can have an adverse effect on directional control near VMCG due to the additional drag of the extended spoilers.

For takeoffs on runways with localizers, RWY appears in column 3 and a yaw bar is visible on the PFD that shows deviation from the localizer centerline. Although it should be crosschecked with external visual indications, the yaw bar should not be used as the primary means of centerline control.

Note: With wet or slippery runway conditions, the PM should give special attention to ensuring the engines have symmetrically balanced thrust indications.



Rotation and Takeoff

Begin the takeoff roll with the sidestick approximately centered. During the takeoff roll do not add sidestick input into the wind unless required to keep wings level.

Note: Excessive sidestick displacement during rotation and liftoff increases spoiler deployment. As spoiler deployment increases, drag increases and lift is reduced which results in reduced tail clearance, a longer takeoff roll, and slower aircraft acceleration.

At liftoff, the aircraft is in a sideslip with crossed controls. A slow, smooth recovery from this sideslip is accomplished by slowly neutralizing the sidestick and rudder pedals after liftoff before the aircraft transitions from the ground mode to the flight mode (approximately 5 seconds).

Gusty Wind and Strong Crosswind Conditions

For takeoff in gusty or strong crosswind conditions, consider the use of a higher thrust setting than the minimum required. When the prevailing wind is at or near 90° to the runway, the possibility of wind shifts resulting in gusty tailwind components during rotation or liftoff increases. During this condition, consider the use of TOGA. The use of a higher takeoff thrust setting reduces the required runway length and minimizes the aircraft exposure to gusty conditions during rotation, liftoff, and initial climb.

If a gust is experienced near VR, as indicated by stagnant airspeed or rapid airspeed acceleration, momentarily delay rotation. This slight delay allows the aircraft additional time to accelerate through the gust and the resulting additional airspeed improves the tail clearance margin. Do not rotate early or use a higher than normal rotation rate in an attempt to clear the ground and reduce the gust effect because this reduces tail clearance margins. Limit sidestick input to that required to keep the wings level. Use of excessive sidestick increases spoiler deployment which has the effect of reducing tail clearance. All of these factors provide maximum energy to accelerate through gusts while maintaining tail clearance margins at liftoff. The aircraft is in a sideslip with crossed controls at this point. A slow, smooth recovery from this sideslip is accomplished after liftoff by slowly neutralizing the sidestick and rudder pedals.

Reduced Takeoff Thrust (Less Than Full Power)

Note: The term “Assumed Temperature Method (ATM)” is synonymous with the term “FLEX.”

Normally, takeoffs are conducted with less than full rated takeoff thrust whenever performance capabilities permit. Lower takeoff thrust reduces EGT, improves engine reliability, and extends engine life.

Takeoff thrust reduction can be achieved using Assumed Temperature Method (ATM). Takeoff with less than full rated takeoff thrust complies with all regulatory takeoff performance requirements. At any time during takeoff, thrust levers may be advanced to the full rated takeoff thrust. Regardless of the method, use the takeoff speeds provided on the WDR corresponding to the specific thrust setting being used.

Note: Takeoff with full rated takeoff thrust is recommended if windshear conditions are suspected.

Assumed Temperature Method (ATM)

CAUTION: Do not use ATM when:

- restricted at particular airports; refer to Delta Special Pages (Green Pages),
- unstable weather conditions exist,
- AWABS is inoperative,
- runway is contaminated with standing water, slush, snow or ice;
- certain MEL (O) PROCEDURES prohibit its use, or
- an ATM thrust setting is not authorized by the WDR.

ATM is achieved by selecting an assumed temperature higher than the actual ambient temperature.

When using ATM, the takeoff thrust setting is not considered a takeoff operating limit since minimum control speeds (VMCG and VMCA) are based on the full rated takeoff thrust. At any time during takeoff, thrust levers may be advanced to the full rated takeoff thrust.

Actual performance is equal to or better than the performance obtained if actually operating at the assumed temperature. This is because the true airspeed at the actual temperature is lower than at the assumed temperature.

Derated Takeoff Thrust (Fixed Derate)

The aircraft does not have the capability to perform a derated thrust takeoff.



Thrust Control

When conducting an ATM takeoff, if more thrust is needed, thrust levers must be advanced manually to the TOGA detent. If conditions are encountered during the takeoff where additional thrust is needed, such as a windshear condition, the crew should not hesitate to manually advance thrust levers to TOGA.

Low Visibility Takeoff

Low visibility takeoff operations may require a takeoff alternate. When selecting a takeoff alternate, consideration should be given to unexpected events such as an engine failure or other non-normal situation that could affect landing minima at the takeoff alternate.

With appropriate runway lighting and/or markings, takeoffs with visibility as low as 500ft/150m RVR may be authorized (FAA). Regulatory agencies may apply takeoff crosswind limits specifically for low visibility takeoffs.

Refer to the FOM, chapter 5.1, Alternate Designation Criteria.

Refer to AM, Ops Specs, Takeoff Minima for RVR requirements.

Post De/Anti-Icing Takeoff

Testing of undiluted de-icing/anti-icing fluids has shown that some of the fluid remains on the wing during takeoff rotation and initial climb. The residual fluid causes a temporary decrease in lift and increase in drag. However, the effects are temporary. Use the normal takeoff rotation rate. Snow (wet or dry), slush, standing water, and ice will adversely affect takeoff performance. Slush, dry snow and standing water affect acceleration. Precipitation in any form affects stopping capability.



Adverse Runway Conditions

Slush, standing water, or deep snow reduces the aircraft takeoff performance because of increased rolling resistance and reduced tire-to-ground friction. In addition to performance considerations, slush or standing water may cause damage to the aircraft. The maximum depth for slush, standing water, or wet snow is 0.5 inch on the runway. For dry snow the maximum depth is 4 inches. To determine runway condition for takeoff, refer to Vol. 1, SP.16, Guidelines for Contaminated Runways, Takeoff Runway Contaminant Decision Tree.

A slippery runway (wet, compact snow, ice) also increases stopping distance during a rejected takeoff. Takeoff performance and critical takeoff data are adjusted to fit the existing conditions. Check the WDR for takeoff performance changes with adverse runway conditions.

Note: If there is an element of uncertainty concerning the safety of an operation with adverse runway conditions, do not takeoff until the element of uncertainty is removed.

During wet runway or slippery conditions, give special attention to ensure that the thrust on the engines advances symmetrically. Any tendency to deviate from the runway centerline must immediately be countered with steering action.

Forward pressure on the sidestick during the initial portion of the takeoff roll increases nose wheel steering effectiveness.

During takeoffs on icy runways, lag in rudder pedal steering and possible nose wheel skidding must be anticipated. Keep the aircraft on the centerline with rudder pedal steering and rudder. The rudder becomes effective between 40 - 60 knots. If deviations from the centerline cannot be controlled either during the start of the takeoff roll or until the rudder becomes effective, immediately reject the takeoff.

Refer to Vol. 1, SP.16, Guidelines for Contaminated Runways.



Takeoff Performance Limit Weights

The Takeoff Performance Limit Weights required by the FARs include:

- Climb Limit Weight
- Obstacle Clearance Limit Weight
- Field Length Limit Weight (which include tire speed and brake energy limits)

The Climb Limit Weight assures that a specified gradient can be maintained after liftoff in still air conditions. The Obstacle Clearance Limit Weight assures that all obstacles along the intended flight path can be cleared with one engine inoperative. The Field Length Limit Weight is the most restrictive weight resulting from the following runway length requirements:

- the distance required to accelerate with all engines, experience an engine failure within 1 second of V₁, continue the takeoff to a height 35 feet above the runway at V₂ speed (Accelerate-Go Distance).
- the distance required to accelerate with all engines, recognize an event within 1 second of V₁, initiate the stopping maneuver and stop within the confines of the runway (Accelerate- Stop Distance).
- 1.15 times the all engine takeoff distance required to reach a point 35 feet above the runway (usually only limiting for 4-engine aircraft).

Delta presents the Climb Limit Weight (CLW) separately on the Weight Data Record (WDR). The Field Length Limit and the Obstacle Clearance Limit are combined into one Runway Allowable Takeoff Weight (RATOW). Headwind and tailwind corrections apply to the RATOW but not the CLW.

The FAR requirements are based on certification flight tests on a dry runway using maximum braking but do not include credit for reverse thrust. Performance limits for wet and contaminated runways do include credit for the use of reverse thrust.

By definition, all V₁ speeds result in accelerate-go distance equal to accelerate-stop distance. Balanced Field Length occurs when the accelerate-go (or accelerate-stop distance) is equal to the length of the available runway. This generally results in the maximum Field Length Limit Weight but not necessarily the maximum RATOW or maximum takeoff weight considering both CLW and RATOW. AWABS presents customized V-speeds on the WDR. The V₁ may be reduced from the balanced V₁ to give improved stopping margins on wet or contaminated runways. When the CLW is limiting but the RATOW provides significant performance margin the V-speeds may be increased to improve climb performance and thereby increase the Climb Limit Weight. Note that the balanced V₂ is generally less than the speed for best angle of climb, so increasing V₂ by a few knots can improve the climb angle or gradient.



Takeoff flaps are chosen to give the best balance of performance considering the Field Length Limits and the climb limits associated with the Climb Limit Weight and the Obstacle Clearance Limit. Larger takeoff flaps reduce the stall speed but increase the drag, so they give better Field Length Limits at the expense of climb performance. Larger flap settings also provide greater tail clearance because liftoff occurs at a smaller angle of attack. Smaller takeoff flap settings give better climb performance but require longer field lengths. RATOW does not necessarily increase or decrease with flap setting changes because it includes both Field Length and Obstacle Clearance (climb) considerations.

Rejected Takeoff Decision

The total energy that must be dissipated during an RTO is proportional to the square of the aircraft velocity. At low speeds (up to approximately 80 knots), the energy level is low. Therefore, the aircraft should be stopped if an event occurs that would be considered undesirable for continued takeoff roll or flight. Examples include Master Caution, unusual vibrations, or tire failure.

As the airspeed approaches V1 during a balanced field length takeoff, the effort required to stop can approach the aircraft maximum stopping capability. Therefore, the decision to stop must be made before V1.

Historically, rejecting a takeoff near V1 has often resulted in the aircraft stopping beyond the end of the runway. Common causes include initiating the RTO after V1 and failure to use maximum stopping capability (improper procedures/techniques). The maximum braking effort associated with an RTO is a more severe level of braking than most pilots experience in normal service.

Rejecting the takeoff after V1 is not recommended unless the captain judges the aircraft incapable of flight. Even if excess runway remains after V1, there is no assurance that the brakes have the capacity to stop the aircraft before the end of the runway.

There have been incidents where pilots have missed MCDU scratch pad messages informing them that the takeoff speeds have been deleted, usually as a result of a runway change. If, during a takeoff, the crew discovers that the V speeds are not displayed and there are no other fault indications, the takeoff may be continued. The lack of displayed V speeds with no other fault indications does not fit any of the published criteria for rejecting a takeoff. In the absence of displayed V speeds, the PM should announce V1 and VR speeds to the PF at the appropriate times during the takeoff roll.



A319/320/321 Flight Crew Training Manual

The takeoff should be rejected for the following:

Event	Prior to 80 knots	80 knots to V1	Above V1
Activation of the Master Caution*	X		
System Failures	X		
Unusual noise or vibration	X		
Tire Failure	X		
Abnormally slow acceleration	X		
Takeoff configuration warning	X		
If a side window opens	X		
Engine failure	X	X	
Fire or fire warning	X	X	
Predictive windshear caution or warning**	X	X	
If the aircraft is unsafe or unable to fly	X	X	X

* Except ECAM message “ENG THR LEVERS NOT SET” or “ENG FLEX TEMP NOT SET” (FLEX temp not entered or ambient temp equals [or exceeds] FLEX temp).

** A321 Only.

If the captain is making the takeoff, the captain must:

- clearly announce “ABORT,” and
- immediately start the Rejected Takeoff Maneuver.

When the first officer is making the takeoff and the captain decides to abort, the captain must:

- clearly announce “ABORT, I HAVE THE AIRCRAFT,”
- immediately start the Rejected Takeoff Maneuver, and
- assume control of the aircraft in a positive manner.

Note: The first officer will maintain directional control of the aircraft until the captain makes a positive input to the controls and states, “I HAVE THE AIRCRAFT.”



Rejected Takeoff Maneuver

The RTO maneuver is initiated during the takeoff roll to expeditiously stop the aircraft on the runway. The PM should closely monitor essential instruments during the takeoff roll and immediately announce abnormalities, such as “ENGINE FIRE”, “ENGINE FAILURE”, or any adverse condition significantly affecting safety of flight. The decision to reject the takeoff is the responsibility of the captain, and must be made before V1 speed. If the captain is the PM, he should initiate the RTO maneuver and then, as time permits, announce the abnormality.

MAX autobrakes will be selected for takeoff to ensure immediate maximum anti-skid braking during a rejected takeoff is applied at speeds above 72 knots. During a rejected takeoff, below 72 knots ground speed, use manual braking. Above 72 knots ground speed, an illuminated DECEL light indicates the autobrakes are commanding maximum braking.

After an RTO, complete any appropriate ECAM actions and then any required non-normal checklist and refer to the QRH, section 0, Rejected Takeoff - Post RTO Considerations.



A319/320/321 Flight Crew Training Manual

Rejected Takeoff Maneuver Table

Captain	First Officer
Without delay, simultaneously: - Retard the thrust levers to IDLE. - Apply maximum manual braking or verify operation of MAX autobrakes. Note: Monitor autobrake system and apply manual wheel brakes if the DECEL light is not illuminated or deceleration is not adequate.	Verify actions as follows: - Thrust levers to IDLE. - Maximum brakes applied.
Apply maximum reverse thrust consistent with condition.	Verify reverse thrust applied.
Verify operation of ground spoilers. Extend ground spoilers if not deployed.	If SPOILERS deployed, call "SPOILERS UP". If SPOILERS not deployed, call "NO SPOILERS".
Continue maximum braking until certain the airplane will stop on the runway.	Call out any omitted action items.
Field length permitting: Initiate movement of the reverse thrust levers to reach the idle reverse detent by taxi speed.	Call out "80 KNOTS".
Notify the tower of the abort and request emergency equipment, if necessary. As soon as practical, make the appropriate RTO PA in accordance with the FOM.	

CAUTION: If difficulty in maintaining directional control is experienced during reverse thrust operation, reduce reverse thrust to reverse idle (or forward idle thrust if required), regain directional control, and reapply reverse thrust as necessary. Do not attempt to maintain directional control by using asymmetrical reverse thrust.



Post RTO Considerations

- Tower Notification: Once stopping is assured, notify ATC. Should a high energy (high speed, heavy weight) RTO occur, consider requesting emergency equipment be dispatched to meet the aircraft in the event of possible tire or brake fire.
- Airport Rescue and Fire Fighting (ARFF): ARFF personnel can provide important information regarding the exterior status of the aircraft. Refer to the FOM, Chapter 6 for hand signals used by ARFF personnel. Consider remaining on the runway if emergency equipment is needed.
- RTO PA: If an evacuation is not required, make a PA as soon as practical and a second PA should be made after the situation has stabilized. If an evacuation is required, make a PA when directed by the Emergency Evacuation checklist.
- Non-Normal Checklists: Complete the Non-Normal checklist (if appropriate) for the condition(s) causing the RTO.
- Prior to taxi: Check entry/exit door status to ensure an evacuation is not in progress. Ensure ground personnel and equipment are clear of the aircraft.
- Parking Brake: Consider not setting the parking brake to facilitate brake cooling and reduce the possibility of brakes fusing. Consider setting the parking brake to ensure the safety of ground personnel or as directed by the Evacuation checklist.
- Brake Cooling: Observe brake cooling schedule and precautions in the ODM.
- Subsequent Departures: Contact Flight Control and refer to FOM, Chapter 3.4, Rejected Takeoff (RTO).
- Refer to the QRH, section 0, Rejected Takeoff - Post RTO Considerations.

Go/Stop Decision Near V1

It was determined when the aviation industry produced the Takeoff Safety Training Aid in 1992 that the existing definition of V1 might have caused confusion because they did not make it clear that V1 is the maximum speed at which the flight crew must take the first action to reject a takeoff. The U.S. National Transportation Safety Board (NTSB) also noted in their 1990 study of rejected takeoff accidents that late initiation of rejected takeoffs was the leading cause of runway overrun accidents. As a result, the FAA has changed the definition of V1 in FAR Part 1 to read as follows:

- V1 means the maximum speed in the takeoff at which the pilot must take the first action (e.g., apply brakes, reduce thrust, deploy speedbrakes) to stop the aircraft within the accelerate-stop distance and
- V1 also means the minimum speed in the takeoff, following a failure of an engine at which the pilot can continue the takeoff and achieve the required height above the takeoff surface within the takeoff distance.

**A319/320/321 Flight Crew Training Manual**

Pilots know that V1 is fundamental to making the Go/Stop decision. Under runway limited conditions, if the reject procedure is initiated at V1, the aircraft can be stopped before reaching the end of the runway.

When the takeoff performance in the AFM is produced, it assumes an engine failure or event one second before V1. In a runway limited situation, this means the aircraft reaches a height of 35 feet over the end of the runway if the decision is to continue the takeoff.

Within reasonable limits, even if the engine failure occurs earlier than the assumed one second before V1, a decision to continue the takeoff will mean that the aircraft is lower than 35 feet at the end of the runway, but it is still flying. For example, if the engine fails 2 seconds before V1 and the decision is made to go, the aircraft will reach a height of 15 to 20 feet at the end of the runway.

Although training has historically centered on engine failures as the primary reason to reject, statistics show engine thrust loss was involved in approximately one quarter of the accidents, and wheel or tire problems have caused almost as many accidents and incidents as have engine events. Other reasons that rejects occurred were for configuration, indication or light, crew coordination problems, bird strikes, or ATC problems.

It is important to note that the majority of RTO accidents were not the result of an RTO initiated because of an engine failure. Full takeoff thrust from all engines was available. With normal takeoff thrust, the aircraft should easily reach a height of 150 feet over the end of the runway, and the pilot has the full length of the runway to stop the aircraft if an air turnback is required.

Making the Go/Stop decision starts long before V1. Early detection, good crew coordination, and quick reaction are the keys to a successful takeoff or stop.

RTO Execution Operational Margins

A successful rejected takeoff at or near V1 is dependent upon the captain making timely decisions and using the proper procedures.



Tail Strike

Tail strike occurs when the lower aft fuselage contacts the runway during takeoff or landing. A significant factor that appears to be common is the lack of flight crew experience in the model being flown. Understanding the factors that contribute to a tail strike can reduce the possibility of a tail strike occurrence.

Note: Anytime fuselage contact is suspected or known to have occurred, accomplish the appropriate NNC.

Takeoff Risk Factors

Any one of the following takeoff risk factors may precede a tail strike:

Mistrimmed Stabilizer

This usually results from using erroneous takeoff data, e.g., the wrong weights, or an incorrect center of gravity (CG). In addition, sometimes accurate information is either entered incorrectly in the flight management system (FMS) or set incorrectly on the stabilizer. The flight crew can prevent this type of error and correct the condition by challenging the reasonableness of the WDR numbers. Comparing the WDR numbers against past experience in the airplane can assist in approximating numbers that are reasonable.

Rotation at Improper Speed

This situation can result in a tail strike and is usually caused by early rotation due to some unusual situation, or rotation at too low an airspeed for the weight and/or flap setting.

Excessive Rotation Rate

Flight crews operating an airplane model new to them, especially when transitioning from an airplane with unpowered flight controls to one with hydraulic assistance, are most vulnerable to using excessive rotation rate. The amount of control input required to achieve the proper rotation rate varies from one model to another. When transitioning to a new model, flight crews may not realize that it does not respond to pitch input in exactly the same way as their previous model.

Improper Use of the Flight Director

With the proper rotation rate, the airplane reaches 35 feet with the desired pitch attitude of about 17°. During rotation the crew must not chase the FD pitch bar. The pitch bar does not give any pitch rate order and following it may lead to overreaction resulting in a tail strike.



Initial Climb - All Engines

After liftoff, use the attitude indicator as the primary pitch reference. The flight director, in conjunction with indicated airspeed, and other flight instruments is used to maintain the proper vertical flight path. Pitch, airspeed, and airspeed trends must be crosschecked whether the flight director is used or not.

After liftoff, SRS commands pitch to maintain an airspeed of $V_2 + 10$ knots until another pitch mode is engaged.

Retract the landing gear after a positive rate of climb is indicated on the altimeter and IVSI. Do not apply brakes after becoming airborne. Automatic wheel braking occurs during gear retraction. After gear and flaps are retracted, the PM should verify that the gear and flap indications are normal.

Immediate Turn after Takeoff - All Engines

CAUTION: Preselecting a heading more than 180° from the runway heading and then pulling the HDG knob will cause the autoflight system to command a turn in the shortest direction, which may be contrary to the ATC clearance.

Obstacle clearance, noise abatement, or departure procedures may require an immediate turn after takeoff. Initiate the turn at the appropriate altitude (normally at least 400 feet AFE).

After completing the turn, and at or above acceleration height, accelerate and retract flaps while climbing.

Note: The possibility of an engine failure along the departure track must be considered. Special engine-out procedures, if available, are preferable to a takeoff weight reduction to ensure all obstacles are cleared.

Roll Modes

At 30 feet RA, NAV or RWY TRK automatically engages (FMA column 3). NAV provides lateral guidance along the flight plan in the FMS. Managed nav departures entered into the FPLN include a waypoint along the extended runway centerline to preclude any turns below 400' AFE. RWY TRK provides lateral guidance along the track that existed at the time it engaged (normally the runway centerline track). This guidance is not necessarily the same as runway heading and could possibly conflict with traffic on parallel runways if a selected heading is not used after 400 feet AFE.

To fly an assigned heading, preselect the heading before takeoff then pull the HDG knob at 400' AFE.

Pitch Modes

There are three climb modes available: Open, Managed, and Selected (V/S or FPA).

The flight director, in conjunction with indicated airspeed and other flight instruments, is used to maintain the proper vertical flight path. Pitch, airspeed, and airspeed trends must be cross-checked whether the flight director is used or not.

Select climb thrust when the FMA flashes LVR CLB (at the thrust reduction altitude). At the acceleration altitude, the flight directors will command a lower pitch attitude and SRS is replaced by OP CLB (CLB if in managed NAV) on the FMA.

Autopilot Engagement

The minimum altitude for autopilot engagement is 100 feet AGL and 5 seconds after liftoff.

The aircraft should be in trim, and the flight director commands should be satisfied before autopilot engagement. This prevents unwanted changes from the desired flight path during autopilot engagement.

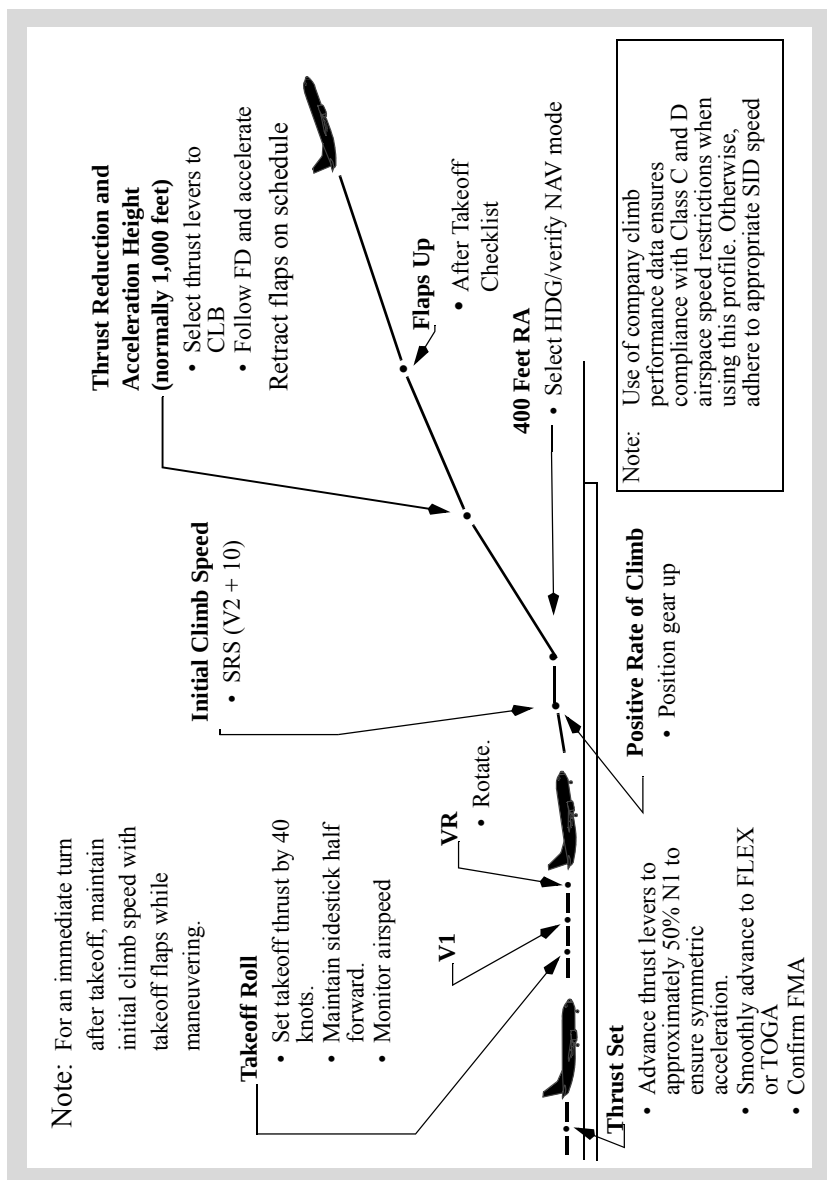
Flap Retraction Schedule

Normally, 1,000 feet AFE is used as the acceleration height to initiate thrust reduction and flap retraction. The altitude selected for acceleration and flap retraction may be specified for each airport. Safety, obstruction clearance, aircraft performance, or noise abatement requirements are usually the determining factors. At the acceleration altitude, SRS is replaced by OP CLB or CLB on the FMA. Do not retract the flaps while in SRS mode.

**A319/320/321 Flight Crew Training Manual**

During flap retraction, selection of the next flap position is initiated when reaching the maneuver speed “F” or “S” for the existing flap position. The maneuver speed for the existing flap position is indicated by “F”, “S”, or Green Dot on the airspeed display. Therefore, when the new flap position is selected, the airspeed is below the maneuver speed for that flap position. For this reason, the airspeed should be increasing when selecting the next flap position. Bank is limited to 15° during the FMS takeoff and approach phases if speed is less than maneuvering speed (“F” or “S”) for the current flap setting.

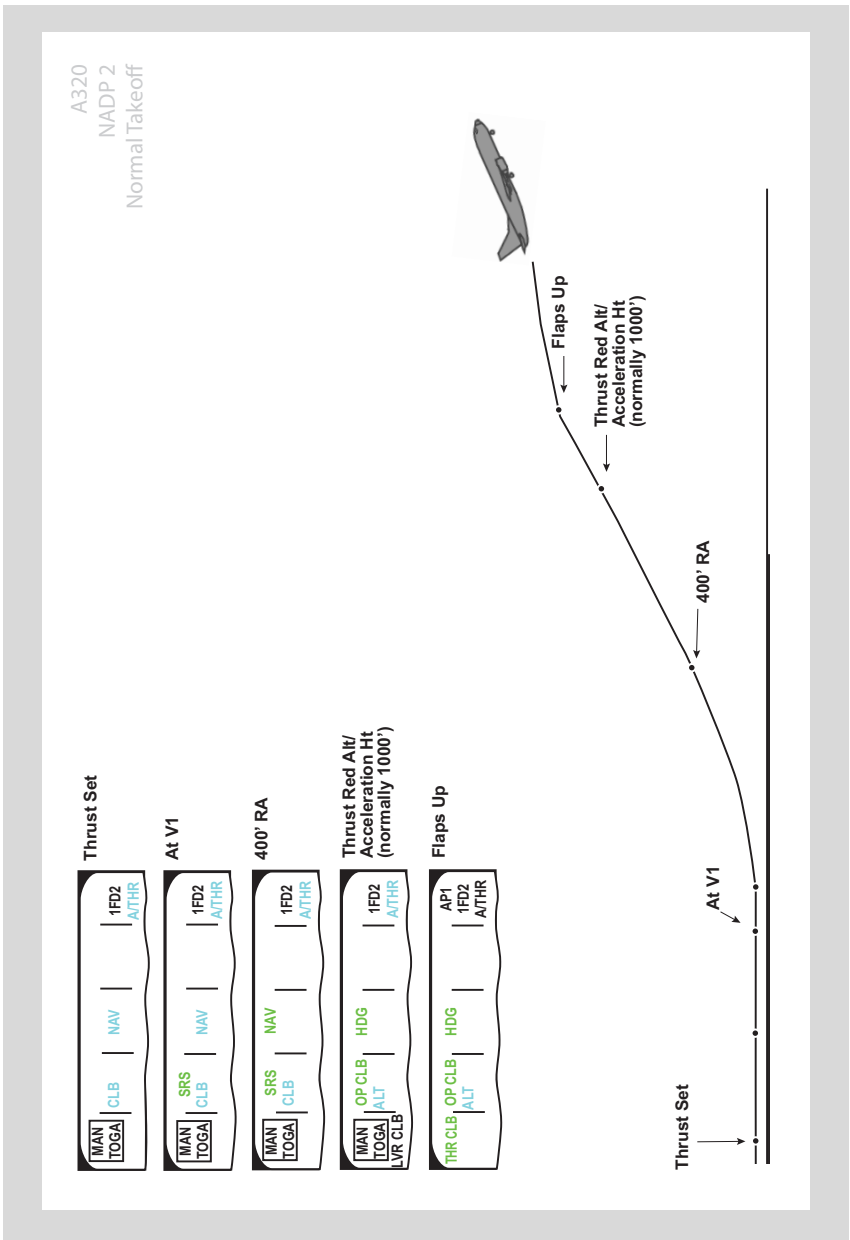
Normal Takeoff Profile (Distant/ICAO NADP 2)





A319/320/321 Flight Crew Training Manual

FMA Progression Profile





Normal Takeoff (Distant/ICAO NADP 2)

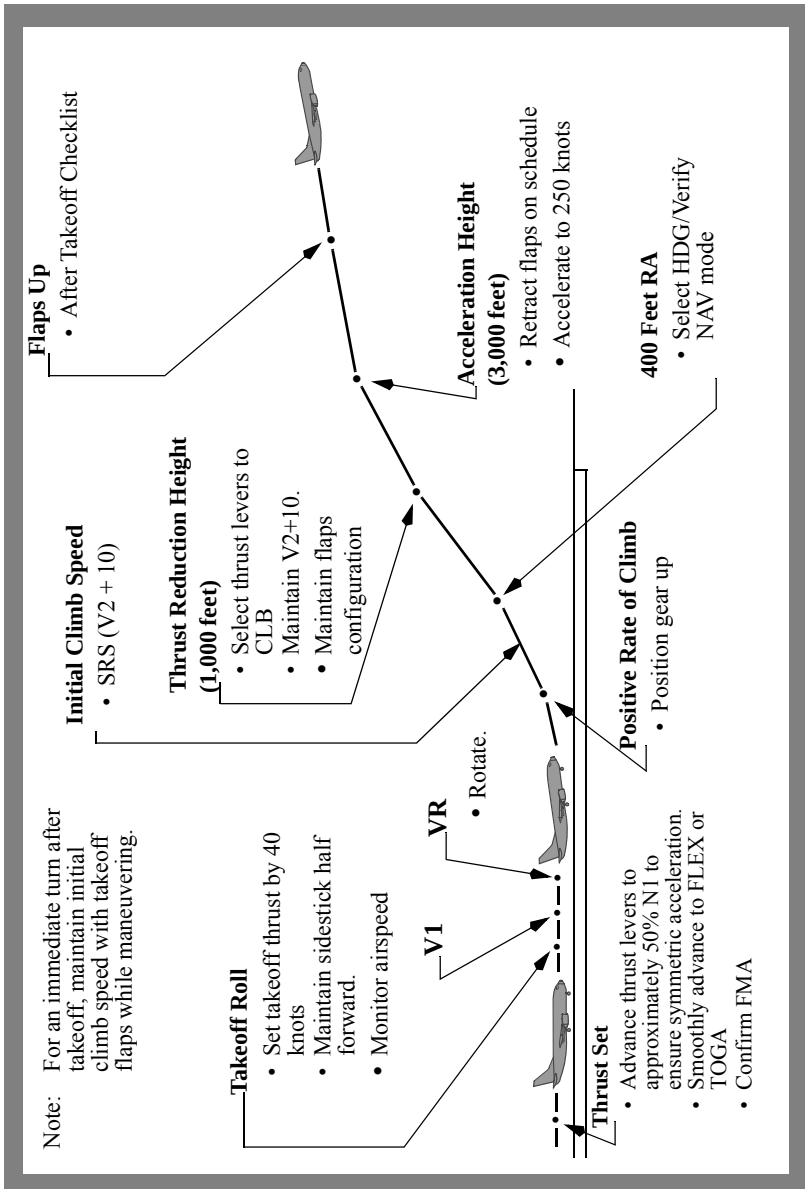
The Normal Takeoff profile (Distant/ICAO NADP 2) is the normal takeoff procedure and is the default FMS profile. The Distant/ICAO NADP 2 reduces noise slightly for communities that are not within the immediate vicinity of the runway end.

- Take off using AWABS generated takeoff power and flaps setting.
- At 1,000 feet AFE, reduce thrust to climb power.
- Simultaneously (at 1,000 feet AFE) reduce rate of climb and accelerate.
- As the airplane accelerates, retract flaps on schedule.
- Accelerate to appropriate climb speed.

Note: AFS will command appropriate pitch for acceleration segment.



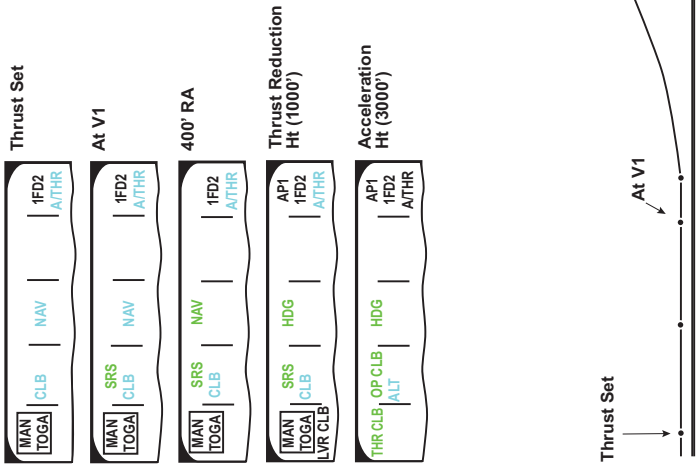
Special Takeoff Profile (Close-In/ICAO NADP 1)





FMA Progression

A320
Special Takeoff
Close In
NADP1



Acceleration Ht
(3000')

Thrust Reduction Ht
(1000')

400' RA

At V1



Special Takeoff (Close-In/ICAO NADP 1)

The Special Takeoff profile (Close-In/ICAO NADP 1) reduces noise for communities within the immediate vicinity of the runway end. The Close-In/ICAO NADP 1 is not the default FMS profile and must be entered on Takeoff Page 2.

- Take off using AWABS generated takeoff power and flaps setting.
- At 1,000 feet AFE reduce thrust to climb power, maintain takeoff flaps.
- Continue to fly commanded airspeed (nominally V₂+10).
- At 3,000 feet AFE reduce rate of climb and accelerate.
- As the airplane accelerates, retract flaps on schedule.
- Accelerate to appropriate climb speed.

Note: AFS will command appropriate pitch for acceleration segment.

Noise Abatement Takeoff

Regulatory agencies such as the FAA and ICAO have established standardized takeoff profiles so that an aircraft will use the same operating procedures throughout the world. Each operator develops specific procedures for flying Noise Abatement Departure Profiles (NADPs) that meet regulatory requirements. Airports are permitted to decide the appropriate NADP to use on each runway. Unless otherwise instructed, airlines will typically use the Distant /ICAO NADP 2.

Departure Speed Restrictions

Following flap retraction, maintain 250 knots unless restricted by the local procedure or terrain considerations. Speed restrictions may be imposed that are either associated with a waypoint, or are non-waypoint specific.

Waypoint-Associated Speed Restrictions

SID waypoint speed restrictions should be verified in the flight plan. They are honored when:

- The restrictions are in the FMS flight plan.
- The constraint waypoint has not sequenced.
- The aircraft's configuration allows (speed restriction vs. flap setting).

The minimum speed the aircraft will maintain in managed speed is the maneuver speed for the current flap setting (e.g., green dot for clean configuration). Therefore, if the speed restriction is less than green dot speed, flap retraction must be delayed as appropriate to ensure the limit speed is not less than the maneuver speed for the current flap setting.

Non-Waypoint Speed Restrictions

If a speed slower than 250 knots is required to comply with SID or -7 page restrictions, and is not associated with a waypoint (e.g., "maintain 230 knots until advised"), and it is not incorporated in the SID with an altitude pseudo-waypoint, it may be entered prior to departure as a PRESEL speed on the PERF CLB page. The pre-selected speed will be displayed as armed on the FMA during the takeoff phase (e.g., 'SPEED SEL:220'). When the CLB phase begins (at the ACCEL altitude), the preselected speed becomes an FCU selected speed. When the speed restriction no longer applies, push the speed knob to re-activate the normal managed speed profile.

Takeoff - Engine Failure

General

Differences between normal and engine out profiles are few. One engine out controllability is excellent during takeoff roll and after liftoff. Minimum control speed in the air is below VR and VREF.

Engine Failure Recognition

Prior to V1

An engine failure at slow speeds prior to V1 quickly affects aircraft heading. Asymmetric thrust as a result of engine failure at low speeds (below VMCG) may result in a loss of directional control because of a lack of rudder effectiveness. The first indication of an engine failure is the induced yaw resulting from the asymmetrical thrust of the operating engine. Failure to promptly reduce thrust on the operating engine may result in a runway excursion. VMCG is defined as the minimum control speed on the ground, with the critical engine inoperative, takeoff power on other engine(s), using rudder control only for directional control.

At or After V1

An engine failure at or after V1 initially affects yaw much like a crosswind effect. Vibration and noise from the affected engine may be apparent and the onset of the yaw may be rapid.

The aircraft heading and Beta Target are the best indicator of the correct rudder pedal input. To counter the thrust asymmetry due to an engine failure, stop the yaw with rudder. If the rudder is not applied to center the Beta Target, the aircraft will sideslip with excessive spoiler used to prevent roll.



Rotation and Liftoff - One Engine Inoperative

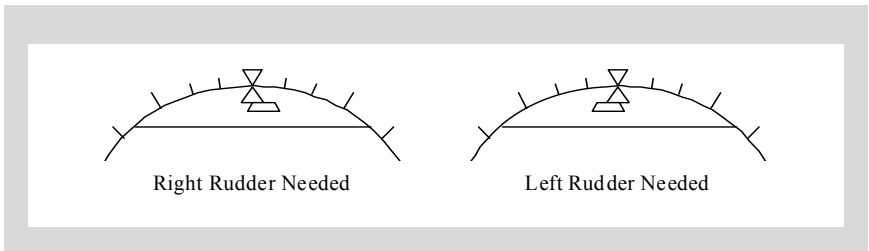
If an engine fails between V1 and liftoff, maintain directional control by smoothly applying rudder proportionate with thrust decay.

During a normal all-engine takeoff, a smooth continuous rotation toward 17° of pitch is initiated at VR. With an engine inoperative, a smooth continuous rotation is also initiated at VR; however, the target pitch attitude is approximately 10° to 12°. For FLAPS 3, heavyweight, or high density altitude takeoffs, the initial pitch attitude is 9.5° nose-up. The rate of rotation with an engine inoperative is approximately half the normal rate than for a normal takeoff. After liftoff follow flight director guidance.

If the engine failure occurs at or after liftoff apply rudder to control heading and keep the wings level. The flight control computers (FCCs) will displace the ailerons to maintain zero roll rate if the sidestick is neutral. Without adequate rudder, however, the FCCs will command aileron movement and spoiler deployment to achieve the requested '0' roll rate.

Lateral Control after Rotation

Shortly after lift-off the blue Beta (β) target will replace the normal yellow sideslip indication on the PFD. Adjust rudder pedal pressure to center the β target (step on the Beta (β) target).



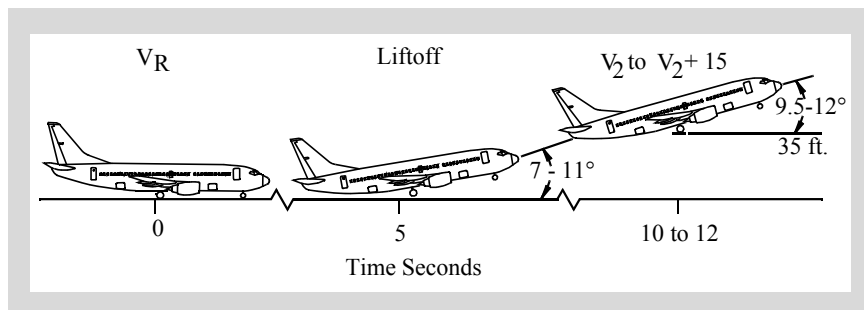
When the target is centered, total drag is minimized even though there is a small amount of sideslip.

Unlike conventional aircraft, no lateral sidestick inputs are required. Since the flight controls have no “feed back” from the control surfaces to the sidestick, use the Beta target.



Typical Rotation - One Engine Inoperative

Liftoff attitude depicted in the following tables should be achieved in approximately 5 seconds. Adjust pitch attitude, as needed, to maintain desired airspeed of V_2 to $V_2 + 15$ knots.



Retract the landing gear after a positive rate of climb is indicated on the altimeter and IVSI.

Retract flaps in accordance with the technique described in this chapter.

Typical Takeoff Tail Clearance - One Engine Inoperative

The tail strike pitch attitude remains the same as during takeoffs with all engines operating.

Initial Climb - One Engine Inoperative

The initial climb attitude should be adjusted to maintain a minimum of V_2 and a positive climb. After liftoff the flight director provides proper pitch guidance. Crosscheck indicated airspeed, vertical speed, and other flight instruments. The flight director commands a minimum of V_2 , or the existing speed up to a maximum of $V_2 + 15$.

If the flight director is not used, attitude and indicated airspeed become the primary pitch references.

Retract the landing gear after a positive rate of climb is indicated on the altimeter and the IVSI. The pilot should use SRS as a tool in this management and cross check SRS information with other flight instrument data.

Indications of an engine fire, impending engine breakup, or approaching or exceeding engine limits should be dealt with as soon as possible, after the aircraft is under control, the gear has been retracted, and a safe altitude (typically 400 feet AGL or above) has been attained. Due to asymmetric thrust considerations, it is recommended that the PF retard the affected thrust lever after the PM confirms that the PF has identified the correct engine. Accomplish the ECAM actions and non-normal checklist items after the flaps have been retracted and conditions permit.



A319/320/321 Flight Crew Training Manual

If an engine failure has occurred during initial climb, accomplish the ECAM actions and appropriate checklist after the flaps have been retracted and conditions permit.

Immediate Turn after Takeoff - One Engine Inoperative

Obstacle clearance or departure procedures may require a special engine-out departure procedure. Refer to AM, Ops Specs, Departure/Missed Approach/Rejected Landing Priorities. If an immediate turn is required, initiate the turn at the appropriate altitude (normally at least 400 feet AFE) and follow the flight directors (the flight directors limit the bank angle when below maneuvering speed to maintain the appropriate safety margin).

Note: The ENG OUT ACC field on the PERF TAKEOFF page does not change any autoflight behavior. When the aircraft reaches the engine inoperative acceleration height, the pilot must take action to accelerate. There is no FMA indication that the engine inoperative acceleration height has been reached.

After completing the turn, and at or above acceleration height, accelerate and retract flaps.

Autopilot Engagement - One Engine Inoperative

When at a safe altitude, above 100 feet AGL and five seconds after takeoff with correct rudder pedal or trim input and the flight director commands satisfied, the autopilot may be engaged.

Flap Retraction - One Engine Inoperative

The standard altitude to initiate acceleration and flap retraction with an engine inoperative is 1,000 feet AFE.

When the engine inoperative acceleration height is reached, the PF (AP ON) or PM (AP OFF) must push the VS knob to level off and begin accelerating.

Note: Selecting TOGA from FLEX while in level flight (V/S 0) before the flaps are retracted will cause SRS to re-engage with an immediate climb as a result.

Retract the flaps in level flight using normal procedures and accelerate to Green Dot.

Note: Using the EXPED function is the easiest and most expedient way to resume the climb after selecting the flap handle up.



When the flaps are retracted and the airspeed is at Green Dot, place the thrust levers in the MCT detent and climb to an altitude clear of obstacles.

Note: If an ATM takeoff was made, the thrust levers must be moved out of the FLEX detent then back into the FLEX detent to change the autothrust mode to MCT.

Accomplish appropriate ECAM actions and NNC/Normal checklists as necessary.

Flaps Up - One Engine Inoperative

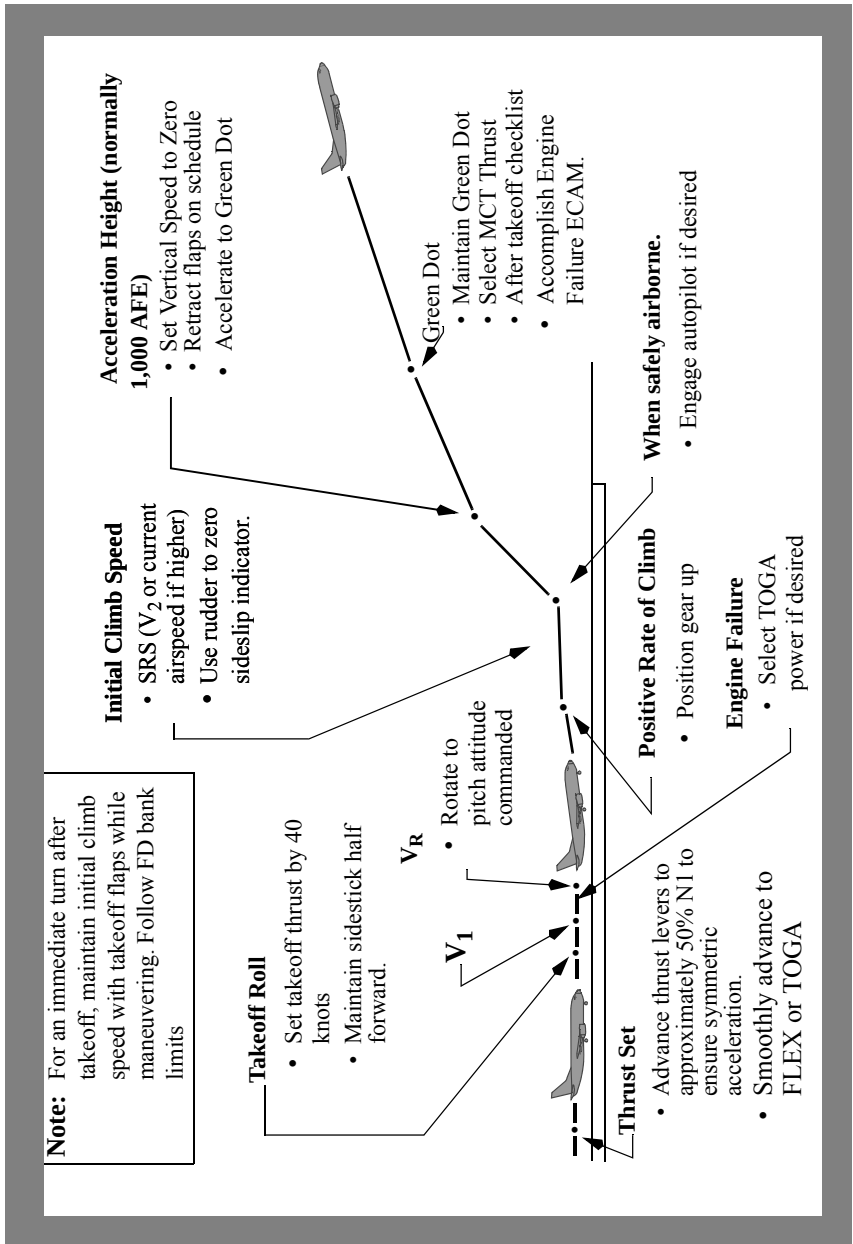
When the flaps are retracted and the airspeed is at Green Dot, verify the thrust levers are in the MCT detent and climb to an altitude clear of obstacles.

Accomplish the appropriate After Takeoff checklist items, ECAM, and non-normal checklist items, as necessary.

Note: When an engine failure occurs after takeoff, noise abatement is no longer a requirement.

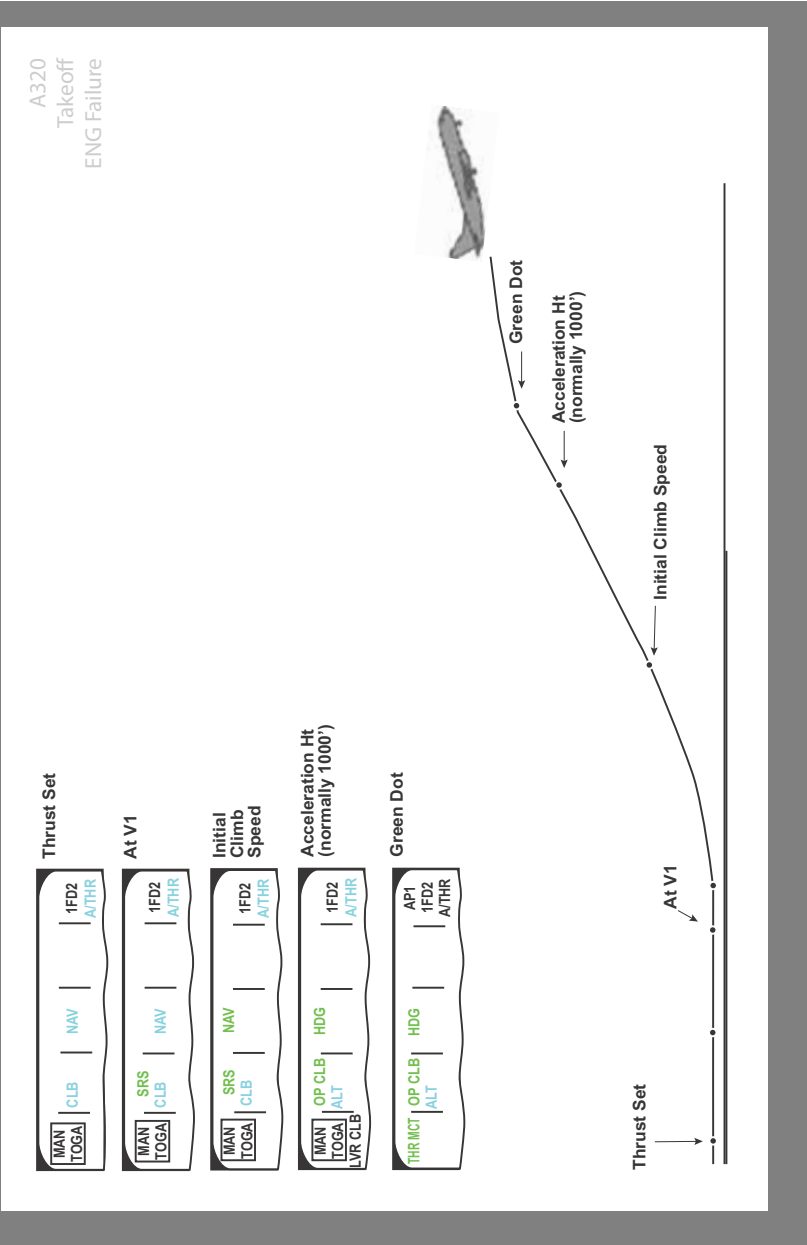


Takeoff Profile - Engine Failure





Takeoff Profile - Engine Failure; FMA Progression





Engine Failure During an ATM Takeoff

Since the ATM takeoff must still comply with all regulatory takeoff performance requirements, it is not necessary to increase thrust beyond the reduced level on the operating engine in the event of an engine failure. However, if more thrust is needed during an ATM takeoff, thrust on the operating engine may be increased to the TOGA detent.

Increasing thrust on the operating engine to the TOGA detent provides additional performance margin. This additional performance margin is not a requirement for the reduced thrust takeoff and its use is at the discretion of the flight crew.

Engine Failure During a Derated Thrust (Fixed Derate) Takeoff

The aircraft is not capable of performing a takeoff using derated takeoff thrust (fixed derate).

Engine Failure During a Combined ATM and Fixed Derate Takeoff

The aircraft is not capable of performing a takeoff using Combined ATM and derated takeoff thrust (fixed derate).



Intentionally
Blank



Climb, Cruise, Descent and Holding

Table of Contents

Chapter 4

Section TOC

Climb	4.1
Climb Modes	4.1
Climb Constraints	4.2
Low Altitude Level Off	4.2
Transition to Climb	4.3
Climb Speed Determination	4.3
Engine Icing During Climb	4.4
Economy Climb	4.4
Economy Climb Schedule - FMS Data Unavailable	4.4
Maximum Rate Climb	4.4
Maximum Angle Climb	4.5
Engine Inoperative Climb	4.5
Cruise	4.6
Cruise Speed Definitions	4.6
Cruise Speed Determination	4.6
Maximum Altitude	4.7
Optimum Altitude	4.8
Recommended Altitude	4.9
Step Climb	4.9
FMS Wind Entries	4.11
FMS Alternate	4.11
Low Fuel Temperature	4.12
Cruise Performance Economy	4.14
Engine Inoperative Cruise/Driftdown	4.15
High Altitude Performance	4.16
ETOPS	4.16



Descent	4.17
Descent Planning	4.17
Descent Speed Determination	4.19
Descent Path	4.19
Descent Constraints	4.20
Early Descent from Cruise	4.26
Approaching Top-of-Descent (TOD)	4.26
Managed Descent From Above Path	4.26
Descent Rates	4.27
Speedbrakes	4.28
Flaps and Landing Gear	4.29
Engine Icing During Descent	4.29
Holding	4.30
Holding Airspeeds	4.31
Procedure Holding	4.31
Holding Pattern Exit	4.31

Climb

Climb Modes

There are three climb modes available: Open, Managed, and Selected (V/S - FPA).

Open Climb

Open Climb is normally used when flying headings or when flying route segments with no altitude or speed constraints.

Open Climb is indicated by 'OP CLB' in column two of the FMA. It automatically replaces SRS mode at the acceleration altitude if the aircraft is not in the Managed NAV mode (e.g., flying a heading). In OP CLB, thrust is fixed (THR CLB) and pitch is varied to maintain the selected or managed climb speed.

Managed Climb

The Managed Climb mode is normally used when flying in Managed NAV. Managed climb is not possible in the heading mode. Managed climb is indicated by CLB in column two of the FMA. It is engaged by selecting an altitude above the aircraft in the FCU and pushing the ALT selector knob. Managed climb automatically replaces SRS mode at the acceleration altitude when lateral guidance is in the 'NAV' mode (column three). In the CLB mode, thrust is fixed (THR CLB) and pitch is varied to maintain the selected or managed climb speed. In this mode, the aircraft honors all FMS entered at or below restrictions but does not necessarily meet all at or above restrictions.

A magenta 'ALT' is displayed in FMA column two when an intermediate level-off is required to meet an FMS-entered constraint. 'ALT' is blue for an FCU-entered altitude. If the constraint altitude is below the FCU altitude, the CLB mode will arm when the target altitude is captured. After the target altitude constraint is passed, the CLB mode will engage and the aircraft will continue the climb. The aircraft will not climb above the FCU-entered altitude.

Selected V/S - FPA

The Vertical Speed (V/S) or Flight Path Angle (FPA) climb modes are used when a specific climb rate or climb angle is desired. The FMS also reverts to V/S when the lateral mode reverts to HDG (e.g., ATC assigns a heading for spacing).

The selected vertical speed or flight path angle is indicated in column two of the FMA (e.g., 'V/S +1800' or 'FPA+ 2.9'). In the V/S or FPA mode, thrust is varied to maintain the selected vertical speed or flight path angle. At high altitudes, caution must be used to ensure airspeed does not degrade in an attempt to maintain too high a climb rate.

Climb Constraints

Climb constraints are automatically entered if “at” constraints in a departure procedure (SID), but must be entered manually if depicted as “expect at.”

Managed Climb is the recommended mode to use when a departure procedure includes altitude constraints. Crews should ensure that all required constraints are in the flight plan. Once confirmed, the highest cleared altitude may be selected in the FCU and Managed Climb selected. The crew then monitors the climb profile to ensure compliance.

When relieved of constraints by ATC, use of OP CLB is recommended. Altitude selection is accomplished by selecting the next desired altitude in the FCU altitude window and pulling the altitude knob. There is no requirement to delete any altitude constraints from the flight plan since the OP CLB mode will not honor the programmed constraints.

Low Altitude Level Off

Occasionally a low altitude climb restriction is required after takeoff. If the aircraft is required to level off below the acceleration altitude, ALT* engages and target speed goes to initial climb speed. In this case, the crew should expect a faster than normal acceleration, and be prepared to retract the flaps and slats promptly.

High Takeoff Thrust - Low Gross Weight

When accomplishing a low altitude level off following a takeoff using high takeoff thrust and at a low gross weight, the crew should consider the following factors:

- altitude capture can occur just after liftoff due to the proximity of the level-off altitude and the high climb rate of the aircraft,
- the FMS will limit F/D and autopilot pitch commands for passenger comfort,
- there may not be enough altitude below the intended level-off altitude to complete the normal capture profile and an overshoot may occur unless crew action is taken.

To prevent an altitude and/or airspeed overshoot, the crew should consider doing one or more of the following:

- use reduced thrust for takeoff at low weights whenever possible,
- disengage the autopilot and complete the level off manually if there is a possibility of an overshoot,
- use manual thrust control as needed to manage speed and prevent flap overspeeds.

Note: An engine failure during ALT* can lead to a loss of Alpha Protection unless the pilot takes prompt action.



Transition to Climb

Maintain flaps up maneuver speed "Green Dot" until clear of obstacles or above minimum crossing altitudes. If there are no altitude or airspeed restrictions, accelerate to the desired climb speed schedule.

Climb Speed Determination

Enroute climb speed is automatically computed by the FMS and displayed on the PERF CLIMB page. It is also displayed on the PFD speed tape after the flaps are selected up. Below the speed transition altitude the FMS targets the transition speed limit stored in the navigation database for the departure airport (typically 250 knots below 10,000 feet MSL). The FMS applies waypoint-related speed restrictions displayed on the FPLN pages, and altitude-related speed restrictions displayed on the PERF CLIMB page.

The FMS provides optimum climb speed modes for economy (ECON) operation and engine out (ENG OUT) operation. A pre-selected climb speed may be entered into the FMS prior to entering the climb phase.

The ECON climb speed is a constant speed/constant Mach schedule optimized by the cost index to obtain the minimum aircraft operating cost. The constant Mach value is set equal to the economy cruise Mach calculated for the cruise altitude entered in the FMS.

For very low cruise altitudes the economy climb speed is increased above normal values to match the economy cruise speed at the entered cruise altitude. For ECON climb, the speed is a function of gross weight (predicted weight at top of climb), predicted top of climb wind, predicted top of climb temperature deviation from ISA, and cost index.

Once airborne, a speed can be selected on the FCU to achieve the maximum rate of climb or the maximum angle of climb (Green Dot).

Note: It is possible to select and fly a speed below Green Dot, but there would be no operational benefit.

When selected speed is used, the predictions on the FPLN page assume the selected speed is maintained until the next planned speed modification, (e.g., 250 knots /10,000 feet MSL), where managed speed is supposed to be resumed. Consequently, the FMS predictions remain meaningful.

When IAS is selected at a lower altitude, there is an automatic change to Mach at a predetermined crossover altitude.

Selected speed does not provide the optimum climb profile and it should only be used when operationally required, (e.g., ATC speed constraint, turbulence penetration, etc.).

Engine Icing During Climb

CAUTION: The engine anti-icing system should be **ON** whenever icing conditions exist or are anticipated. Failure to follow the recommended anti-ice procedures can result in engine stall, overtemperature, or engine damage. Refer to Vol. 1, SP.16.

Engine icing may form when not expected and may occur when there is no evidence of icing on the structural icing indicator probe or other parts of the aircraft. Once ice starts to form, accumulation can build very rapidly. Although one bank of clouds may not cause icing, another bank, which is similar, may cause icing.

Economy Climb

The normal economy climb speed schedule of the FMS minimizes trip cost. It varies with gross weight and is influenced by cost index. The FMS generates a fixed speed schedule as a function of cost index and weight.

Economy climb speed normally exceeds 250 knots for all gross weights. FMS climb speed is limited to 250 knots below 10,000 feet (FAA Airspace), or a lower waypoint speed restriction, if entered. If the use of a higher speed below 10,000 feet is allowed, ECON speed provides additional cost savings.

Economy Climb Schedule - FMS Data Unavailable

- Below 10,000 feet - 250 knots
- Above 10,000 feet - 300/0.80M

Maximum Rate Climb

A maximum rate climb provides both high climb rates and minimum time to cruise altitude. Maximum rate climb can be approximated by:

- turbulent penetration speed

Note: The FMS does not provide maximum rate climb speeds.



Maximum Angle Climb

Maximum angle climb speed is normally used for obstacle clearance, minimum crossing altitude, or to reach a specified altitude in a minimum distance. It varies with gross weight and provides approximately the same climb gradient as flaps up maneuver speed (Green Dot).

Selecting EXP CLB will approximate a maximum angle climb. The MCDU PERF CLB page displays the time and distance required to achieve the selected altitude by climbing at Green Dot speed.

Note: The use of EXPEDITE CLB above FL250 is not recommended.

Avoid reducing to Green Dot at high altitude and heavy weight, since the decrease in excess thrust available may lengthen the time to accelerate back to ECON Mach.

It is not necessary to slow all the way to Green Dot to increase the rate of climb. Selecting a slower speed on the FCU will increase climb rate while in the Open Climb or Managed Climb mode.

Selected speed does not provide the optimum climb.

Engine Inoperative Climb

The recommended engine inoperative climb speed is Green Dot and varies with gross weight and altitude. At high altitudes and weights, a fixed Mach is used as an upper limit on the engine-out climb speed. The FMS will not automatically adjust the speed as a result of an engine failure. Instead, the pilot is expected to select an appropriate speed.

If a thrust loss occurs at other than takeoff thrust, set maximum continuous thrust (MCT) on the operative engine. The F/D pitch bar will provide proper pitch guidance to maintain airspeed assuming a fixed thrust climb mode such as CLB or OP CLB.

Note: If computed climb speeds are not available, use Green Dot speed and maximum continuous thrust.

Cruise

This section provides general guidance for the cruise portion of the flight for maximum passenger comfort and economy.

Cruise Speed Definitions

Maximum Range Cruise (MRC) (Cost Index zero)

- Based on aircraft weight, altitude, and OAT
- Provides theoretical maximum nautical air miles per pound of fuel burned

Long Range Cruise (LRC)

- Based on aircraft weight, altitude, and OAT
- Provides 99% of the fuel mileage of MRC
- Provides a stable speed and reduces hourly costs with reduced flight times compared to fixed Mach.

ECON (dependent upon the Cost Index entered)

- Allows operators a custom ratio of hourly to fuel costs
- Based on aircraft weight, flight level, OAT, and actual winds
- Varies speed command as wind field changes
- Provides minimum cost operation for the selected cost index
 - are optimized for flight between M0.76 and M0.80
 - Slower speeds increase flight times with minimal reduction in fuel burn
 - Faster speeds result in rapidly increasing burns with reducing time benefit
- ECON flight is more cost-efficient than fixed Mach or LRC

Cruise Speed Determination

Cruise speed is automatically computed by the FMS and displayed on the PERF CRZ page. The default cruise speed mode is economy (ECON) cruise.

If required to cruise below your flight planned altitude, insert the new flight level in the PROG page and fly the ECON speed for the new (lower) cruise altitude.

Headwinds increase the ECON CRZ speed. Tailwinds decrease ECON CRZ speed, but not below the zero wind maximum range cruise airspeed.

Required Time of Arrival (RTA) speed is generated to meet a time required at an RTA specified waypoint on the F-PLN VERT REV page.

Note: The FMS will adjust the managed speed in order to arrive at the waypoint within 30 seconds of the RTA for waypoints within 2,000 nm. The use of RTA can result in substantial speed changes which may require ATC notification.



Cost Index

Performance data requires entry of the Cost Index and is the basis for economy speed (ECON). ECON is a speed schedule calculated to minimize operating cost during CLIMB, CRUISE, and DESCENT.

A low cost index causes a lower cruise speed. A cost index of zero ignores the cost of time resulting in maximum range cruise and a minimum fuel speed schedule. A low cost index may be used when fuel costs are high compared to operating costs. A cost index of 150 calls for maximum flight envelope speeds resulting in a minimum time speed schedule.

The flight plan may indicate Cost Index changes while enroute. The FMS allows Cost index modifications until approach phase activation.

If for any reason the Cost Index modification changes either the indicated airspeed by more than 10 knots or 0.02 Mach, or true airspeed by more 5% or 10 knots from the planned Mach Number/TAS, inform the appropriate controlling agency.

Maximum Altitude

Maximum altitude (REC MAX) is the highest altitude at which the aircraft should be operated. It is determined by these basic characteristics, which are unique to each aircraft model. The FMS-predicted maximum altitude is the lowest of:

- maximum certified altitude - the altitude determined during certification considering structural limit (limits on the fuselage), rapid descent capability, or other factors determined by the certifying authority
- thrust limited altitude - the altitude at which sufficient thrust is available to provide a specific minimum rate of climb. Refer to the tables in the ODM. Depending on the thrust rating of the engines, the thrust limited altitude may be above or below the maneuver altitude capability
- buffet or maneuver limited altitude - the altitude at which a specific maneuver margin exists prior to buffet onset. The minimum margin available is 0.3g prior to buffet.
- buffet or maneuver limited altitude - the altitude at which a specific maneuver margin exists prior to buffet onset (minimum 0.2g for FAA).
- The altitude the aircraft can fly in level flight at MAX CRZ rating.
- The altitude which yields a speed higher than Green Dot, and lower than VMO/MMO.

Although each of these limits are checked by the FMS, available thrust may limit the ability to accomplish anything other than relatively minor maneuvering.

Inserting a FL above REC MAX into the MCDU will be accepted only if it provides a buffet margin greater than 1.2 g. Otherwise, it will be rejected and the message “CRZ ABOVE MAX FL” will appear on the MCDU scratchpad. Unless there are overriding operational considerations, REC MAX should be considered as the upper cruise limit. The REC MAX altitude is displayed on the PROG page.

The minimum maneuver speed indication on the airspeed display does not guarantee the ability to maintain level flight at that speed. Decelerating the aircraft to the Alpha Prot may create a situation where it is impossible to maintain speed and/or altitude because as speed decreases aircraft drag may exceed available thrust, especially while turning. Flight crews intending to operate at or near the maximum operation altitude should be familiar with the performance characteristics of the aircraft in these conditions.

Note: To get the most accurate altitude limits from the FMS, ensure that the aircraft weight and temperature entries are correct.

The FMS provides a real-time bank angle limiting function. This function protects the commanded bank angle from exceeding the current available thrust limit.

Turbulence at or near maximum altitude can momentarily increase the aircraft's angle-of attack.

Flight above REC MAX altitude is not recommended.

Optimum Altitude

The optimum altitude (OPT ALT) is the cruise altitude at which the aircraft incurs the lowest cost for a given flight plan, cost index, and gross weight. A minimum of a 1.3g buffet margin is provided at the OPT ALT. Optimum altitude considers the effects of temperature deviations from standard day and cruise winds at altitude. Optimum altitude continues to increase as weight decreases during the flight. The FMS continuously updates it during the cruise phase, and displays it on the MCDU PROG page. The PROG page displays dashes for this value when the system detects an engine-out condition.

Crews should constantly be aware of the optimum altitude and attempt to fly there unless turbulence or ATC limitations dictate otherwise. Thrust limits will be reached prior to the 1.3g buffet margin.

For shorter trips, optimum altitude as defined above may not be achievable since the top of descent (TOD) point occurs prior to completing the climb to optimum altitude.

The selected cruise altitude should normally be as close to optimum as possible. As deviation from optimum cruise altitude increases performance economy deteriorates.

Some loss of thrust limited maneuver margin can be expected above optimum altitude. The higher the aircraft flies above optimum altitude, the more the thrust margin is reduced. Before accepting an altitude above optimum, determine that it will continue to be acceptable as the flight progresses under projected conditions of temperature and turbulence.

**A319/320/321 Flight Crew Training Manual**

Projected temperature and turbulence conditions along the route of flight should be reviewed when requesting/accepting initial cruise altitude as well as subsequent step climbs.

Flight crews have two sources of flight information available, the FPS flight plan and the FMS.

Flight Planning Data:

- Purpose is to assure the captain and the dispatcher that the flight can be operated safely.
- Is calculated prior to departure.
- Uses forecast weights, winds, and temperatures available at dispatch.
- Is intentionally calculated so that normal ATC restrictions, weather, turbulence, etc., don't immediately result in a divert.

FMS Flight Operating Data:

- Provides guidance on how to operate the flight most efficiently, based on input of updated forecast conditions and actual weight.
- Is calculated in real time, using actual weights, winds, and temperatures as well as input of updated forecast conditions.
- Selects the altitude and cruise Mach to provide the maximum nautical ground miles per pound of fuel burned or best ECON speed and flight level, depending on FMS mode.
- If followed accurately can result in significantly less fuel burn than the flight plan predicts.

Recommended Altitude

Recommended altitude is equivalent to optimum altitude.

Step Climb

Flight plans not constrained by short trip distance are typically based on conducting the cruise portion of the flight close to optimum altitude. Since the optimum altitude increases as fuel is consumed during the flight, it is necessary to climb to a higher cruise altitude periodically to achieve the flight plan fuel burn. This technique, referred to as Step Climb Cruise, is typically accomplished by entering an appropriate step climb value in the FMS according to the available cruise levels. For most flights, one or more step climbs may be required before reaching TOD.



It may be especially advantageous to request an initial cruise altitude above optimum if altitude changes are difficult to obtain on specific routes. This minimizes the possibility of being held at a low altitude/high fuel consumption condition for long periods of time. The requested/accepted initial cruise altitude should be compared to the REC MAX and OPT altitudes. Remember, a cruise REC MAX altitude is dependent upon the cruise level temperature. If the cruise level temperature increases above the REC MAX, maximum cruise thrust may not maintain desired cruise speed.

Since the Airbus is normally thrust limited before it is aerodynamically limited, consider the temperature at the desired altitude when considering a higher altitude.

Step altitudes can be planned at waypoints or they can be optimum step points calculated by the FMS. Optimum step points are a function of the route length, flight conditions, speed mode, present aircraft altitude, STEP CLIMB altitude, and gross weight. Step Climbs listed on the flight plan should be used as a guide, provided the takeoff weight and en route conditions remain as planned. The OPT ALT on the PROG page provides accurate inflight information since it is based on "real time" data. Using the FMS "STEP ALTS" function will allow the pilot to accurately evaluate the effect of a step climb.

Flight planned step climbs should be entered into the FMS. This allows for a much more accurate calculation of destination EFOB. Selecting "STEP ALTS" from the FPLN VERT REV page displays step plan climb options. It may be utilized to enter geographic step climbs (waypoints from the FPLN page), or an optimum step climb. If the FPS flight plan includes one or more step climbs, these should be inserted into the FMS flight plan after flight plan uplink to provide accurate predictions.

Fuel for Enroute Climb

The additional fuel required for a 4,000 foot enroute climb varies from 200 to 400 pounds depending on the aircraft gross weight, initial altitude, air temperature, and climb speed. The fuel increment is largest for high gross weights and low initial altitudes. Additional fuel burn is offset by fuel savings in the descent. It is usually beneficial to climb to a higher altitude if recommended by the FMS or the flight plan, provided the wind information used is reliable.



FMS Wind Entries

Wind and temperature values should be uploaded or entered into the FMS for all cruise segment waypoints during preflight. If time limitations do not permit the completion of wind and temperature FMS entries during the preflight, enter as many wind and temperature values as feasible. The remaining entries can be completed as workload permits. Cruise and descent winds are normally uploaded into the FMS.

Entering the wind values for all available flight levels and waypoints will ensure the most accurate FMS predictions. The temperature must be entered at cruise altitude at each way point. The range of flight levels must be entered for all waypoints.

Wind and temperature values propagate along the route; therefore, enter new wind values for subsequent waypoints only when a difference exceeding 10° or 10 knots exists from the previous waypoint. Enter a new temperature value for subsequent waypoints only when a difference of $\pm 2^\circ$ exists.

FMS Alternate

The FUEL PRED page and ALTERNATES page can be used to monitor the EFOB at arrival. The ALTERNATES page can be updated to provide EFOB values for enroute planning.

If the destination alternate needs to be deleted:

- Enter NONE into the ALTN field of INIT page A.
- Or laterally revise the destination airport [6L], select the ALTN prompt then select the NO ALTN prompt and insert.

If an alternate needs to be added after departing without an alternate:

- Enter the alternate 4-letter airport identifier in the ALTN CO RTE field on INIT page A.
- Insert the ALTN fuel value into the ALTN field on the FUEL PRED page provided by dispatch. (This action overwrites the FMS calculated value. The company calculated fuel burn is always more conservative than the FMS calculated value.)
- Insert the RESERVE FUEL value in the FINAL/TIME field on the same page.

If a change to the ALTN is required:

- Overwrite the airport in the ALTN field [2L] on INIT page A.
- Change the ALTN fuel burn on the FUEL PRED page.

When holding, continue to use the HOLD page for last exit information:

- LAST EXIT UTC: The time the hold must be departed to arrive at the destination with reserve fuel and alternate fuel (if applicable) intact.



-
- **LAST EXIT FUEL:** The amount of fuel to exit the hold to arrive at the destination with reserve fuel and alternate fuel (if applicable) intact.

If a diversion to the alternate is required:

- Laterally revise the F-PLN waypoint from where the diversion will begin.
- Select the **ENABLE ALT** prompt and insert.

The result will be a new destination (the alternate) immediately after the waypoint selected. These steps simply create a new destination in a quick and efficient manner.

After enabling the alternate:

- The cost index is set to "0."
- A cruise altitude based on distance to the alternate is entered on the **PROG** page:
 - 10,000 ft for alternates within 100 NM,
 - FL220 for alternates 100-200 NM, or
 - FL310 for alternates greater than 200 NM.
- The **FMS** phase of flight changes to **CLB**.

Low Fuel Temperature

Fuel temperature changes relative to total air temperature. For example, extended operation at high cruise altitudes tends to reduce fuel temperature. In some cases the fuel temperature may approach the minimum fuel temperature limit.

Fuel freezing point should not be confused with fuel ice formation caused by frozen water particles. The fuel freezing point is the temperature at which the formation of wax crystals appears in the fuel. The Jet A fuel specification limits the freezing point to -40°C maximum, while the Jet A-1 limit is -47°C maximum. In the Commonwealth of Independent States (CIS), the fuel is TS-1 or RT, which has a maximum freezing point of -50°C, which can be lower in some geographical regions. The actual uplifted freezing point for jet fuels varies by the geographical region in which the fuel is refined.

Unless the operator measures the actual freezing point of the loaded fuel at the dispatch station, the maximum specification freezing point must be used. At most airports, the measured fuel freezing point can yield a lower freezing point than the specification maximum freezing point. The actual delivered freezing temperature can be used if it is known. Pilots should keep in mind that some airports store fuel above ground and, in extremely low temperature conditions, the fuel may already be close to the minimum allowable temperature before being loaded.

**A319/320/321 Flight Crew Training Manual**

For blends of fuels, use the most conservative freezing point of the fuel on board as the freezing point of the fuel mixture. This procedure should be used until three consecutive refuelings with a lower freezing point fuel have been completed. Then the lower freezing point may be used. If fuel freezing point is projected to be critical for the next flight segment, wing tank fuel should be transferred to the center wing tank before refueling. The freezing point of the fuel being loaded can then be used for that flight segment.

Fuel temperature should be maintained within AFM limitations as specified in the Limitations chapter of the Vol. 1.

Maintaining a minimum fuel temperature should not be a concern unless the fuel temperature approaches the minimum temperature limit. The rate of cooling of the fuel is approximately 3° C per hour, with a maximum of 12° C per hour possible under the most extreme conditions.

Total air temperature can be raised in the following three ways, used individually or in combination:

- climb or descend to a warmer air mass,
- deviate to a warmer air mass,
- increase Mach number.

Note: In most situations, warmer air can be reached by descending but there have been reports of warmer air at higher flight levels. Air temperature forecasts should be carefully evaluated when colder than normal temperatures are anticipated.

It takes from 15 minutes to one hour to stabilize the fuel temperature. In most cases, the required descent would be 3,000 to 5,000 feet below optimum altitude. In more severe cases, descent to altitudes of 25,000 feet to 30,000 feet might be required. An increase of 0.01 Mach results in an increase of 0.5° to 0.7° C total air temperature.

Cruise Performance Economy

The flight plan fuel burn from departure to destination is based on certain assumed conditions. These include takeoff gross weight, cruise altitude, route of flight, temperature, enroute winds, and cruise speed.

Actual fuel burn should be compared to the flight plan fuel burn throughout the flight.

The planned fuel burn can increase due to:

- temperature above planned,
- a lower cruise altitude than planned,
- cruise altitude more than 2,000 feet above optimum altitude,
- speed faster than planned or appreciably slower than long range cruise speed when long range cruise was planned,
- stronger headwind component,
- fuel imbalance, and
- an aircraft which is out of trim.

Cruise fuel penalties can be approximated using the following guidance:

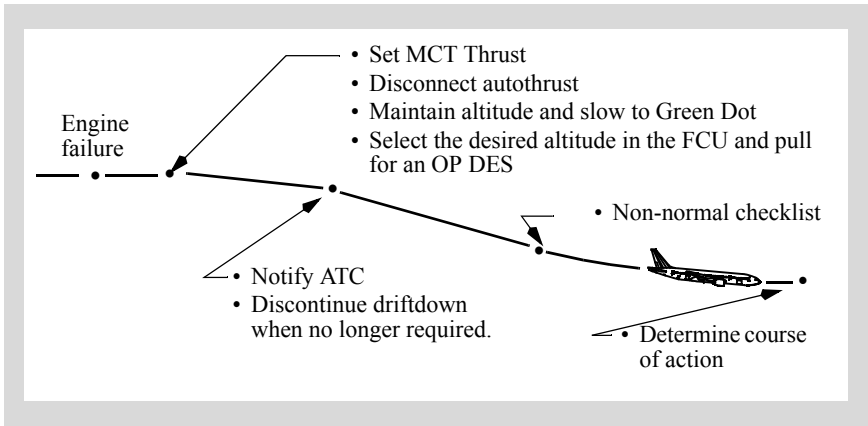
- ISA + 10° C: 1% increase in trip fuel,
- 2,000 feet above optimum altitude: 2% increase in trip fuel,
- 4,000 feet below optimum altitude: 4% increase in trip fuel,
- 6,000 feet below optimum altitude: A-319 12.2%, A-320 9.5% to 14% increase in trip fuel,
- cruise speed 0.01M above LRC: 1% to 2% increase in trip fuel.

For cruise within 2,000 feet of optimum, long range cruise speed can be approximated by using 0.79 M. Long range cruise also provides the best buffet margin at all cruise altitudes.

Note: If a discrepancy is discovered between actual fuel burn and flight plan fuel burn that cannot be explained by one of the items above, a fuel leak should be considered. Accomplish the applicable non-normal checklist.



Engine Inoperative Cruise/Driftdown



Performance of a non-normal checklist or sudden engine failure may lead to the requirement to perform a engine-out driftdown.

Engine inoperative cruise information is available from the FMS.

If an engine failure occurs, **PROCEED TO THE NEAREST SUITABLE AIRPORT** in point of time. If an immediate landing is not feasible, use the following procedures:

- Set Maximum Continuous Thrust (MCT) on the remaining engine.
- Disconnect the autothrust using the instinctive disconnect pb on the thrust levers.
- Maintain altitude and allow the airspeed to slow to Green Dot speed.
- Select Green Dot speed airspeed on the FCU.

To maintain maximum altitude for terrain clearance:

- Set the DRIFTDOWN TO altitude from the MCDU PERF page in the FCU and pull altitude knob to select OP DES.
- Maintain Green Dot airspeed and MCT power.

When driftdown (terrain clearance) is no longer required:

- Set the Long Range Cruise (EO REC MAX) altitude from the MCDU PROG page in the FCU and pull altitude knob to select OP DES (if not previously accomplished).
- Activate managed speed (push speed knob).
- Re-engage autothrust.

Note: Refer to the ODM Single Engine Maximum Altitude / Long Range Cruise (LRC) chart if the FMS is inoperative.

If downline terrain is a factor, maintain the maximum single engine altitude.

If downline terrain is not a factor, descend to the desired altitude and establish the maximum range cruise speed.

If an altitude higher than the maximum engine-out range altitude is required, maintain Green Dot speed and MCT to achieve a climbing cruise.

Since maximum range speed is faster than Green Dot speed, the altitude capability at the maximum range speed will be lower than the engine-out ceiling obtained at Green Dot speed.

High Altitude Performance

The aircraft exhibits excellent stability throughout the high altitude / high Mach range. Mach buffet is not normally encountered at high Mach cruise. The aircraft does not have a Mach tuck tendency.

As speed nears MMO, drag increases rapidly. At high weights, sufficient thrust may not be available to accelerate to MMO in level flight at normal cruising altitudes.

Flight Control Sensitivity at High Speed and High Altitude

On aircraft operating in Normal Law, control sensitivity is managed by flight control computers. Flight control laws and protections cannot be overridden in Normal law.

Low Speed at Altitude

On occasion, aircraft have experienced low speed events at cruise altitude where a descent is necessary to regain cruise airspeed. Such cases often result from changing atmospheric conditions where the aircraft becomes thrust limited e.g., higher than standard temperatures aloft. Unexpected turbulence, mountain wave activity, altitude selection above recommended FMS altitudes, and exchanging airspeed for altitude for a rapid climb can also contribute to being slow at cruise altitude.

Prevention includes being aware of FMS-predicted maximum and recommended altitudes, planned and actual cruise airspeed, and known areas of turbulence or mountain wave activity. Crews should also be familiar with basic engine settings such as N1, and fuel flow.

Should the aircraft slow below Green Dot, be proactive in initiating the required descent to regain cruise airspeed.

ETOPS

ETOPS is not approved for the aircraft.



Descent

Descent Planning

Determine the arrival and approach to be flown. If expecting a STAR or R/D (runway dependent) STAR, select the STAR, Approach and appropriate transitions. Verify the waypoints and any associated altitude and airspeed restrictions, including “Expect” constraints, match the ATC clearance and the charted Jeppesen procedure. Also reconcile all route discontinuities. If the STAR and/or runway is changed, complete the entire arrival and approach selection process again to prevent the possibility of incorrect routing or inadequate obstacle clearance.

When not required to fly the entire arrival (e.g., expect vectors to the approach at a waypoint), the subsequent waypoints may be deleted from the arrival for accurate destination ETAs and fuel estimates.

Flight deck workload typically increases as the aircraft descends into the terminal area. Distractions should be minimized and administrative and nonessential duties completed before descent or postponed until after landing. Perform essential duties early in the descent so more time is available during the critical approach and landing phases.

Operational factors and/or terminal area requirements may not allow following the optimum descent schedule. Terminal area requirements can be incorporated into basic flight planning, but ATC, weather, icing, and other traffic may require adjustments to the planned descent schedule.

Proper descent planning is necessary to arrive at the desired altitude at the proper speed and configuration. The distance required for the descent is approximately 3 NM/1,000 feet altitude loss for no wind conditions using ECON speed. Rate of descent is dependent upon thrust, drag, airspeed schedule and gross weight.

Heightened vigilance is required during descents as this is where the greatest number of pilot altitude deviations occur. 'Descend at pilot discretion' descent clearances and crossing restriction clearances that are late require that the pilot understand:

- An initial descent will not begin without pilot action (there is no “arming” the descent).
- Phase of flight must be considered during descent planning. If the flight phase is changed from DES to CRZ (by recruising), a new descent will not begin without pilot action.
- Managed DES will not engage unless managed NAV is engaged. If the pilot selects HDG, managed DES reverts to V/S.
- Altitude constraints are honored only in managed DES, not OP DES.
- Inputs made on the FCU must be verified on the FMA.
- FMS constraints displayed on the PFD and ND must be understood.



When a descent with a constraint is received by ATC, a 3-step process should be considered: SET, EVALUATE, and EXECUTE:

- SET the altitude in the FCU.
- EVALUATE descent mode. The PF mentally computes a 3:1 descent ratio and decides which descent is appropriate (managed DES, OP DES, V/S, or FPV mode).
- EXECUTE. Initiate the descent at the appropriate time using the FCU functions and verifying the FMA.

Descent planning is the creation of an energy management plan. Aircraft energy, in the form of altitude and airspeed, begins at the top of descent and must be managed to arrive on the approach so as to meet stabilized approach criteria.

Calculation of 3:1 Descent Ratio

As a backup to FMS generated TOD points, the 3:1 descent ratio can be used to plan and execute an idle descent. This descent ratio provides for a comfortable idle descent path by losing approximately 1,000 feet every 3 miles.

The basic equation is: $(\text{altitude to lose} / 1,000) \times 3 = \text{distance required}$

For example, if cruising at 35,000 feet and given a clearance to descend to 10,000 feet, the altitude lost equals 25,000 feet (35,000 - 10,000). In this example, the 3:1 calculation becomes 25,000 feet / 1,000 times 3. Simply stated, $25 \times 3 = 75$. It will take approximately 75 miles to descend 25,000 feet using the 3:1 ratio. In order to arrive 30 miles from the field at 10,000 feet, add the 75 miles to the 30 miles resulting in a TOD point at 105 miles from the field. In order to properly use the 3:1 distance, a valid distance to the field or the crossing waypoint has to be available.

Continuously update the 3:1 calculation. For example, descending through 25,000 feet the aircraft is 60 miles from the field. 15,000 feet remains to be lost. $15 \times 3 = 45$ miles. Adding 45 miles to the end of descent at 30 miles from the field yields 75 miles needed if on the 3:1 descent. Since the aircraft is only 60 miles out, the aircraft is high and the descent rate needs to be increased.

Prior to descent, modify the calculated distance for expected conditions. Subtract mileage for strong headwinds or add mileage if a tailwind exists. Add mileage if planning to use engine anti-ice or if a speed reduction is expected.

**A319/320/321 Flight Crew Training Manual**

Use the bottom of descent arrow to monitor the descent. The bottom of descent arrow displayed on the ND provides a visual indication of where the aircraft will intercept the altitude set in the FCU ALT window, based on the current rate of descent. If given a descent clearance to cross 30 miles from the field at 10,000 feet, create a corresponding fix on the FLT PLAN page. Once the descent has started, monitor the bottom of descent arrow's position relative to the end of descent fix. The 3:1 descent ratio assumes a direct course to the field or waypoint. Any additional maneuvering adds distance to the descent allowing a shallower descent rate.

Descent Speed Determination

The default FMS descent speed schedule is an economy (ECON) descent from cruise altitude to the airport speed transition altitude. The normal FMS descent speed profile with a cost index of 55 is between Mach .76/290 knots to Mach .79/320 knots based on weight and cruise altitude. Occasionally when cruising at low altitudes the FMS will select a lower than normal descent speed. If this occurs, the pilot may modify the speed prior to entering the descent phase, while in the descent phase or utilize selected speed. For flights into high demand airports, enter "300" to fit into the flow of traffic.

Descent Path

The FMS computes the descent path in an attempt to achieve the following objectives:

- Adhere to the vertical flight plan elements (altitude and speed constraints).
- Fly the most economical path utilizing the optimum speed profile (ECON or pilot entered speed).
- Fly the most comfortable path.

The descent profile is computed from the runway backwards to the TOD point when in the cruise phase. It is composed of the descent path and the approach path. The descent path begins at the TOD and ends at the DECEL point. The approach path starts at the DECEL point and ends at the runway threshold. The descent path is recomputed whenever a change occurs in the flight plan or other data. For example, the profile is recomputed when the pilot selects a specific instrument approach or changes the destination weather data (winds, QNH, or temperature). The TOD is displayed on the ND track as a white downward arrow.

Descent Constraints

Note: The MORE DRAG message may indicate speed brakes are required to make the target altitude.

Note: Application of speedbrakes while on the VNAV path will result in aircraft remaining on VNAV managed descent path (does not aid in increasing descent rate if on path).

Descent constraints may be automatically included in the F-PLN page as part of an arrival procedure or they may be manually entered through the MCDU F-PLN page. The aircraft will attempt to meet these constraints as long as Managed Descent (DES) mode is being used.

If the DES mode is maintained as the active pitch mode, the lowest altitude restriction may be set in the FCU altitude window. The descent must be monitored to ensure compliance with all altitude constraints. If at any time the active pitch mode is changed from DES to any other descent mode (OP DES, V/S, etc.), the next altitude restriction must be reset in the FCU altitude window.

The crew should be aware that an ATC “DIR TO” clearance automatically removes the speed/altitude constraints assigned to the waypoints deleted from the F-PLN page. However, if intermediate waypoints are relevant, (e.g., for terrain awareness, etc.) then “DIR TO” with ABEAM PTS may be an appropriate selection as constraints can be re-entered into these waypoints if required.

Descent Modes

The pilot has four different descent modes to choose from depending upon the circumstances. The four modes (Managed descent, Open descent, Vertical Speed descent and Flight Path Angle descent) are discussed below.

Managed Descent

The Managed Descent (DES) mode will honor the constraints entered in the FMS and allow time to repressurize the aircraft, while maintaining a fuel efficient descent path. It considers wind data entered into the FMS but not holding patterns. The FMS must be in a Managed NAV lateral mode (“NAV” or “LOC” in green in FMA column three) for the DES mode to remain engaged.

The DES mode will not engage when Managed NAV is armed but not engaged (“NAV” in blue in the FMA column three below “HDG” in green). Also, the DES mode will not engage if the FMS is in the CLB phase of flight because the aircraft never reached cruise altitude and entered the CRZ phase of flight.

The DES mode will not engage automatically. It is engaged by selecting a lower altitude in the FCU ALT window and pushing the ALT selector knob.

**A319/320/321 Flight Crew Training Manual**

If DES is engaged before the top of descent point, the FMS will command a gentle initial descent of 1,000 feet/min (in some cases 500 feet/min). This descent rate will continue until intercepting the planned profile or reaching the altitude selected on the FCU. The point where the descent profile will be intercepted is displayed on the ND as a blue lightning bolt.

If cleared to “Descend Via” with published instructions to either transition from Mach to a specific IAS or to maintain a specific speed throughout the arrival, crews should manually enter the required speed into the PERF DES page prior to TOD. In the event of an amended clearance, the speed can be modified on the DES page after descent has been initiated.

The descent profile can be modified to include altitude and speed constraints at any waypoint. This is accomplished by making a vertical revision at the desired waypoint and entering the altitude (and/or speed) constraint in the ALT (and/or SPD) CSTR prompt.

The descent profile can also be modified to include altitude and airspeed constraints between waypoints. This is accomplished by creating an along track (place/distance) waypoint and then making a vertical revision and entering the constraint. An along track waypoint is created by entering the identifier of a waypoint on the MCDU flight plan into the scratchpad, followed by a slash, and a + or - distance (e.g., MSP/-40). The scratchpad waypoint is entered in the MCDU flight plan on top of the original waypoint (i.e., on top of MSP). If the new along track waypoint becomes the “TO” waypoint, the lateral mode must be in HDG before the FMS will allow the pilot to insert the new waypoint. The message “SELECT HDG/TRK FIRST” alert appears in the scratchpad if you are in NAV mode.

In the DES mode, altitude and airspeed constraints (if in managed speed) in the FMS will be honored as long as the FMS is in the DES phase of flight. The descent phase is entered automatically if any of the following occur:

- the TOD point is reached and a lower altitude is selected on the FCU,
- a lower altitude is selected on the FCU when within 200 nm of the destination, or
- the FCU is set to the higher of FL200 or below, or the highest constraint altitude.

The aircraft will not descend below the altitude selected on the FCU.

There is no need to enter the present altitude in the PROG page to re-enter the cruise phase of flight to generate a new idle descent path. The FMS will compute a new idle descent profile from the present position to the first downline constrained waypoint whenever any of the following actions are performed:

- DIR TO (any type) to any waypoint,
- ALT CSTR addition, change, or deletion at the TO waypoint,

- change or reinsertion of SPD/Mach on the PERF DES page, or
- Cost Index (CI) change or reinsertion.

Autothrust Interaction

If managed speed is used, the autothrust will maintain airspeed within a maximum of 20 knots of the FMS target airspeed. This speed range is displayed on the PFD.

Use of managed speed gives the FMS more latitude to vary the pitch and remain on the profile without changing thrust.

Note: Idle thrust segments contained in the Managed Descent profile are based on idle thrust plus a small additive. This gives the FMS more flexibility to maintain the descent profile. FMA column one will display MACH or SPEED when using the additive and THR IDLE when not using it.

If the aircraft deviates above the descent profile the FMS will create a pseudo-waypoint (displayed on the ND as a lightning bolt) to indicate where the descent profile will be intercepted if the PF uses half speedbrakes and ECON speed (at idle thrust). If the intercept point is near the altitude constraint waypoint, the PFD and MCDU will display a MORE DRAG message.

If the target airspeed is being maintained during a Managed Descent and the aircraft is on the FMS descent path, extending the speedbrakes will not increase the descent rate. Instead, extending the speedbrakes will cause thrust to be added to maintain the selected airspeed, or if in managed speed, slow and maintain the speed at the bottom of the bracket.

In the DES mode, the blue level-off arrow, displayed on the ND when the descent is started, indicates where the descent profile will reach the altitude selected on the FCU. It does not necessarily represent where the aircraft will reach the FCU altitude unless the aircraft is on the profile.

The aircraft may deviate from the managed descent profile when:

- encountering unexpected winds,
- engine anti-ice is used (idle thrust increases),
- a slower airspeed is selected (e.g., for turbulence), or
- the lateral route is changed (e.g., cleared direct).

Unique to the descent phase of flight is the ability to change the managed descent speed on the PERF page during the descent phase. Doing so will cause the FMS to recalculate the descent path. This feature allows the pilot to change the descent speed should ATC assign a speed (or Mach) or turbulence is encountered during the descent.

Note: Changing the speed, and recalculating the path, does not guarantee that subsequent constraints will be met.

**A319/320/321 Flight Crew Training Manual**

During the descent, the PF should monitor the deviation path indicator (donut) on the altitude scale on the PFD.

The donut represents the FMS descent profile. When the donut is centered the aircraft is on the descent profile. If the donut is at the bottom of the indicator scale, the aircraft is more than 500 feet above the descent path. Vertical deviation information is shown digitally on the PROG page in the VDEV field. A minus (-) value indicates feet below the path whereas a positive (+) value indicates feet above the path. This will guide the PF in the amount and duration of correction required to return to the profile. When above the path, the PF should consider selecting a higher airspeed or using speedbrakes to increase the descent rate to return to the path.

Open Descent

In the Open Descent (OP DES) mode, the FMS uses idle thrust and varies the pitch to maintain the target airspeed (selected or managed). It does not follow a calculated descent path (as does Managed Descent).

OP DES is useful for making constant speed descents, at idle thrust, while flying in the heading mode. In Open Descent, the FMS constraints are not honored. In managed speed, the 250 knot airspeed restriction below 10,000 feet is honored.

Open Descent is engaged by selecting a lower altitude in the FCU ALT window and pulling the ALT selector knob. To increase the rate of descent while in the Open Descent mode, select a higher airspeed or increase drag (e.g., with the speedbrakes). Selecting a slower airspeed shallows the descent and extends the level-off point.

The level-off point is displayed on the ND when the Open Descent begins and indicates where the aircraft will reach the selected altitude based on the existing descent rate. By comparing the level-off arrow with the waypoints (or the range marks) displayed on the ND, the PF can choose the amount and duration of correction needed to return the aircraft to the descent profile.

The descent path indicator on the PFD will be available during an Open Descent if the aircraft's path is within 4 nm of the managed descent path, but references the Managed Descent profile. In this case the descent path may provide a good comparison of the aircraft's energy and the descent progress.

The FMS makes smooth pitch and power changes during Open Descent. If rapid changes are required (e.g., TCAS or EGPWS warning), disconnect the autopilot, turn off the FDs, and manually fly the aircraft.

Autothrust Interaction

In the Open Descent mode, the autoflight system reduces the thrust to idle and maintains the specified selected or managed speed by varying the pitch.

Approaching the target altitude, the autothrust smoothly advances the thrust to maintain the target speed as the aircraft levels off.

Note: The flight director pitch guidance must be followed when hand flying the aircraft. The target airspeed will not be maintained if the pitch guidance is not followed. If the airspeed is allowed to decrease to below VLS, both flight directors disengage and the A/THR reverts from fixed thrust to the variable thrust SPEED mode.

In OP DES, extending the speedbrakes will increase the descent rate. This will cause the level-off arrow to move closer to the aircraft on the ND.

Because Open Descent uses idle thrust, it may not be appropriate for small altitude changes (less than 2,000 feet) where the thrust would be at idle for only a short period of time. Consider using vertical speed mode for small altitude changes.

The bottom of descent point is displayed on the ND when the Open Descent begins and indicates where the aircraft will reach the selected altitude based on the existing descent rate. By comparing the bottom of descent arrow with the waypoints (or the range marks) displayed on the ND, the PF can choose the amount and duration of correction needed to return the aircraft to the descent profile.

Vertical Speed Descent

In the Vertical Speed (V/S) descent mode, the FMS commands a pitch to maintain the selected vertical speed and varies the thrust to maintain the target airspeed.

The Vertical Speed mode is useful for making small (less than 2,000 feet) altitude changes and for flying a constant descent rate. In the Vertical Speed mode, FMS altitude and speed constraints are not honored.

The Vertical Speed mode may also engage as a result of a pitch mode reversion. For instance, one of the requirements for a Managed Descent is that Managed Lateral NAV be engaged. Selecting HDG during a Managed Descent causes DES mode to revert to the V/S mode.

When determining a V/S to meet an altitude assignment, divide the change in altitude by the time available. For instance, the V/S needed to be level 10,000 feet lower in 5 minutes is 2,000 feet/minute. The PF must adjust the V/S for changing winds conditions during the descent and monitor the airspeed to comply with flight plan constraints.

**A319/320/321 Flight Crew Training Manual**

In a Vertical Speed descent, the level-off arrow displayed on the ND indicates where the aircraft will reach the selected altitude based on the existing descent rate. Comparing the level-off arrow with the waypoints (or the range marks) displayed on the ND will aid the pilots in monitoring the descent progress. The V/S mode is useful when given an altitude / time constraint (e.g., “Be level at FL250 in 5 minutes or less.”)

Autothrust Interaction

In Vertical Speed mode, the autothrust maintains the target airspeed. If the selected V/S is too steep to maintain the target airspeed at idle thrust, the airspeed will increase until approaching VMAX. At this point the selected V/S automatically shallows to avoid exceeding the limiting speed.

If the target airspeed is being maintained with V/S selected, extending the speedbrakes will not increase the descent rate or slow the aircraft. The speedbrakes are useful in V/S only if the target airspeed cannot be maintained.

Flight Path Angle

In the Flight Path Angle (FPA) descent mode, the FMS will command a pitch to maintain the selected flight path angle. The FPA mode is useful when given an altitude / distance constraint (e.g., cross ABC at FL 250.) With FPA selected, the FMS commands pitch and thrust to maintain the selected flight path angle and speed.

FPA mode is selected by pressing the HDG-V/S and TRK-FPA pb on the FCU. An FPA can be engaged by selecting a lower altitude in the FCU ALT window, pulling the FPA selector knob and dialing a negative flight path angle. When choosing an FPA to meet an altitude constraint, divide the change in altitude by the distance available. For instance, the FPA needed for an altitude constraint 10,000 feet lower and 50 nm away is 2.0°.

Once selected, the PF needs to check the level-off arrow on the ND to ensure that the constraint will be met. During this descent, the FPA should not need to be changed even if the winds vary.

In an FPA descent, the level-off arrow displayed on the ND indicates where the aircraft will reach the selected altitude based on the existing flight path. Comparing the level-off arrow with the waypoints (or the range marks) displayed on the ND will aid the pilots in monitoring the descent progress.

Autothrust Interaction

In the FPA mode, the autothrust maintains the target airspeed. If the selected FPA is too steep to maintain the target airspeed at idle thrust, the airspeed will increase until reaching VMAX. At this point the selected FPA automatically shallows to avoid exceeding the limiting speed.

If the target airspeed is being maintained with FPA selected, extending the speedbrakes will not increase the descent rate or slow the aircraft. The speedbrakes are useful in FPA only if the target airspeed cannot be maintained.

ALT*

As the aircraft approaches the target altitude in all the descent modes, the FMS changes to the Altitude Capture mode. This is indicated on the FMA by ‘ALT*’ in column two. The Altitude Capture mode makes a smooth level off by decreasing the vertical speed and increasing thrust as necessary. Refer to Vol. 2, Autoflight, for a comprehensive discussion of ALT.*

Early Descent from Cruise

Entering a lower cruise altitude in the FCU and engaging Managed Descent will result in the FMS commanding a 1,000 fpm descent until the descent path is intercepted.

Approaching Top-of-Descent (TOD)

Crews must be aware of the TOD point when issued a descent crossing restriction, as the aircraft will not begin the descent automatically. This scenario (descent not initiated at the TOD) is a common cause of altitude deviations. The only FMGC indication of flight beyond the TOD is a DECELERATE message displayed on the MCDU and PFD. This message is displayed in the climb or cruise phase if in managed speed.

Managed Descent From Above Path

When descending in managed DES and well above the indicated managed descent path, an increase in descent rate may be necessary to acquire the managed descent path. An increase in speed and/or drag will increase the descent rate, which will aid in joining the managed descent path. Speed changes using the FMS DESCENT page will “redraw” the VNAV PATH based on the updated speed.



Descent Rates

Descent Rate tables provide typical rates of descent below 20,000 feet with idle thrust and speedbrakes extended or retracted.

Target Speed	Rate of Descent (Typical)	
	Clean	With Speedbrake
0.78M / 280 knots	2,500 fpm	4,000 fpm
250 knots	2,000 fpm	2,500 fpm
Green Dot	1,100 fpm	1,600 fpm

Normally, descend with idle thrust and in clean configuration (no speedbrakes). Maintain cruise altitude until the TOD and then maintain the descent path. Deviations from this schedule may result in arriving too high at destination and require circling to descend, or arriving too low and far out requiring extra time and fuel to reach destination.

The speedbrake may be used to correct the descent profile if arriving too high or too fast.

A good crosscheck is to be at 10,000 feet AFE, 30 miles from the airport, at 250 knots. Then use the 3:1 descent path based on flying distance to the runway to establish the descent for the approach.

Losing airspeed can be difficult and may require a level flight segment. For planning purposes, it requires approximately 45 seconds and 4 nm to decelerate from 280 to 250 knots in level flight without speedbrakes. It requires an additional 55 seconds and 3 nm to decelerate to flaps up maneuver speed at average gross weights. This equates to approximately 10 knots/nm at level flight. Using speedbrakes to aid in deceleration reduces these times and distances by approximately 50%.

Maintaining the desired descent profile and using the map mode to maintain awareness of position ensures a more efficient operation.

Speedbrakes

The PF should keep a hand on the speedbrake lever when the speedbrakes are used in flight. This helps prevent leaving the speedbrake extended when no longer required.

There are no airspeed restrictions on the use of speedbrakes.

During rapid descents from high altitude, the aircraft may pitch up slightly when speedbrakes are applied, especially if they are extended rapidly. This pitch change, coupled with a rapid thrust reduction, may cause ALPHA PROT to become active and automatically retract the speedbrakes during a rapid descent. To initiate a rapid descent without inhibiting speedbrake extension, ensure that the aircraft is established nose down prior to extending the speedbrakes.

A319

Maximum speedbrake extension is not limited with an A/P engaged. Speedbrake extension always corresponds to the lever position. However, the actual spoiler extension at FULL is approximately equal to $\frac{1}{2}$ deflection on the A320.

Use of speedbrakes does not appreciably affect airplane roll response. While using the speedbrakes in descent, allow sufficient altitude and airspeed margin to level off smoothly. Lower the speedbrakes before thrust is added. Speedbrakes may be used in flap handle positions 0, 1, 2, and 3.

A320

Speedbrake deflection with the autopilot engaged is limited to $\frac{1}{2}$. With the A/P engaged, speedbrake deflection corresponds to the lever position from the retract (RET) position to the detent at the $\frac{1}{2}$ position. Movement beyond the $\frac{1}{2}$ position yields no further extension. However, if the handle is beyond the $\frac{1}{2}$ position when the A/P is disconnected, the speedbrakes rapidly extend to match the handle position. With the A/P off, if the speedbrakes are extended beyond $\frac{1}{2}$ and the A/P is then engaged, the speedbrakes rapidly retract to $\frac{1}{2}$. Speedbrakes may be used in flap handle positions 0, 1, 2, and 3.

Note: With the A/P engaged, limit speedbrake lever deflection to $\frac{1}{2}$.

A321

Maximum speedbrake extension is not limited with an A/P engaged. Speedbrake extension always corresponds to the lever position. However, the actual spoiler extension at FULL is approximately equal to $\frac{1}{2}$ deflection on the A320. Speedbrakes may be used in flap handle positions 0, 1, and 2.

Note: Speedbrakes are inhibited with flaps 3 and FULL.



Flaps and Landing Gear

Normal descents are made in the clean configuration to pattern or instrument approach altitude. If greater descent rates are desired, extend the speedbrakes. When thrust requirements for anti-icing result in less than normal descent rates with speedbrakes extended, or if higher than normal descent rates are required by ATC clearance, additional drag may be used in accordance with aircraft limitations (e.g., gear, speedbrakes, flaps).

Extend the flaps when in the terminal area and conditions require a reduction in airspeed below Green Dot. Normally select flaps 1 prior to the approach fix going outbound, or just before entering downwind on a visual approach.

Engine Icing During Descent

CAUTION: Failure to follow the recommended anti-ice procedures can result in engine stall, overtemperature, or engine damage.

The use of anti-ice and the increased thrust required increases the descent distance. Therefore, proper descent planning is necessary to arrive at the initial approach fix at the correct altitude, speed, and configuration.

Engine icing may form when not expected and may occur when there is no evidence of icing on the structural icing indicator probe or other parts of the aircraft. Once ice starts to form, accumulation can build very rapidly. Although one bank of clouds may not cause icing, another bank, which is similar, may induce icing.

Note: The engine anti-icing system should be ON whenever icing conditions exist or are anticipated.

Holding

When informed of an in-flight delay, to save fuel:

- Slowing down is a more desirable alternative than extended off course vectors. Coordinate the speed reduction with ATC.
- Stay high as long as possible to minimize fuel flow.
- Request extended legs in the holding pattern since fuel flow increases in turns.

Protected holding airspace is based on using specified maximum speeds and entry procedures. These procedures must be followed closely unless a specific clearance to deviate is obtained.

Maintain clean configuration if holding in icing conditions or in turbulence.

In extreme wind conditions or at high holding speeds, the defined holding pattern protected airspace may be exceeded. However, the holding pattern depicted on the map display will not exceed the limits.

If time and crew work load permit, the MCDU should be used to “construct” the holding procedure on the ND. In this manner, it may be viewed by the pilot as it is flown by the autoflight system.

A holding pattern is entered into the FMS by making a lateral revision at the desired waypoint and then selecting the HOLD prompt. This will display the DATABASE HOLD page if a holding pattern at that waypoint already exists in the database. Otherwise, the COMPUTED HOLD page will be displayed.

Enter (or modify if not correct) the INB CRS, TURN direction, and TIME/DIST.

- Verify the information with the other crewmember and press the INSERT* prompt. Once inserted, display the holding pattern on the ND and verify that it is correct. If able, engage managed NAV and managed speed.

CAUTION: The size of the depicted holding pattern is based on speed assumptions. When operating in the selected speed mode the holding pattern may not conform to the protected airspace limits. Pilot intervention may be required to stay in holding airspace.



Holding Airspeeds

For maximum holding airspeeds, refer to AM, Ops Specs, Holding.

If Green Dot is greater than the ICAO or FAA maximum holding speed, holding may be conducted at flaps 1, using flaps 1 maneuver speed. Flaps 1 uses approximately 9% more fuel than flaps up. Holding speeds in the FMS provide an optimum holding speed based upon fuel burn and speed capability; but are never lower than flaps up maneuver speed.

Procedure Holding

When a procedure holding pattern is selected from the navigation database and the FMS shows PROC HOLD on the legs page, the following is true when the PROC HOLD is the active leg:

- exiting the holding pattern is automatic; there is no need to select EXIT HOLD
- if the crew desires to remain in holding a new holding pattern must be entered.

Holding Pattern Exit

When exiting the holding pattern, the FMS flight plan must be updated to enable proper waypoint sequencing. This can be done by:

- Selecting the IMM EXIT prompt on the MCDU FLT PLN page. This commands a DIRECT TO the holding fix.
- Entering a waypoint in the DIRECT TO field of the MCDU FLT PLN.
- Clearing the holding fix from the MCDU FLT PLN while not in managed NAV.
- Selecting a heading (the holding pattern must be cleared from the F-PLN).

CAUTION: The PF must ensure that the ‘TO’ waypoint displayed on the ND is correct when leaving the holding pattern.

The target airspeed will change to the speed appropriate for the phase of flight when exiting the holding pattern (e.g., from Green Dot airspeed to ECON descent speed). This may result in a thrust increase while the aircraft is descending. This change in airspeed can be performed more smoothly if the PF uses selected speed to gradually increase thrust or by activating the approach phase.



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Approach and Missed Approach**Chapter 5****Table of Contents****Section TOC**

Approach	5.1
Instrument Approaches	5.1
Approach Category	5.1
Approach Clearance	5.2
Procedure Turn	5.2
Radio Altimeter	5.3
Sidestep	5.3
Maneuver Margin	5.3
Landing Performance Data	5.3
Quick Reference Landing Length	5.4
Flap Configurations for Approach and Landing	5.5
Flap Extension	5.5
ILS Approach	5.6
ILS Approach Profile	5.6
Approach	5.8
ILS PRM Approach	5.16
ILS Approach - Landing Geometry	5.18
Non - ILS Instrument Approaches	5.19
Non - ILS Instrument Approach Using APP NAV Profile	5.19
Approach Guide	5.21
Non-ILS Approach Using LOC & FPA Mode Profile	5.22
Approach Guide	5.24
General	5.24
Non - ILS Instrument Approaches - General	5.24
Instrument Approach Using APP NAV	5.28
RNAV(RNP) AR Approach Using APP NAV Mode	5.33

Circling Maneuver	5.37
Circling Maneuver Profile	5.38
Approach Guide	5.40
Circling Maneuver - General	5.40
Obstruction Clearance	5.41
Missed Approach - Circling	5.42
Visual Approach	5.43
Visual Approach Profile	5.43
Approach Guide	5.45
Visual Approach - General	5.45
Downwind and Base Leg	5.45
Internal Visual Cues	5.45
Final Approach	5.45
High Energy Approach	5.46
Engine Inoperative Approach Operations	5.48
ILS Approach Profile - One Engine Inoperative	5.48
ILS Approach - Engine Inoperative	5.50
Non-ILS Instrument Approach Profile Using LOC & FPA Mode - One Engine Inoperative	5.51
Non-ILS Approach - One Engine Inoperative	5.53
Non-ILS Approach Profile Using Approach Nav Mode - One Engine Inoperative	5.54
Circling Maneuver Profile - One Engine Inoperative	5.56
Circling Maneuver - One Engine Inoperative	5.58
Engine Failure On Final Approach	5.58
Go-Around and Missed Approach Profile - One Engine Inoperative	5.59
Go-Around and Missed Approach - One Engine Inoperative	5.61
Engine Failure During Go-Around and Missed Approach	5.61



Go-Around and Missed Approach - All Approaches	5.62
Go-Around and Missed Approach Profile - All Approaches	5.62
Go-Around and Missed Approach - All Engines Operating	5.64
Go-Around after Touchdown	5.69

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Approach

Instrument Approaches

All safe instrument approaches have certain basic factors in common. These include good descent planning, careful review of the approach procedure, accurate flying, and good crew coordination. Thorough planning is the key to a safe, unhurried, professional approach.

Ensure the waypoint sequence on the FLT PLN page, altitude and speed restrictions, and the map display reflect the ATC clearance. Last minute ATC changes or constraints may be managed by appropriate use of the FCU heading, altitude, and airspeed selectors. Updating the waypoint sequence on the FLT PLN page should be accomplished only as time permits.

Complete the approach preparations before arrival in the terminal area. Set decision altitude or height DA(H), derived decision altitude (DDA), or minimum descent altitude or height MDA(H). Do not completely abandon enroute navigation procedures even though ATC is providing radar vectors to the initial or final approach fix. Check ADF/VOR selector set to the proper position. Verify ILS, ADF, or VOR are tuned and identified if required for the approach.

Note: The requirement to tune and identify nav aids can be satisfied by confirming that the tuned nav aid frequency is replaced by the correct alphabetical identifier on the PFD/ND or by aurally identifying the nav aid.

Check that the marker beacon is selected on the audio panel, if needed. The course and glideslope signals are reliable only when localizer and glideslope pointers are in view, and the ILS identifier is received. Confirm the published approach inbound course is set or displayed.

Do not use radio navigation aid facilities that are out of service even though flight deck indications appear normal. Radio navigation aids that are out of service may have erroneous transmissions that are not detected by aircraft receivers and no flight deck warning is provided to the crew.

Approach Category

Refer to AM, Ops specs, Aircraft Approach Categories.



Approach Clearance

When cleared for an approach and on a published segment of that approach, the pilot is authorized to descend to the minimum altitude for that segment. When cleared for an approach and not on a published segment of the approach, maintain assigned altitude until crossing the initial approach fix or established on a published segment of that approach. If established in a holding pattern at the final approach fix, the pilot is authorized to descend to the procedure turn altitude when cleared for the approach.

If using a managed descent (DES), for the initial portion of the approach, all altitude and speed constraints must be confirmed prior to starting the approach. The DES profile will comply with all altitude constraints but may cross “at or above” constraints above the minimum altitudes to optimize the descent profile. Select the appropriate vertical mode (i.e., FPA, G/S or FINAL APP) for the approach prior to reaching the FAF.

When conducting an instrument approach from a holding pattern, continue on the same pattern as holding. Turn inbound on the procedure turn heading.

Procedure Turn

On most approaches the procedure turn must be completed within specified limits, such as within 10 nm of the procedure turn fix or beacon. The FMS will attempt to stay within these limits, but may be restricted by bank angle, entry angle, speed, or wind. An amber scratchpad message “TURN AREA EXCEEDANCE” appears 1.5 minutes prior to procedure turn entry if the FMS predicts it will exceed the limits of the airspace. This message will also appear if the FMS calculates it will exceed the PT limits while established in the procedure. The published procedure turn altitudes are normally minimum altitudes.

Cross the procedure turn fix at Flaps 1 maneuvering airspeed. If a complete arrival procedure to the localizer and glide slope capture point has been selected via the MCDU, the initial approach phase may be completed using NAV and DES or other appropriate modes. If the procedure turn fix is crossed at an excessively high ground speed, the procedure turn protected airspace may be exceeded. The procedure turn should be monitored using the map to ensure the aircraft remains within protected airspace.

Refer to the AM, Ops specs, Procedure Turns and Procedure Turns (ICAO).



Radio Altimeter

A Radio Altimeter (RA) is normally used to determine DH when a DA(H) is specified for Category II, or to determine alert height (AH) for Category III approaches. Procedures at airports with irregular terrain may use a marker beacon instead of a DH to determine the missed approach point. The radio altimeter may also be used to crosscheck the primary altimeter over known terrain in the terminal area. However, unless specifically authorized, the radio altimeter is not used for determining MDA(H) on instrument approaches. Also, it should not be used for approaches where use of the radio altimeter is not authorized (RA NOT AUTHORIZED). However, if the radio altimeter is used as a safety backup, it should be discussed in the approach briefing.

Sidestep

Refer to AM, Ops specs, Sidestep Approaches.

Maneuver Margin

Flight profiles should be flown at, or slightly above, the recommended maneuver speed for the existing flap configuration. These speeds approximate maximum fuel economy and allow full maneuvering capability.

Full maneuver margin exists for all normal landing procedures whenever speed is at or above the maneuver speed for the current flap setting (Green Dot, “F”, or “S”). At least adequate maneuver margin exists during a go-around at go-around thrust.

Airspeeds recommended for non-normal flight profiles are intended to restore near normal maneuvering margins and/or aerodynamic control response.

The configuration changes are based on maintaining full maneuvering and/or maximum performance unless specified differently in individual procedures.

Landing Performance Data

The ODM FAR Dry Landing Field Length chart shows distances for flaps Full and 3, where the Actual Landing Distance is 60% of the FAR Landing Field Lengths indicated. This chart is used for dispatch purposes. The distances are based on the following:

- the distance to a complete stop from 50 feet above the runway threshold at VLS
- maximum braking, speed brakes extended and no thrust reverse.

The ODM Operational Landing Distances table show landing distances based on runway condition/braking action and landing weight. These tables assume zero wind, two engines full reverse thrust, Speed at threshold = VREF, includes a 15% safety margin and 1,500 feet air distance from threshold to touchdown and are based on a 2,000 feet pressure altitude.

For specific charts refer to ODM, section 3.

Quick Reference Landing Length

Flap 3 or full approaches and landings may be conducted normally without reference to the ODM landing distance tables according to the following guidance.

Quick Reference Landing Length		
Includes a 15% Safety Margin Refer to the ODM for landings with abnormal configurations; MCO's affecting landing distance, or if above the maximum landing weight (MLW).		
Quick Reference Minimum Runway Length	Autobrake	319/320/321
	Lo	10,000 ft
	Med	8,000 ft

Assumptions:

- Airport elevation 4,000 ft or lower (including KSLC and KDEN)
- Touchdown no later than 1,500 ft. from threshold
- Up to Max Landing Weight
- Wet or Dry runway
- Zero wind and runway slope
- Two Engines at Full Reverse Thrust

Additional stopping performance is available by:

- Increased manual braking
- Landing at a lower altitude
- Landing at a lower weight



Flap Configurations for Approach and Landing

During maneuvering for an approach, when the situation dictates an earlier than normal speed reduction, the use of flaps 3 with the gear up is acceptable.

FLAPS 3 Landing

Flaps 3 is the fleet's preferred landing configuration. Both flaps 3 and full landing configurations are considered "normal"; choose the landing flap configuration that best fits the landing environment.

Flap Extension

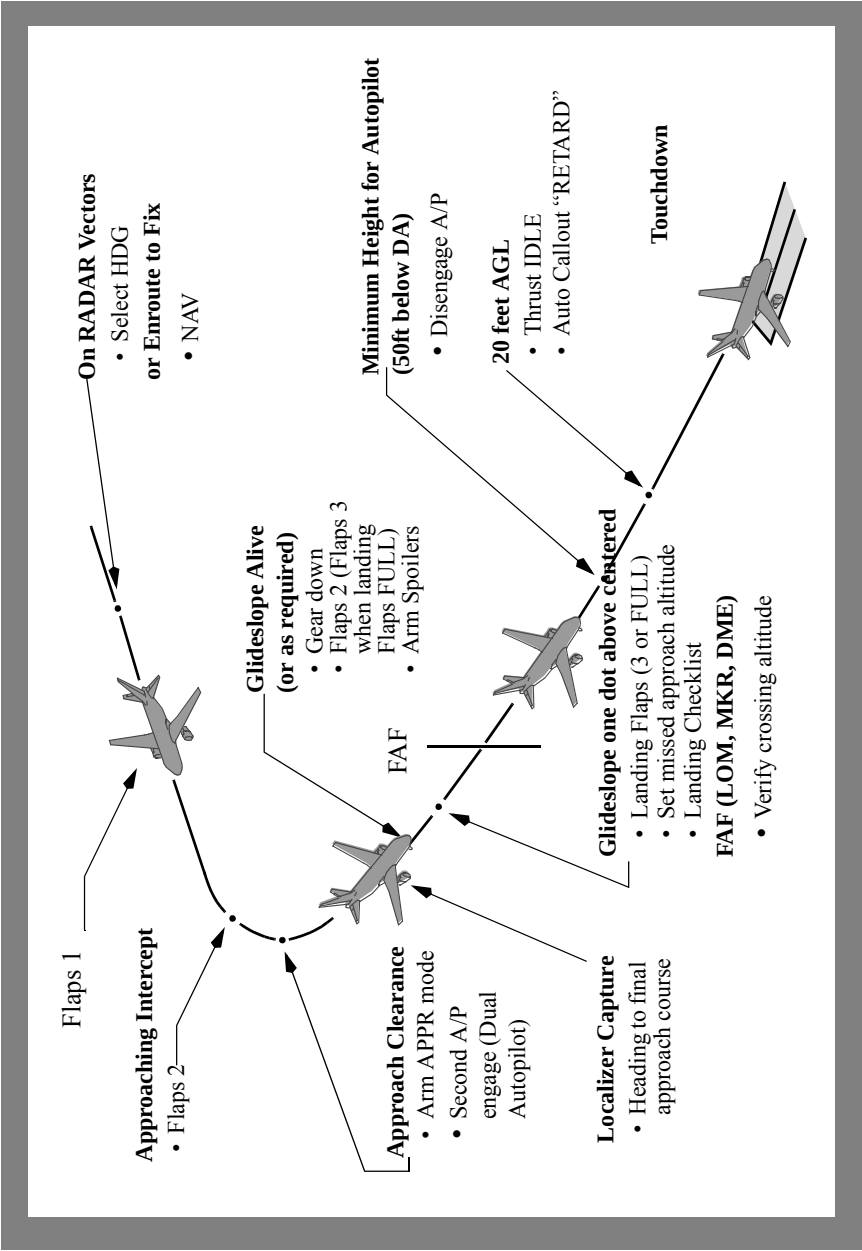
During flap extension, selection of the flaps to the next flap position should be made when approaching, and before decelerating below, the maneuver speed for the existing flap position.

During maneuvering for an approach, when the situation dictates an earlier than normal speed reduction, the use of Flaps 1, 2, or 3 with the gear up is acceptable. Flaps 3 is the normal landing flap position. Flaps FULL may also be utilized. Runway length and surface condition must be taken into account when selecting a landing flap position.

Note: In order to prevent inadvertent flap overspeeds, do not extend flaps until 10 knots below VFE NEXT unless directed by a non-normal procedure.

VLS (V Lowest Selectable Speed) is the lowest speed that the autothrust system will allow, regardless of what speed is selected. It provides a maneuver margin above stall speed regardless of configuration. VLS is essentially the same speed as VREF. The term is used interchangeably on the ECAM and the MCDU PERF APP page.

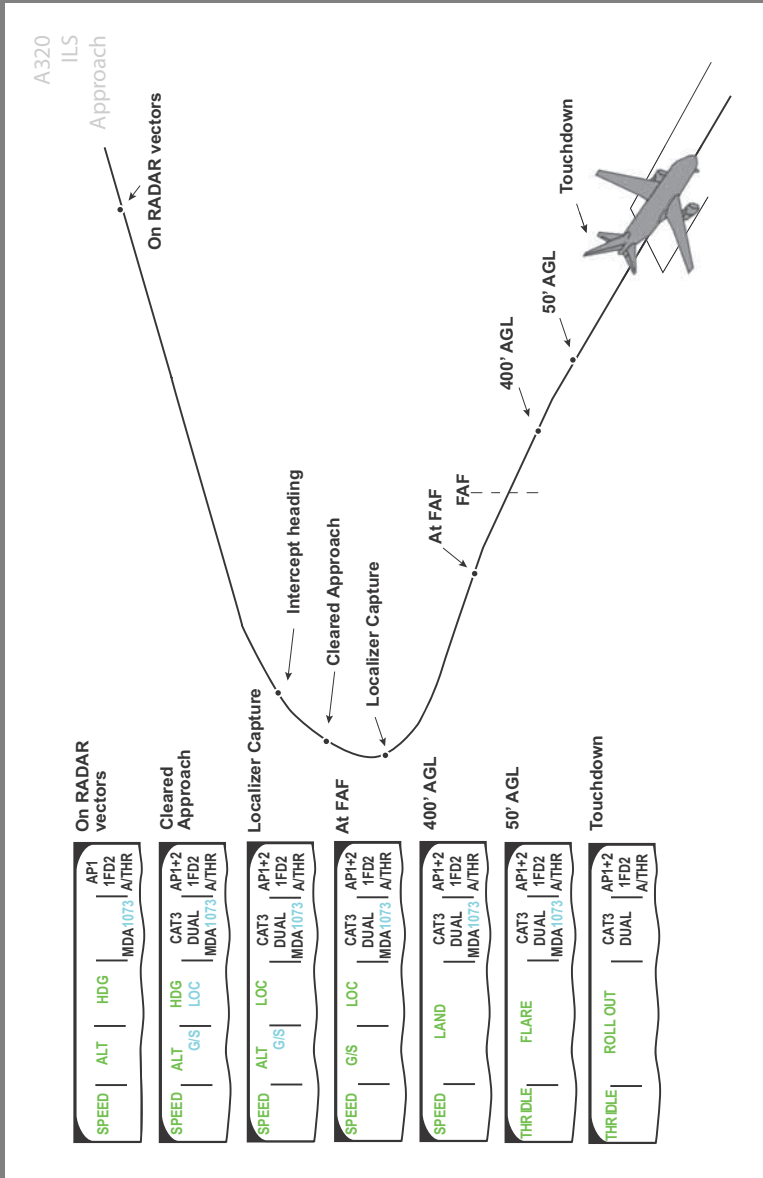
ILS Approach
ILS Approach Profile





A319/320/321 Flight Crew Training Manual

FMA Progression



Approach

ILS Approach - General

The ILS approach flight pattern assumes all preparations for the approach, such as review of approach procedure and setting of minima and radios, are complete. It focuses on crew actions and avionics systems information. It also includes unique considerations during low weather minima operations. The flight pattern may be modified to suit local traffic and ATC requirements.

Transitioning to Final Approach

Both pilots should not be “heads-down” during the approach. In some cases, such as high density traffic, or when an arrival procedure is used only for reference, revising the FMS may not be appropriate.

Throughout the approach transition and approach, adjust the map display and range to provide a scaled view of the area.

The arrival and approach transition may be flown using HDG SEL, Track or Managed Nav for lateral tracking and managed descent (DES), open descent, FPA or V/S for altitude changes. DES is the preferred descent mode when the FMS is programmed for the intended arrival. When DES is not available, use Open Descent for altitude changes greater than 2,000 feet. For smaller altitude changes, V/S permits a more appropriate descent rate.

When maneuvering to intercept the localizer (approximately 15 nm from touchdown), extend flaps to 1 and slow to S speed prior to reaching the IAF.

Select APP pb and engage the second autopilot when:

- crew confirms ILS raw data, frequency or identification, and course on the PFD by selecting the (I)LS pb on the FCU,
- the aircraft is on an inbound intercept heading,
- all of the altitude constraints on the STAR have been met, and
- clearance for the approach has been received.

After selecting, observe the LOC and G/S flight mode annunciations are armed. To preclude a false capture, do not select the APPR or LOC pb until the aircraft is within the normal service volume for the ILS (normally 18 miles from the threshold). After the APPR pb is pushed, the aircraft will descend on the glideslope when the GS is intercepted regardless of the status of the LOC capture. If ATC issues an altitude restriction until intercepting the LOC, the pilot should not arm the APPR pb until able to accept a descent on the GS.

The glideslope may be captured before the localizer. To avoid unwanted glideslope capture, LOC mode may be selected initially, followed by the APP mode. The glideslope may be captured from either above or below.



Altitude Constraints on Published Instrument Approaches

The ILS glideslope is a fixed angle from the runway regardless of temperature. On warmer than standard days, true altitude is higher than aircraft indicated altitude. Conversely, when colder than standard temperatures exist, true altitude is below aircraft indicated altitude. Using the ILS glideslope prior to the published Precision Final Approach Fix (PFAF), Glideslope Intercept Point or “Feather” when temperatures are higher than standard can place the aircraft below minimum crossing altitudes for fixes prior to the PFAF.

The use of Managed DES prior to the PFAF when cleared for the approach protects against violating an altitude constraint. Once all altitude constraints prior to the PFAF have been met, intercept the ILS glideslope for the remainder of the approach. For significant hot or cold temperature deviations, selecting DES, OP DES, or V/S to adjust the descent rate may be needed to assist with glideslope capture prior to the PFAF, depending on the amount of deviation.

Final Approach

At localizer capture, the heading display on the FCU will disappear. For normal localizer intercept angles, very little overshoot occurs. Bank angles up to 30° may be commanded during the capture maneuver. For large intercept angles some overshoot can be expected.

Use the ARC mode display to maintain awareness of distance to go to the final approach fix. When the glideslope pointer begins to move (glideslope alive), extend the landing gear, select flaps 2 (or 3 if landing flaps FULL) and engage managed speed.

Select managed speed before reaching the outer marker. At glideslope capture, observe the flight mode annunciations for correct modes. At this time, select landing flaps, and do the Landing checklist. The pilot monitoring should continue standard callouts during final approach and the pilot flying should acknowledge callouts.

Check for correct crossing altitude when crossing the final approach fix (FAF or OM).



There have been incidents where airplanes have captured false glideslope signals and maintained continuous on glideslope indications as a result of an ILS ground transmitter erroneously left in the test mode. False glideslope signals can be detected by crosschecking the final approach fix crossing altitude and VNAV path information before glideslope capture. A normal pitch attitude and descent rate should also be indicated on final approach after glideslope capture. Further, if a glideslope anomaly is suspected, an abnormal altitude range-distance relationship may exist. This can be identified by crosschecking distance to the runway with altitude or crosschecking the airplane position with waypoints indicated on the navigation display. The altitude should be approximately 300 feet per nm of distance to the runway for a 3° glideslope.

If a false glideslope capture is suspected, perform a missed approach if visual conditions cannot be maintained.

Autoland

The pilots should monitor the quality of the approach, flare, and landing, including speedbrake deployment and autobrake application.

Below 2,500 feet radio altitude, the radio altimeters begin to register. The autoland status annunciation should display CAT 3 DUAL or CAT 3 SINGLE. As the lowest weather minimums are directly related to the system status, both pilots must observe the autoland status annunciation.

When established on the glideslope and no later than 1,000 feet AGL, set the missed approach altitude in the altitude window of the FCU.

Normal autoland operations should not require pilot intervention. However, pilot intervention should be anticipated in the event inadequate aircraft performance is suspected, or when an automatic landing cannot be safely accomplished. The fail operational capability of the autopilots protect against any probable system failure and can safely land the aircraft. The pilot should not interfere below AH (typically 100 feet HAT) unless it is clearly evident pilot action is required. Guard the controls on approach through landing and be prepared to take over manually, if required. Manual landings during CAT II or CAT III approaches are not permitted.

Decision Altitude or Height - DA(H)

A Decision Altitude or Height is a specified altitude or height in an ILS or some approaches using a Managed NAV path where a missed approach must be initiated if the required visual reference to continue the approach has not been established. The “Altitude” value is measured by a barometric altimeter and is the determining factor for minima for Category I approaches, (e.g., ILS, or Approach NAV). The “Height” value specified in parenthesis, typically an RA height above the touchdown zone (HAT), is advisory. The RA may not reflect actual height above terrain.



For most Category II approaches, the Decision Height is the controlling minima and the altitude value specified is advisory. A Decision Height is usually based on a specified radio altitude above the terrain on the final approach or touchdown zone.

On radio altimeter not authorized (RA NOT AUTH) CAT II approaches, the minimums are based on a DA (barometric altitude) rather than a DH (height above the terrain).

Do not continue the approach below DA(H) unless the aircraft is in a position from which a normal approach to the runway of intended landing can be made and suitable visual reference can be maintained. Upon arrival at DA(H), or any time thereafter, if any of the above requirements are not met, immediately execute the missed approach procedure. When visual contact with the runway is established, maintain the glideslope to the flare. Do not descend below the visual glide path.

Alert Height - AH

Alert heights are used for fail operational Category III operations. Alert height is a height above the runway, above which a Category III approach must be discontinued and a missed approach initiated if a specified failure occurs. Radio altimeters are set to an alert height to assist in monitoring autoland status. Most regulatory agencies do not require visual references below alert height.

Descent Below Decision Altitude or Height - DA(H)

Refer to AM, Ops specs, CAT I Approach Requirements (Precision & Non-precision), Descent Below DA(H)/MDA.

Low Visibility Approaches

A working knowledge of approach lighting systems and regulations as they apply to the required visual references is essential to safe and successful low visibility approaches. A review of the approach and runway lighting systems available during the approach briefing is recommended as the pilot has only a few seconds to identify the lights required to continue the approach. For all low visibility approaches, a review of the airport diagram, SMGCS chart (if available) expected runway exit, runway remaining lighting, and expected taxi route during the approach briefing is recommended.

RVR

Refer to AM, Ops specs, CAT I Approach Requirements (Precision & Non-precision).

Visual References

Refer to AM, Ops specs, CAT I Approach Requirements (Precision & Non-precision), Descent Below DA(H)/MDA.

Category III operations using fail operational autoland systems normally do not require specific visual references below AH.

Category II and III Systems Requirements

System requirements described in this section do not include all of the systems and equipment required for each type of operation. Reference the AM, OPS-30S.4, CAT II Approach Requirements and CAT III Approach Requirements; QRH, NNOI.1; or MDM for specific systems and equipment needed for Category II and Category III operations.

Autoland Capabilities

Refer to the applicable Vol. 1 limitations for AFS limitations and a description of demonstrated autoland capabilities.

Autolands are permitted with either CAT 3 DUAL or CAT 3 SINGLE annunciated on the FMA. Below 100 feet radio altitude CAT3 DUAL and CAT 3 SINGLE approach categories are memorized until the LAND track mode is disengaged or the two autopilots are disengaged. Therefore, a single failure occurring below 100 feet will not change the FMA annunciation (e.g., below 100 feet CAT3 DUAL will not change to CAT 3 SINGLE).

Note: For autoland use flaps 3 or FULL.

Note: Autoland should not be attempted unless the final approach course path is aligned with the runway centerline. If the localizer beam is offset from the centerline the AFS may cause the aircraft to depart the runway.

Fail Operational

Fail operational refers to an autoflight system capable of completing an ILS approach, autoland, and rollout following the failure of any single system component after passing alert height. Fail operational is displayed on the FMA as CAT 3 DUAL.

Fail Passive

Fail passive refers to an autoflight system which, in the event of a failure, causes no significant deviation of aircraft flight path or attitude. Fail passive is displayed on the FMA as CAT 3 SINGLE.

ILS Performance

Most ILS installations are subject to signal interference by either surface vehicles or aircraft. To prevent this interference, ILS critical areas are established near each localizer and glideslope antenna. In the United States, vehicle and aircraft operations in these critical areas are restricted any time the weather is reported less than 800 foot ceiling and/or visibility is less than 2 miles (3200m).

**A319/320/321 Flight Crew Training Manual**

Flight inspections of ILS facilities do not necessarily include ILS beam performance inside the runway threshold or along the runway unless the ILS is used for Category II or III approaches. For this reason, the ILS beam quality may vary and autolands performed from a Category I approach at these facilities should be closely monitored.

Autolands on Contaminated Runways

AFS ROLLOUT mode performance cannot be assured when used on contaminated runways. The ROLLOUT mode relies on a combination of aerodynamic rudder control, nose wheel steering, and main gear tracking to maintain the runway centerline using localizer signals for guidance. On a contaminated runway, nose wheel steering and main gear tracking effectiveness, and therefore aircraft directional control capability, is reduced. To determine the maximum crosswind, use the most restrictive of the autoland crosswind limitation, or during low visibility approaches, the maximum crosswind authorized by the controlling regulatory agency.

Refer to Vol. 1, SP.16, Guidelines For Contaminated Runways.

If an autoland is accomplished on a contaminated runway, the pilot must be prepared to disengage the autopilot and take over manually should directional control become inadequate.

Transition to Manual Approach or Landing

A transition to a manual approach can be accomplished during the approach. Ensure visual cues are sufficient prior to disengaging the autopilot. After autopilot disengages, continue to keep the FD in the crosscheck and gradually transition to a visual landing. Anticipate the effect of existing crosswinds on the final portion of the approach and landing.

During the transition, inadvertently removing the crosswind correction established by the autopilot may allow the aircraft to drift off the centerline.

Intercepting Glideslope from Above

Normally the ILS profile is depicted with the aircraft intercepting the glideslope from below in a level flight attitude. However, there are occasions when flight crews are cleared for an ILS approach when they are above the G/S. In this case, there should be an attempt to capture the G/S prior to the FAF. The map display can be used to maintain awareness of distance to go to the FAF. The use of autopilot is also recommended.

Note: Before intercepting the G/S from above, the flight crew must ensure that the localizer is captured before descending below the cleared altitude or the FAF altitude.



The following technique will help the crew intercept the G/S safely and establish stabilized approach criteria by 1,000 feet AFE:

- Select the APPR pb.
- In IMC, set the GSIA altitude in the FCU altitude window.
- In VMC, set 1,000 feet AFE in the FCU altitude window.
- Initiate a descent rate that will intercept the glideslope early enough to comply with the stabilized approach criteria. The descent may be made using OP DES mode (with a selected speed greater than VAPP) or V/S mode (preferably in managed speed).

Note: If the aircraft enters the altitude capture (ALT*) mode before glideslope capture (G/S*), the aircraft will begin to level off at the FCU altitude without regard to the glideslope. To eliminate the ALT* and resume the descent to capture the glideslope, turn the FCU altitude knob up to a higher altitude and turn the V/S knob down to continue descent. If the stabilized approach parameters cannot be met, execute a missed approach.

- After the glideslope is captured, resume normal ILS procedures.

Note: If the glideslope is not captured or the approach not stabilized by 1,000 feet AFE, initiate a go-around. Because of glideslope capture criteria, the glideslope should be captured and stabilized approach criteria should be established by 1,000 feet AFE, even in VMC conditions.

Delayed Flap Approach

If conditions warrant, the final flap selection may be delayed to conserve fuel or to accommodate speed requests by air traffic control.

Intercept the glideslope at assigned speed or flaps maneuvering speed. The thrust required to descend on the glideslope may be near idle. Establish final configuration so that flaps are fully extended by 1,000 feet AFE, allow the speed to bleed off to the final approach speed. Complete the Landing checklist.

At all times comply with stabilized approach criteria.

Raw Data - (No Flight Director)

Raw data approaches are normally used during training to improve the instrument scanflow. If a raw data approach is required during normal operations, refer to the MDM for the possibility of increased landing minima.

The raw data for an ILS approach, to include ILS DME, is located on the PFD, but the ROSE ILS mode of the ND can be used, if desired. Any VOR or NDB crossing radial that is required for the approach can be displayed on the ND needles by selecting the proper mode on the EFIS control panel.

**A319/320/321 Flight Crew Training Manual**

The magnetic course/bearing information from the VOR/ADF pointers on the ND may be used to supplement the PFD localizer deviation indication during initial course interception. Begin the turn to the inbound localizer heading at the first movement of the localizer diamond or CDI on the ND.

After course intercept, the track diamond on the bottom of the PFD may be used to assist in applying proper drift correction and maintaining desired course. Once on the localizer, bank as necessary to keep the track diamond over the desired course marker (magenta dagger). This method automatically corrects for wind drift with very little reference to actual heading required.

Large bank angles are rarely required while tracking inbound on the localizer. Use 5° to 10° of bank angle.

When the glideslope diamond begins to move (glideslope alive), ask for “GEAR DOWN, FLAPS 3 (2 if landing flaps 3)” and slow to “F” speed. When the glideslope is one dot above the centered position, ask for “FLAPS FULL (or 3 if landing flaps 3), LANDING CHECKLIST” and slow to the final approach speed. The normal pitch and power when on the glideslope with gear down and FLAPS FULL is 4° nose up and 55% N1 (5° nose up and 52% N1 for flaps 3). When established on the glideslope, preset the missed approach altitude in the altitude window. Once on the localizer and glideslope, use small, smooth pitch, power, and heading corrections to stabilize on the approach. Apply corrections at approximately the same rate and amount as the flight path deviations.

The missed approach procedure is the same as a normal missed approach. If the Flight Directors are operational, they will automatically appear when a pilot moves the thrust levers to the TOGA detent.



ILS PRM Approach

PRM Procedures

Refer to the Vol. 1, NOI, ILS Precision Runway Monitor (PRM) Considerations.

Refer to Airport Specific Attention All Users Page.

- Use automatic ILS approach procedures. Select the APPR pb after being cleared for the approach.
- Recognize the importance of flying a precise approach. Maintaining localizer centerline is especially important during ILS PRM approaches due to the distance between parallel runway centerlines.

PRM Breakout Maneuvers: General

When breakout instructions are issued, it is important to initiate a turn without delay. This is accomplished more quickly by selecting the AP and FD off and hand flying the turn. The bank angle should not exceed 30°.

Transition to a smooth climb or descent as instructed.

Climbing breakouts: Pitch to 10° for an initial target. Use TOGA power if necessary.

Note: If TOGA is selected (with flaps 1 or greater) the flight directors display SRS and GA TRK. In this case the breakout heading will need to be reset and the HDG mode re-engaged.

Descending breakouts: Do not exceed 1,000 fpm. Recognize if the aircraft is already tracking the glideslope (at approximately 900 fpm) that little or no change of pitch or rate of descent may be required.



A319/320/321 Flight Crew Training Manual

PRM Breakout Maneuver

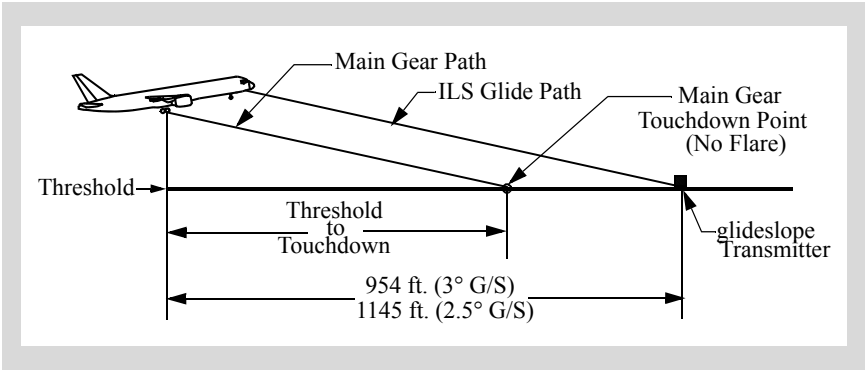
Pilot Flying	Pilot Monitoring
If ATC calls "Traffic Alert" during the PRM approach:	
A/P - Disengage	F/D (both) - OFF
Initiate a turn to the heading directed by ATC Note: If ATC breakout instructions coincide with a TCAS RA, follow the vertical guidance of the RA and the lateral guidance directed by ATC.	
- Maintain Autothrust ON - Initiate climb or descent as directed Note: If descending, vertical speed should not exceed 1,000 FPM.	- Set the breakout altitude in the FCU ALT window - Set the breakout heading in the FCU HDG window - Communicate with ATC as required
	When established near the breakout heading: - F/D (both) - ON - Set breakout heading - Select V/S (approx. +/- 1000 fpm)
When breakout is complete, reset automation to appropriate level.	
- Autopilot as desired - Select speed for desired flap setting. - Call GEAR UP if landing gear is down - Call for flap retraction on schedule - Select managed speed if desired - After Takeoff checklist	Make FCU configuration changes as requested by the PF

CAUTION: If performing a descending maneuver, delay cleaning up the aircraft until established on the breakout altitude.

ILS Approach - Landing Geometry

The following diagrams use these conditions:

- Flaps Full
- ILS antenna crosses threshold at 50 ft
- No flare

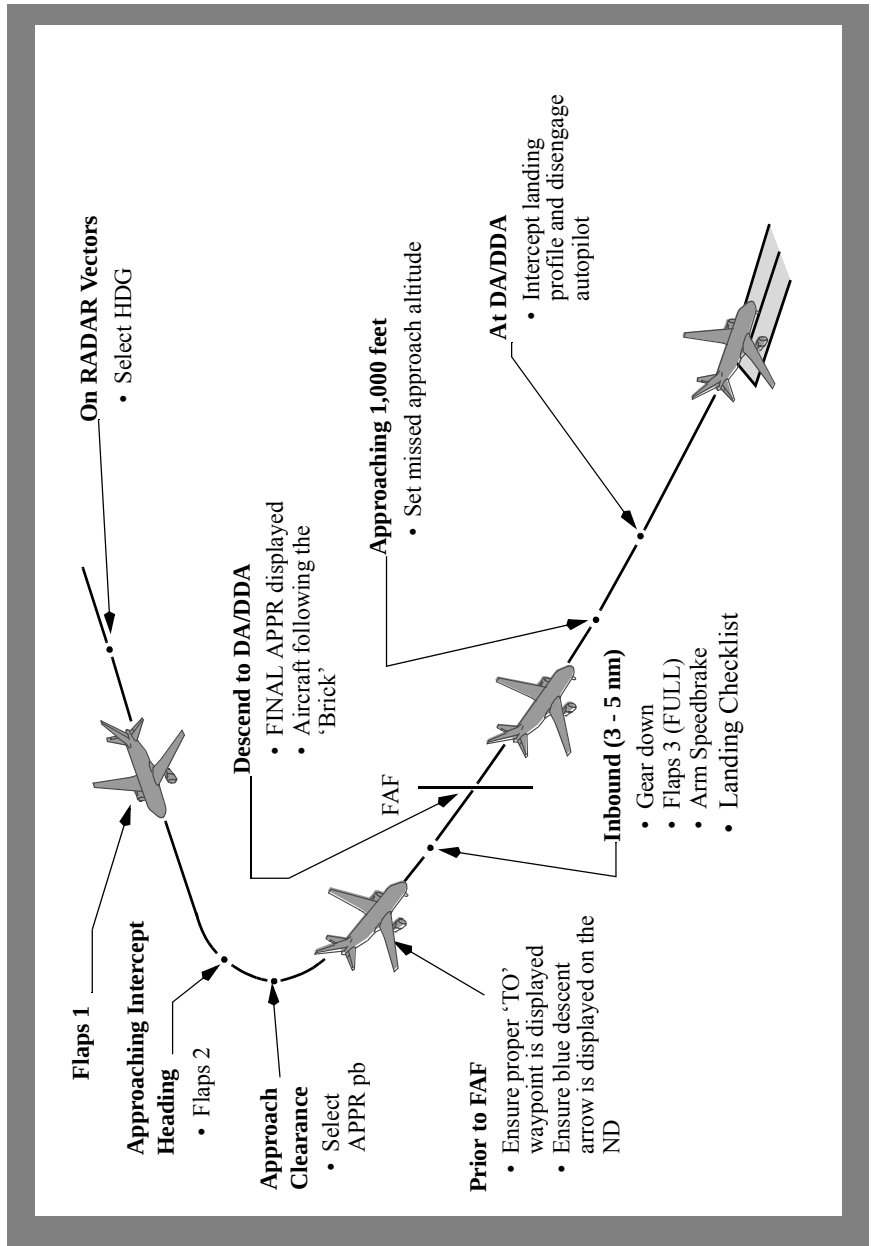


A319 / 320 Model	Flaps Full		Main Gear over Threshold		Threshold to Main Gear Touchdown Point - No Flare (feet)
	Glide Path (degrees)	Airplane Body Attitude (degrees)	Pilot Eye Height (feet)	Main Gear Height (feet)	
A320	2.5	4.0	56	34	779
	3.0	4.0	56	34	648
A319	2.5	4.7	56	33	722
	3.0	5.2	56	33	626

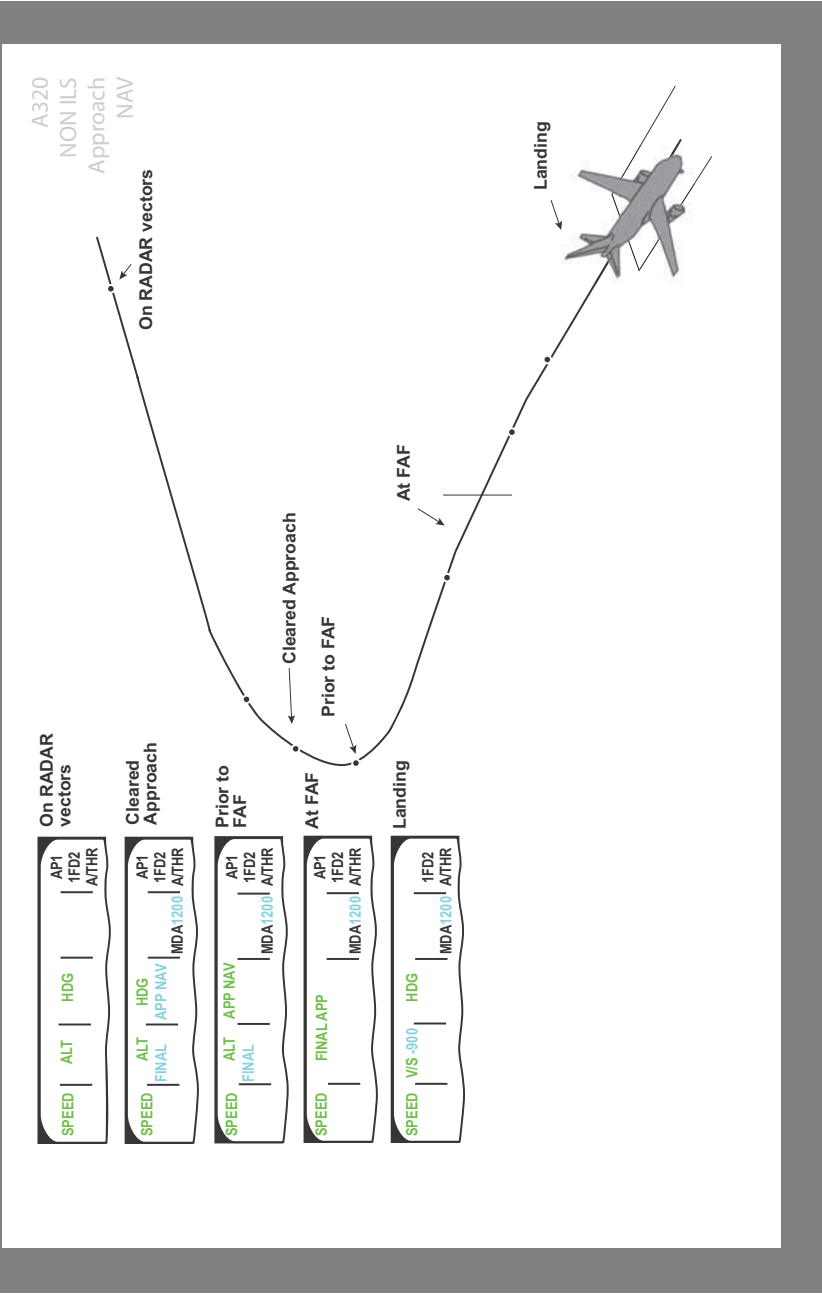


Non - ILS Instrument Approaches

Non - ILS Instrument Approach Using APP NAV Profile



FMA Progression

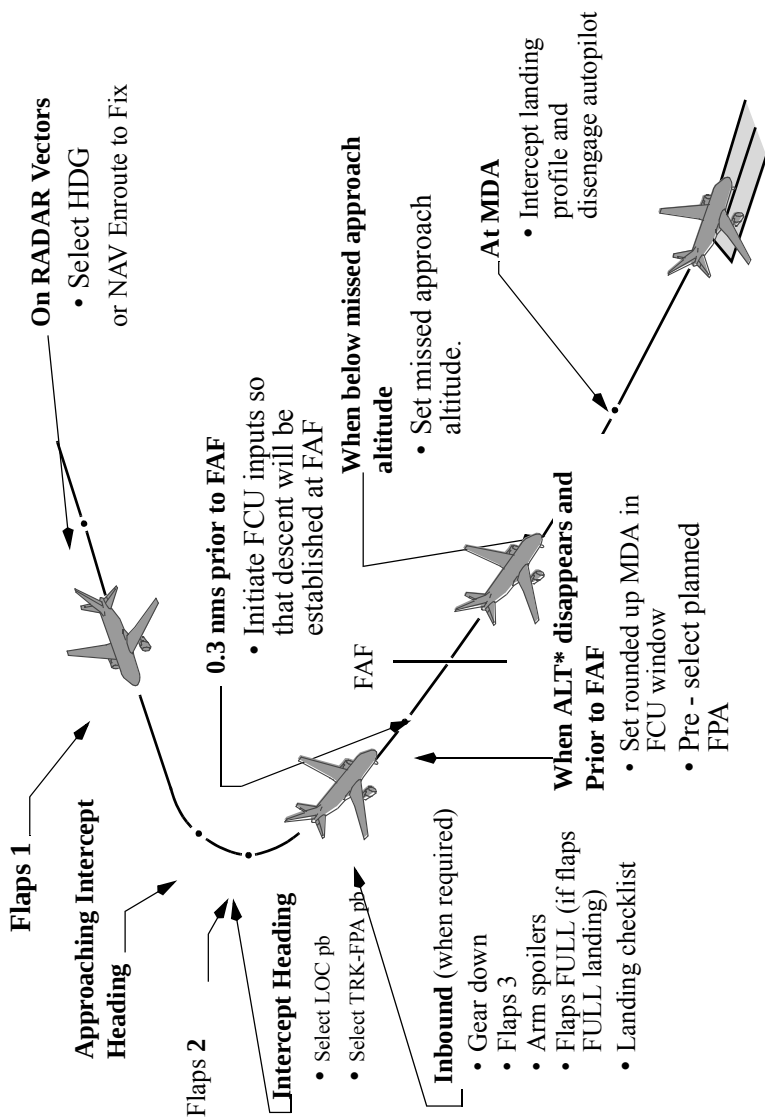




Approach Guide

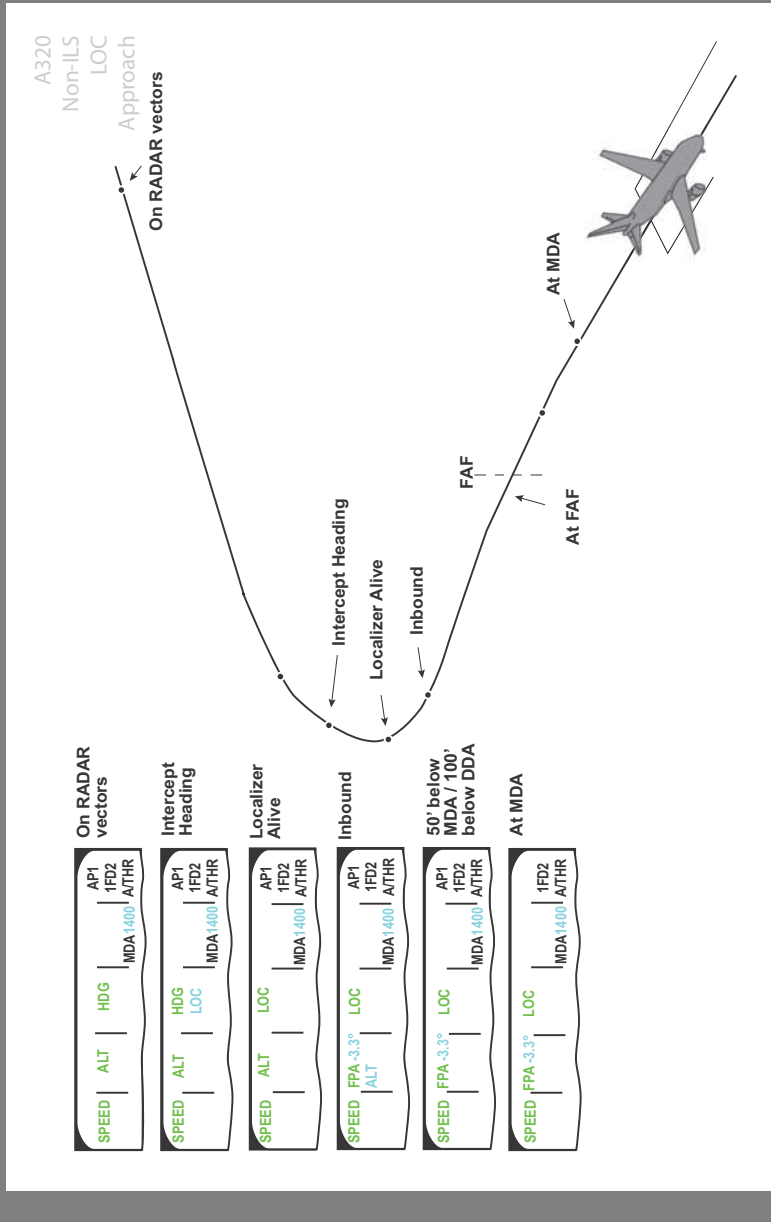
Refer to Vol. 1, NOI.3 for approach guidance.

Non-ILS Approach Using LOC & FPA Mode Profile





FMA Progression



Approach Guide

Refer to Vol. 1, NOI.3 for approach guidance.

General

Non-ILS approaches are defined as:

- RNAV approach - an instrument approach procedure that relies on aircraft area navigation equipment for navigational guidance. The FMS is FAA-certified RNAV equipment that provides lateral and vertical guidance referenced from an FMS position. The FMS uses multiple sensors (as installed) for position updating to include GPS, DME-DME, VOR-DME, LOC-GPS, and IRS.
- RNAV Visual approach - a visual approach that relies on aircraft navigation equipment to align the aircraft with a visual final. The approach is selected in the FMS and flown in the same way as an RNAV approach until reaching the visual segment.
- GPS approach - an approach designed for use by aircraft using stand-alone GPS receivers as the primary means of navigation guidance. However, aircraft using FMS as the primary means of navigational guidance, have been approved by the FAA to fly GPS approaches provided an RNP of 0.3 or smaller is used.
- VOR approach
- NDB approach
- LOC, LDA or similar approaches.

Note: The A319/320/321 aircraft are not currently approved for Localizer Back Course operations.

Non - ILS Instrument Approaches - General

The following sections describe methods for flying non-ILS Continuous Descent Final Approach (CDFA). These methods provide a constant angle approach, which reduces exposure to crew error and CFIT accidents. These methods also make it much easier for the crew to achieve a stabilized approach to a landing once suitable visual reference to the runway environment has been established.

A typical Instrument Approach using Managed Nav or, as illustrated, assumes all preparations for the approach; such as review of the approach procedure and setting of minima and radio tuning have been completed. The procedures illustrated focus generally on crew actions and avionics systems information. The flight pattern may be modified to suit local traffic and ATC requirements.

The following discussions assume a straight-in instrument approach is being flown.



Types of Approaches

The aircraft uses the following non-ILS approach strategies:

- Approach Nav Mode: A non-ILS approach where the FMS database provides the course and glide path guidance. The APPR Nav mode is Used for RNAV (GPS), RNAV(RNP), VOR, and NDB approaches.
- LOC & FPA Mode: A non-ILS approach where lateral guidance is provided by selecting the LOC pb which commands the aircraft to track the localizer signal. The Loc Nav & FPA mode is used for LOC and LDA without glideslope approaches.

The Approach NAV and LOC & FPA approaches have the following features in common:

- The approach must be contained in the FMS database.
- Each approach is flown using a constant angle descent from the FAF to minimums.
- The aircraft can maintain a relatively constant pitch and thrust on final approach.
- At minimums, the aircraft is in a position to make a normal landing without major pitch or thrust changes.

Use of the Autopilot During Approaches

Automatic flight is the required method of flying non-ILS approaches in IMC conditions.

Raw Data Monitoring Requirements

Throughout the VOR or NDB approach, monitor raw data and maintain approach tolerances. Use raw data to define stepdown fixes. Enter the appropriate frequency and course on the MCDU RAD NAV page, if desired, and display the raw data on the ND or DDRMI (VOR ONLY).

Note: Any VOR or NDB approach may be flown when raw data is unavailable. Refer to AM, Ops specs, CAT I Approach Requirements (Precision & Non-precision), Ground Based Equipment.

Typical Navigation Display

The following diagram represents a typical navigation display with the ND ROSE display selected.



MAP Displays and Raw Data

The Rose Nav or Arc mode should be used to the maximum extent practicable. These displays improve situational awareness during the approach, including final approach and missed approach routing. They also increase crew awareness of progress and position during the approach.

They are particularly useful when the inbound course does not align with runway centerline and allows the pilot to clearly determine the type of alignment maneuver required. They can be used to integrate weather radar returns, terrain or traffic information within the approach path and airport area.

Note: When appropriate, compare aircraft position on the map with ILS, VOR, and DME systems to detect possible map shift errors. The VOR pointers should be displayed on the map.



RNAV (GPS or GNSS) Approaches

RNAV (GPS or GNSS), VOR, and NDB approaches are accomplished using the Approach NAV mode. The FMS database provides the course and glide path guidance so that use of a ground based navigation radio such as VOR, NDB, or ILS is not required. The one major difference between RNAV and VOR or NDB approaches is that VOR and NDB approaches require that raw data from a navigation radio (VOR or NDB) be monitored (if available). The aircraft is capable of flying to LNAV/VNAV or LNAV minimums. Do NOT use LPV minimums.

RNAV (GPS or GNSS), VOR, and NDB approaches allow the aircraft to follow the FMS lateral NAV course (APP NAV) and the FMS vertical NAV descent path (FINAL APP) on final. The system utilizes a constant angle descent to arrive at the Decision Altitude (DA) in a position to conduct a normal landing. At the DA, the PF will execute a go-around or disengage the autopilot and land. Inside the FAF, this approach is similar to an ILS approach in that both the lateral and vertical paths are managed for the pilot.

Descent guidance during an RNAV (GPS or GNSS), VOR, and NDB approach are displayed on the PFD by the vertical deviation indicator (brick). With the APPR pb selected, the aircraft will intercept and follow the brick regardless of the altitude set on the FCU.

Use of Approach NAV

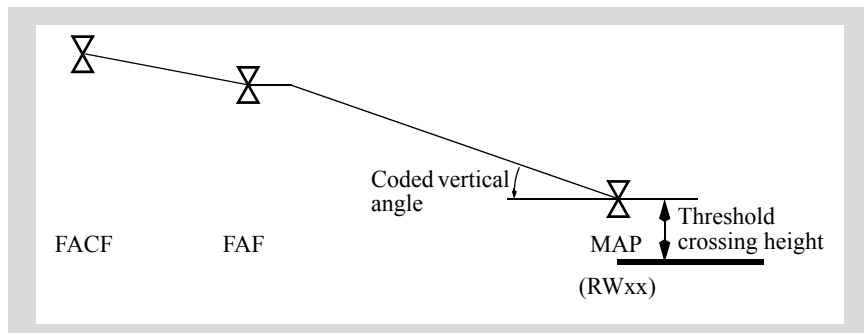
Database Selection

Select the approach (and APPR-VIA, if appropriate) from the FMS database. If being radar vectored, an APPR-VIA may be selected to provide situational awareness.

CAUTION: Do not make any lateral or vertical (altitude constraint) revisions to the F-PLN between the final approach course fix (FACF) and the runway or missed approach waypoint.

CAUTION: Do not select the APPR pb during a procedure turn (MCDU indicates PROC-T) until established on the inbound leg and cleared for the approach.

Compare the FMS F-PLN to the Jeppesen approach chart. Verify that the database final approach course, altitudes, distances, and approach angle are valid and/or reasonable.



Instrument Approach Using APP NAV

Approach Preparations for RNAV (GPS or GNSS), VOR, and NDB

Ensure that the field temperature is within the temperature range displayed on the approach chart.

Note: If the field temperature is outside the temperature range listed on the approach chart header, the LNAV minimums must be used.

Check that GPS PRIMARY is displayed on the MCDU PROG page. If GPS PRIMARY is not displayed, an RNAV approach is not authorized.

Select the CSTR pb on the EFIS control panel.

Configure to Flaps 1 and slow to 'S' speed before reaching the initial approach fix. Descend so as to arrive at the final approach fix altitude at or prior to the FAF while complying with all published stepdown altitudes and ATC instructions. Intercept the final approach course outside the FAF. Late interception of the final approach course will delay the engagement of FINAL APP and the descent to minimums.

Transition to an RNAV (GPS or GNSS), VOR, and NDB Approach

Outside the FAF use normal descent procedures to comply with altitude constraints. Do this until FINAL APP is active. Once FINAL APP is active, the aircraft will follow the brick, which may include level segments prior to the FAF. Check the following on base leg after selecting the APPR pb:

- APP NAV is armed on the FMA.
- The proper 'TO' waypoint is displayed.



A319/320/321 Flight Crew Training Manual

- The crosstrack error is displayed on the ND. The crosstrack error will not be displayed once the course is captured.
- The managed course will be intercepted before reaching the FAF.

Establish the landing configuration and slow to the target approach speed. Prior to reaching the FAF, ensure that:

- The proper 'TO' waypoint is displayed on the ND.
- The final approach fix altitude is reached before the FAF waypoint (to intercept the brick).
- The blue descent arrow is displayed on the ND (indication that FINAL APP will engage).
- The brick is visible at or above the current altitude or FINAL APP is engaged.

Final Approach Using the Approach Nav

Note: Timing is not used to determine the missed approach point for RNAV(GPS) approaches. The missed approach point for a RNAV (GPS) approach occurs when the aircraft reaches the DA.

Passing the FAF ensure that:

- FINAL APP is displayed in green on the FMA.
- The aircraft begins a descent (follows the brick).
- The aircraft is tracking to the MAP.
- The PF sets the missed approach altitude on the FCU.
- The correct missed approach track is displayed in blue on the ND.

The PF must disengage the autopilot no lower than 50 feet below the DA.

Note: The PF must disengage the autopilot no lower than 50 feet below the DA/MDA, or 100 feet below the DDA (if used).

Decision Altitude (DA) or Minimum Descent Altitude (MDA)

When specifically authorized by the appropriate regulatory authority, approaches may be flown to the following minima:

- a published VNAV DA and
- a published MDA used as a decision altitude.

When either of the above minima are not specifically authorized, use the MDA specified for the instrument procedure.

The following diagram illustrates an approach procedure containing DA(H) and MDA(H) minimums for approaches using LNAV/VNAV or LNAV only.



STRAIGHT-IN LANDING RWY 28R				CIRCLE - TO - LAND	
LNAV/VNAV DA(H) 740' (727')		LNAV MDA(H) 1000' (987')		Max Kts	MDA(H)
ALS out		ALS out		90	
A	2	RVR 40 or 3/4	RVR 60 or 1 1/4	120	1000' (987') - 2
B		RVR 50 or 1	1 1/2	140	1140' (1027') - 3
C		2 1/2	3	165	1160' (1147') - 3
D					

The pilot monitoring should expand the instrument scan to include outside visual cues when approaching DA, MDA, or DDA. Do not continue the approach below DA or MDA unless the aircraft is in a position from which a normal approach to the runway of intended landing can be made and suitable visual reference can be maintained. Upon arrival at DA, MDA, or DDA or any time thereafter, if any of the above requirements are not met, immediately execute the missed approach procedure.

When suitable visual reference is established, maintain the descent path to the flare. Do not descend below the visual glide path. While vertical path guidance may still be used as a reference once the aircraft is below DA or MDA, the primary means of approach guidance is visual.

LOC or LDA

LOC and LDA without glideslope approaches are accomplished using the LOC and FPA Mode. LDA with glideslope approaches are accomplished using the standard ILS procedures. LOC and LDA approaches are selected from the FMS database. Lateral guidance for these approaches is provided by selecting the LOC pb which commands the aircraft to track the localizer signal. When 0.2 nm prior to the final descent point, the PF selects a FPA to follow the descent path indicator. The FMS will not capture the donut. The PF adjusts the FPA so as to stay on the descent path (keep the donut centred). At minimums, the PF either disengages the autopilot and lands or executes a go-around.



Approach Preparation

Select the LOC or LDA approach (and APPR VIA, if desired) from the FMS database. If being radar vectored, an APPR VIA may be used to provide situational awareness.

Do not make any lateral or vertical (altitude constraint) revisions to the F-PLN between the FAF and the runway or missed approach waypoint.

Enter the published LOC or LDA minimums into the MDA field of the MCDU PERF APPR page (at international airports, enter published minimums + 50 feet).

Check that GPS PRIMARY is displayed on the MCDU PROG page. If GPS PRIMARY is not displayed, HIGH ACCUR must be annunciated.

Select the LS pb on the FCU to display ILS raw data on the PFD. ILS/DME information is also obtained by selecting the LS pb.

Select the CSTR pb on the EFIS control panel.

Verify the LOC identifier and course on the PFD match those on the Jeppesen approach plate.

Select the GPWS G/S MODE pb to OFF to avoid glideslope warnings on final approach.

Compare the FMS F-PLN to the Jeppesen approach chart. Verify that the database final approach course, altitudes, distances, and approach angle are valid and/or reasonable.

Transition to a LOC Approach

Configure Flaps 1 and slow to 'S' speed before reaching the initial approach fix. Use managed descent, open descent, or flight path angle to descend prior to the FAF.

Outside the FAF/OM, the descent path indicator guidance may be followed if it is coded in the FMS database.

When cleared for the approach, push the LOC pb on the FCU, select TRK-FPA, and ensure:

- LOC is armed on the FMA,
- the proper TO waypoint is displayed, and
- the cross track error is displayed on the ND.

Localizer raw data is displayed on the bottom of the PFD. Situational awareness is enhanced if the PF selects NAV or ARC display on the ND. The approach tolerance for all LOC and FPA mode approaches is 1/2 Dot.



Prior to reaching the FAF/OM, accomplish the following items:

- Check that LOC is displayed in green on the FMA.
- Establish the landing configuration and slow to the target approach speed.
- Initially set the rounded-up MDA in the FCU altitude window.

Final Approach

- Preselect the final FPA on the FCU.
- Approximately 0.2 nm before the OM/FAF, pull the FPA knob to begin the descent to the MDA/DDA.

Note: The autoflight system reacts slowly. Pulling the FPA knob 0.2 nm before the OM/FAF makes for a smoother approach and does not violate any FAR.

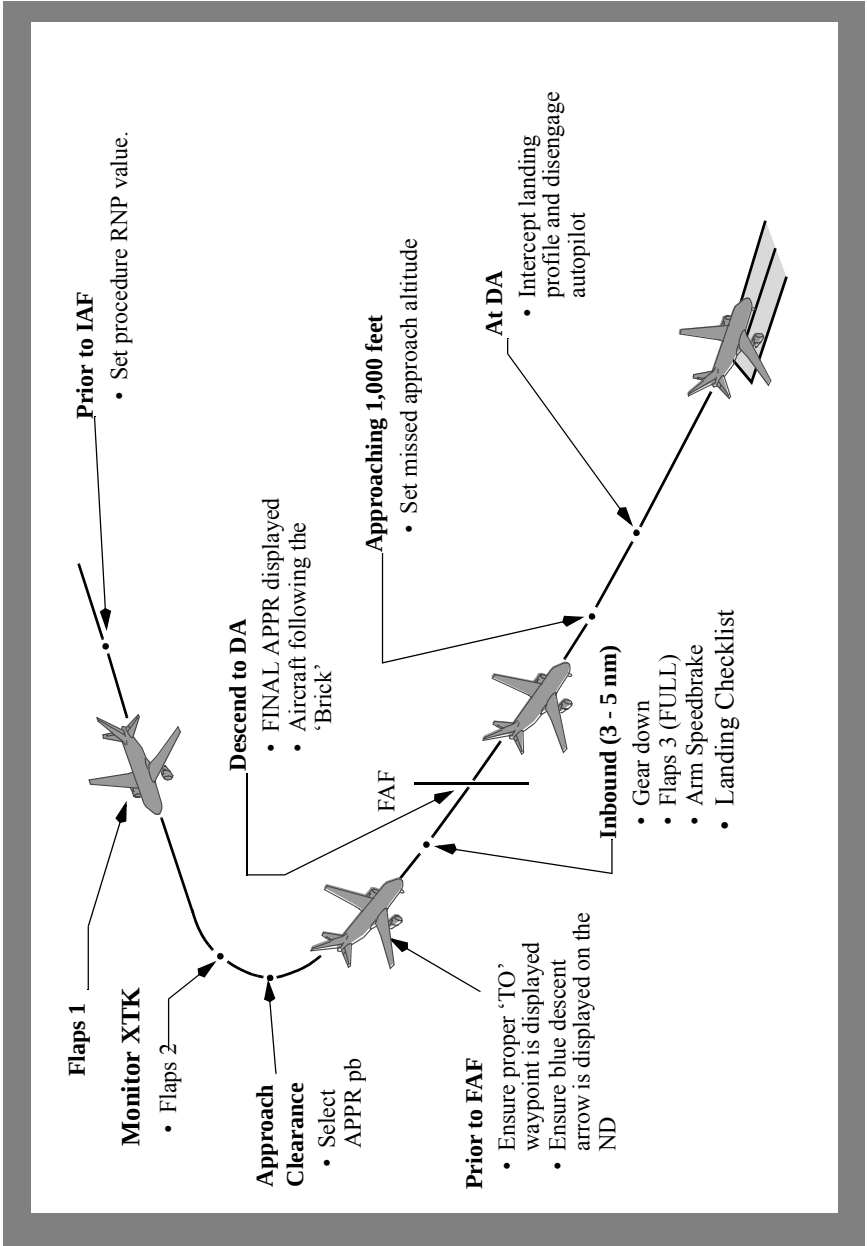
Note: Timing is not used to determine the missed approach point. The missed approach point occurs when the aircraft reaches the MDA/DDA.

- Upon reaching the descent point:
 - Adjust the FPA on the FCU to track the descent path indicator.
 - The charted FPA should keep the aircraft above step down altitudes and they do not need to be set into the ALT window on the FCU. However, it is still the pilot's responsibility to ensure that all step down altitude constraints are met.
 - Once established on the FPA descent and below the missed approach altitude, set the missed approach altitude.
 - The autopilot must be disengaged no lower than 50 feet below minimums.

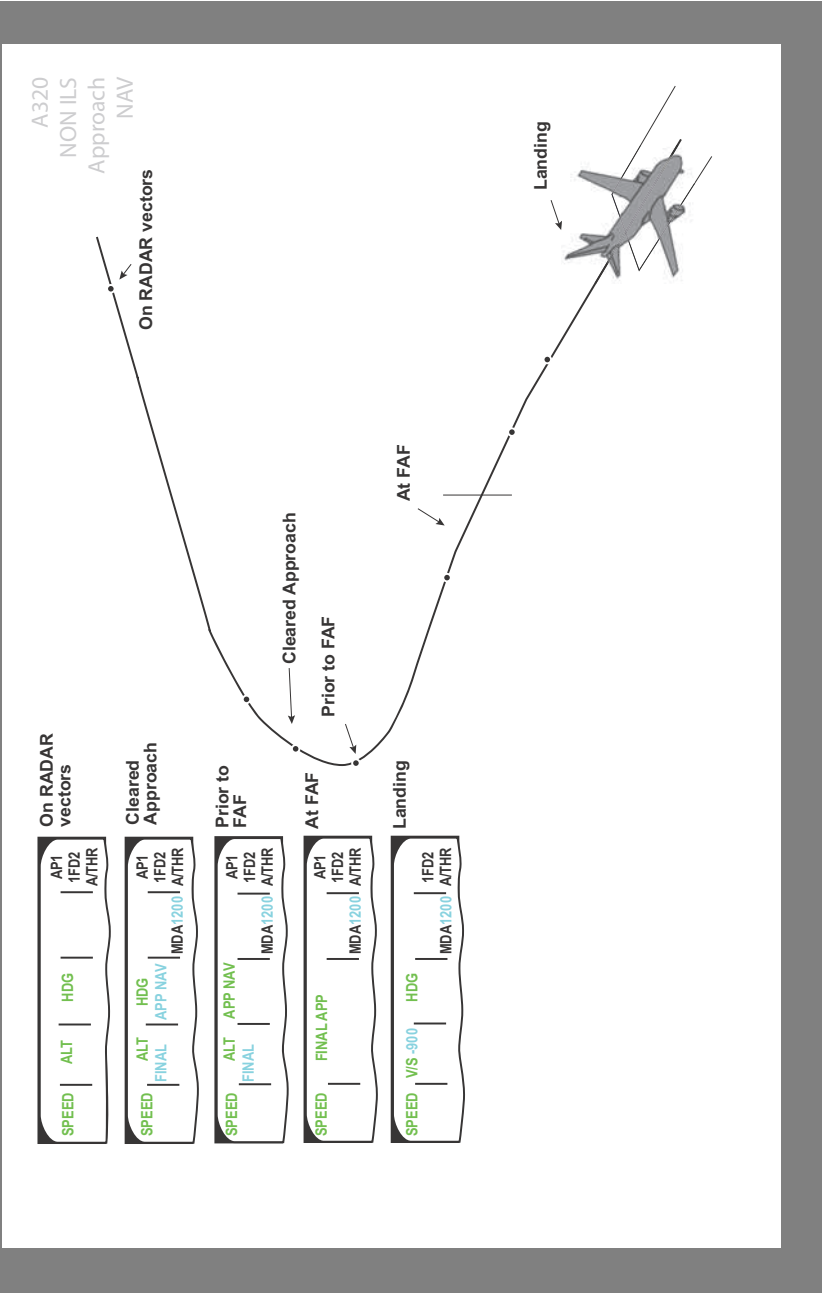
Note: The autopilot will not automatically disengage 50 feet below the MDA/DDA. If the PF elects to go-around the autopilot should remain engaged. If the PF elects to land the autopilot must be disengaged.

Note: The aircraft will capture and fly the LOC signal regardless of the FMS TO waypoint. If a go-around is subsequently performed, and the TO waypoint is not correct, the aircraft will not follow the FMS missed approach procedure.

RNAV(RNP) AR Approach Using APP NAV Mode



FMA Progression





RNAV (RNP) - Expanded Approach Guide APPR Mode

Approach Preparation Using RNAV (RNP)

Select the approach procedure from the ARRIVAL page of the FMS. If the IAF has an "at or above" altitude restriction, it may be changed to an "at" altitude restriction using the same altitude. Speed modifications are allowed as long as the maximum published speed is not exceeded. No other lateral or vertical modifications should be made at or after the IAF.

Prior to beginning the approach, in addition to briefing the approach, Crews may need to:

- Review Vol. 1 RNAV (RNP) Approach Guide,
- Assess RNAV Equipment Procedures (Ref. QRH NNOI),
- Select the approach procedure, normally without modifications, from the navigation database,

Note: Conditions permitting, when ATC clears the crew to proceed direct to a fix, a DIR TO is acceptable unless the fix is the beginning of an RF leg or the fix is the FAF for the procedure.

- Coordinate Range and Radar Display,
- Inhibit of RADIONAV updating per the RNAV (RNP) Approach Guide.

Dispatch is responsible for verifying PRAIM only when the flight is dispatched to a destination (or alternate) requiring an RNAV approach. If a lack of coverage is predicted, it will be included as a Flight Plan Remark in the flight paperwork.

The crew should select the highest available RNP permitted by prevailing weather conditions. Crew entry of the RNP prevents automatic RNP changes until the crew deletes the RNP entry.

Airbus aircraft use Category D minimums for all RNAV (RNP) approaches. Category D allows a maximum speed of 165 knots while on an RF leg between the FAF and DA. If GS Mini commands a higher speed than 165, selected speed must be used to ensure turning radius isn't exceeded. Once aligned with the landing runway, managed speed can be selected.

If the altimeter setting is changing rapidly, the crew should obtain an update just before starting the approach. A local altimeter setting is required for all RNP approaches.

When cleared for the approach, select the APPR pb and verify 'APPR NAV' armed or active and 'FINAL' armed. A blue descent arrow and "brick" at or above the aircraft, indicates FINAL will engage the descending leg of the vertical profile.

A319/320: If APPR is armed prior to reaching the circled "D" DECEL point, the descent arrow will be white and the pilot must initiate the descent.



Cold Temperature Altitude Corrections

In the design of RNP procedures, the allowable temperature range is normally specified and the procedure design accounts for operations and obstacle clearance for any temperature within the specified range. Pilots must abide by any temperature restrictions on the approach. See Fleet Bulletin 15-11 Cold Weather Altimeter Corrections for additional guidance.

Final Approach Using RNAV (RNP)

Speed limits published on the approach chart must be complied with to ensure adequate bank angle margins for the smaller radius-to-fix (RF) legs when strong winds exist. Additionally, a maximum of 165 knots is required when on an RF leg from the FAF to the DA. Bank angles will rarely exceed 15° when flying short radius RF legs unless the ground speed is very high due to strong tailwinds or high aircraft speed.

The FMS monitors navigation system accuracy and integrity, so there is no need for the crew to monitor reception of GPS signals. If the GPS signal is lost during the approach due to loss of both GPS receivers and/or loss of satellite position data, a 'GPS PRIMARY LOST' alert occurs followed by a 'NAV ACCUR DOWGRAD' message. 'GPS PRIMARY' indicates both GPS system accuracy and health (RAIM). EPE ('ESTIMATED') includes averaged position accuracy and therefore does not display full GPS system accuracy.

Maximum Lateral and Vertical Deviations for RNAV (RNP) Operations

RNP-based approach operations are normally designed to a lateral containment standard that equals twice the value of the RNP that is published for the procedure. To provide an adequate safety margin to account for path tracking errors, crews are expected to maintain course within 1.0 x RNP. For example, an RNP 0.30 approach will have a total lateral containment limit of 0.60 NM. Pilots are responsible for monitoring crosstrack (XTK) to ensure containment is not exceeded, as no automated exceedance alert is available. Airbus indicates a lateral deviation may first be indicated by displacement of the FD crossbars. If lateral XTK approaches the limit, an immediate correction back to the path is needed. If the deviation reaches the limit, a missed approach is required unless the crew has suitable visual reference to continue to a landing and is aligned with the landing runway. In the event of a missed approach for excessive deviation, the crew must continue to make corrections back to the required course until a safe altitude is reached and/or a new clearance is obtained.

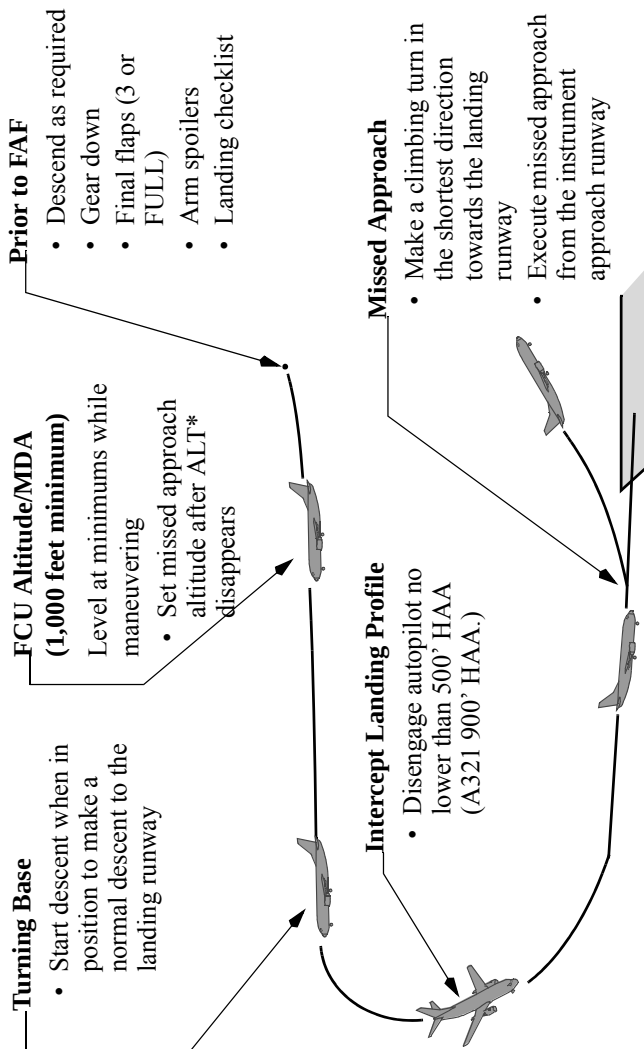
The vertical tolerance for the final approach segment is plus or minus $\frac{3}{4}$ dot or 75 feet. This means that a missed approach must be initiated prior to reaching $\frac{3}{4}$ dot deflection during the segment from the FAF to the MAP. Prior to the FAF, the vertical limit below the path is determined by the minimum altitude at the next (active) waypoint published on the approach chart.



Circling Maneuver

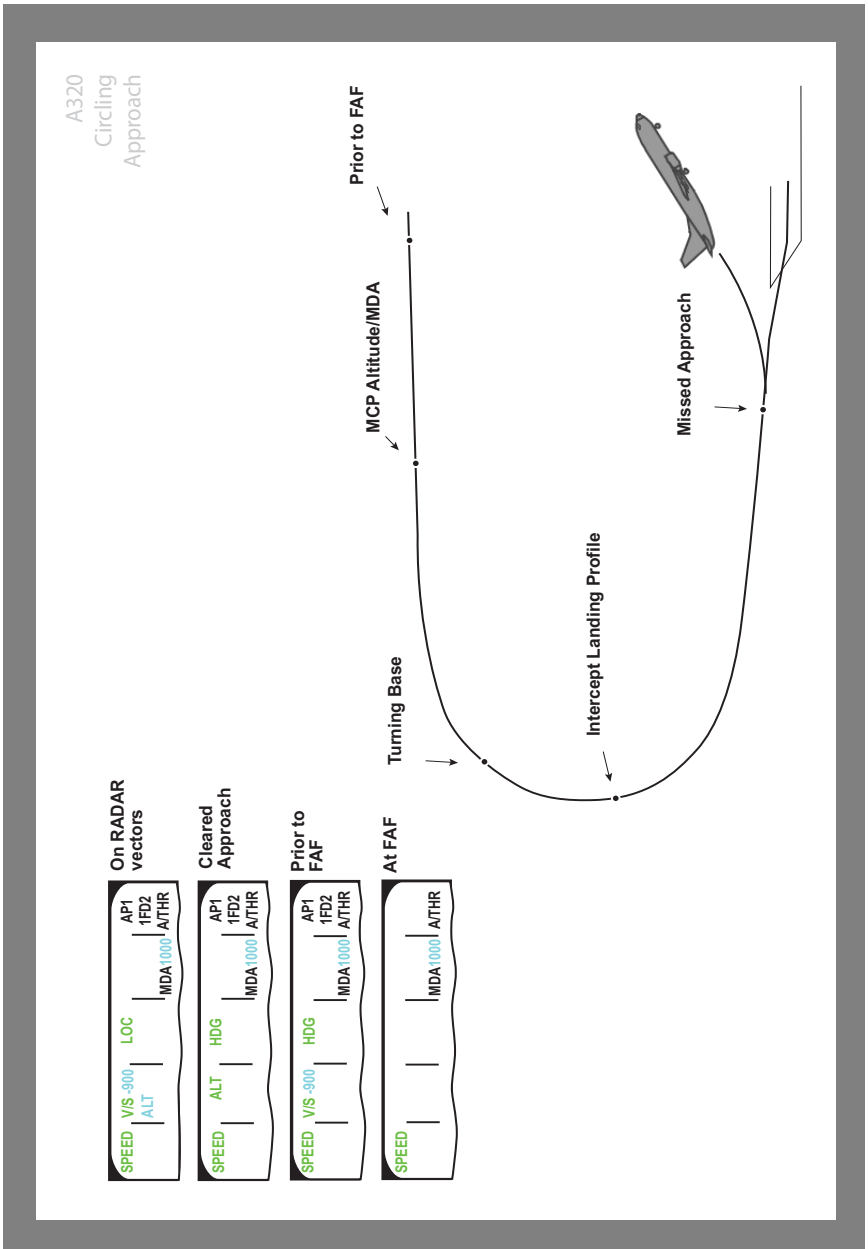
A circling approach may be flown following an instrument approach using APP mode or TRK/FPA provided the FCU altitude is set in accordance with the circling approach procedure.

Circling Maneuver Profile





FMA Progression



Approach Guide

Refer to Vol. 1, NOI.3 for approach guidance.

Circling Maneuver - General

The following guidance supplements normal approach preparations and procedures for the type of approach to be flown.

To minimize challenges of flying cross-cockpit, consider the direction of the circling maneuver when assigning PF duties.

The circling maneuver is flown in the landing configuration with the Landing checklist complete. The circling maneuver is conducted in VFR conditions. Weather requirements are 1,000 foot ceiling and 3 miles visibility or Category D circling minimums, whichever is higher. Use the greater of published circle-to-land MDA or airport elevation plus 1,000 feet as the circling MDA.

The circling maneuver may be flown following any instrument approach procedure.

Approaching the MDA select the V/S zero to level at the MDA.

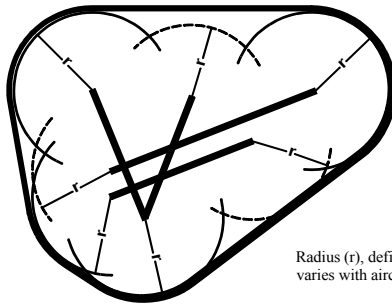
When the runway environment is in sight and ready to begin the circling maneuver, use the HDG knob to maneuver to downwind for the landing runway.

Direct the PM to activate the SEC F-PLN and make the runway the “TO” waypoint. The information displayed on the ND to include the distance to the runway and the cross track error can be used to position the aircraft on a proper downwind, base, and final.

When in a position to make a normal approach to the landing runway, turn toward the runway and begin a descent. The aircraft should be aligned with the runway before reaching 500 feet AGL. The “donut” can be used as a reference to a 3° glide path to the runway. If not following the flight directors, turn both of them off until established on final.

Obstruction Clearance

Obstruction clearance areas during the circling maneuver are depicted in the following figure. Circling approach minimums for both FAA and ICAO criteria are based on obstruction clearance for approach maneuvering within a defined region of airspace. For circling approaches, maximum aircraft speeds are shown on the approach plate instead of aircraft approach categories. Distances are determined by the maximum IAS during the circling maneuver and are depicted in the table following the figure.



Radius (r), defining size of areas, varies with aircraft airspeed.

FAA

Maximum IAS	Circling Area Radius (r) from Threshold	Expanded Circling Area Radius (r) from Threshold
140 knots (Cat C)	1.7 nm	2.7 nm
165 knots (Cat D)	2.3 nm	3.6 nm

ICAO

Maximum IAS	Circling Area Radius (r) from Threshold
180 knots	4.2 nm
205 knots	5.28 nm

Note: Expanded circling radius is indicated by a  in the minima block of the Jeppesen chart.

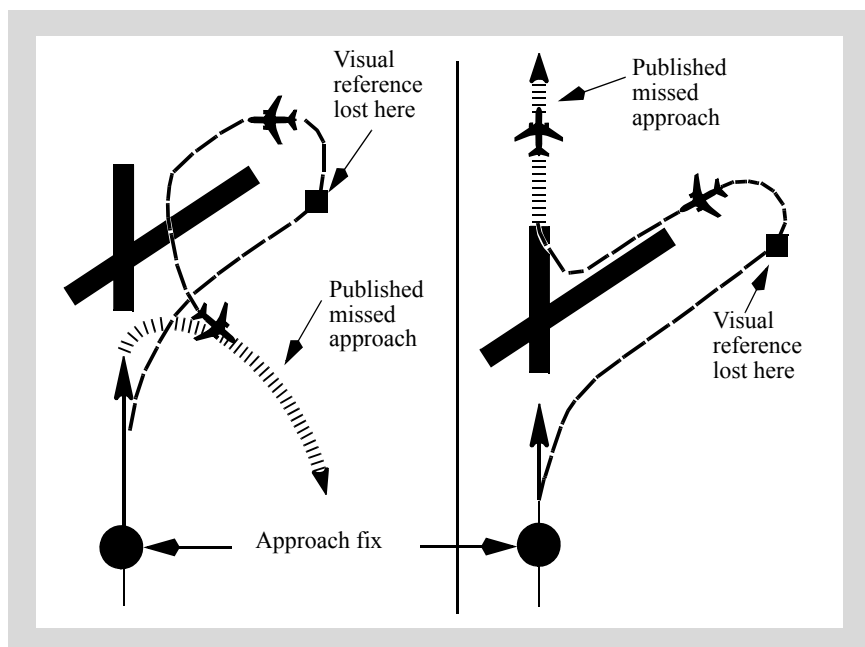
Note: Adjust aircraft heading so the aircraft ground track does not exceed the obstruction clearance distance from the runway at any time during the circling maneuver.

Note: Aircraft maneuvering outside of circling airspace do not have guaranteed obstacle clearance protection.

Missed Approach - Circling

If a missed approach is required at any time while circling, make a climbing turn in the shortest direction toward the landing runway. Continue the turn until established on an intercept heading to the missed approach course corresponding to the instrument approach procedure just flown. This may result in a turn greater than 180° to intercept the missed approach course. Maintain the missed approach flap setting until close-in maneuvering is completed.

Different patterns may be required to become established on the prescribed missed approach course. This depends on aircraft position at the time the missed approach is started. The following figure illustrates the maneuvering that may be required. This ensures the aircraft remains within the circling and missed approach obstruction clearance areas.



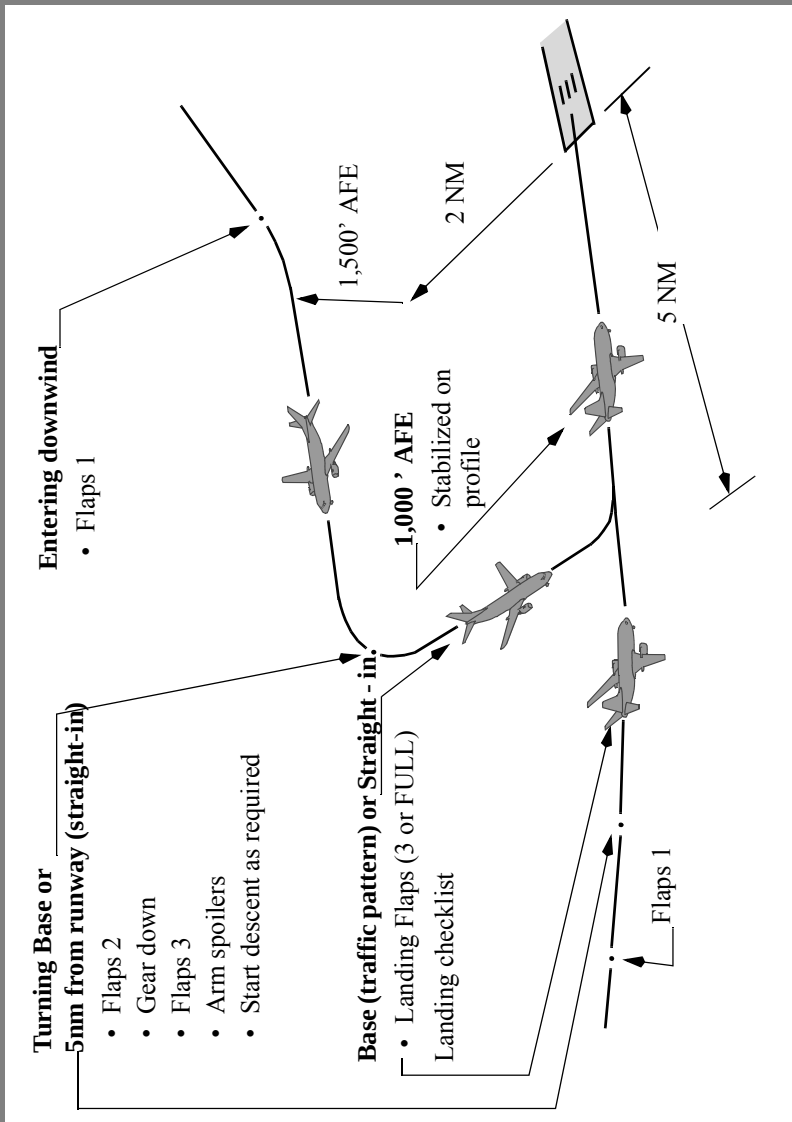
In the event that a missed approach must be accomplished from below the MDA, consideration should be given to selecting a flight path which ensures safe obstacle clearance until reaching an appropriate altitude on the specified missed approach path.

Refer to Go-Around and Missed Approach - All Approaches, this chapter.

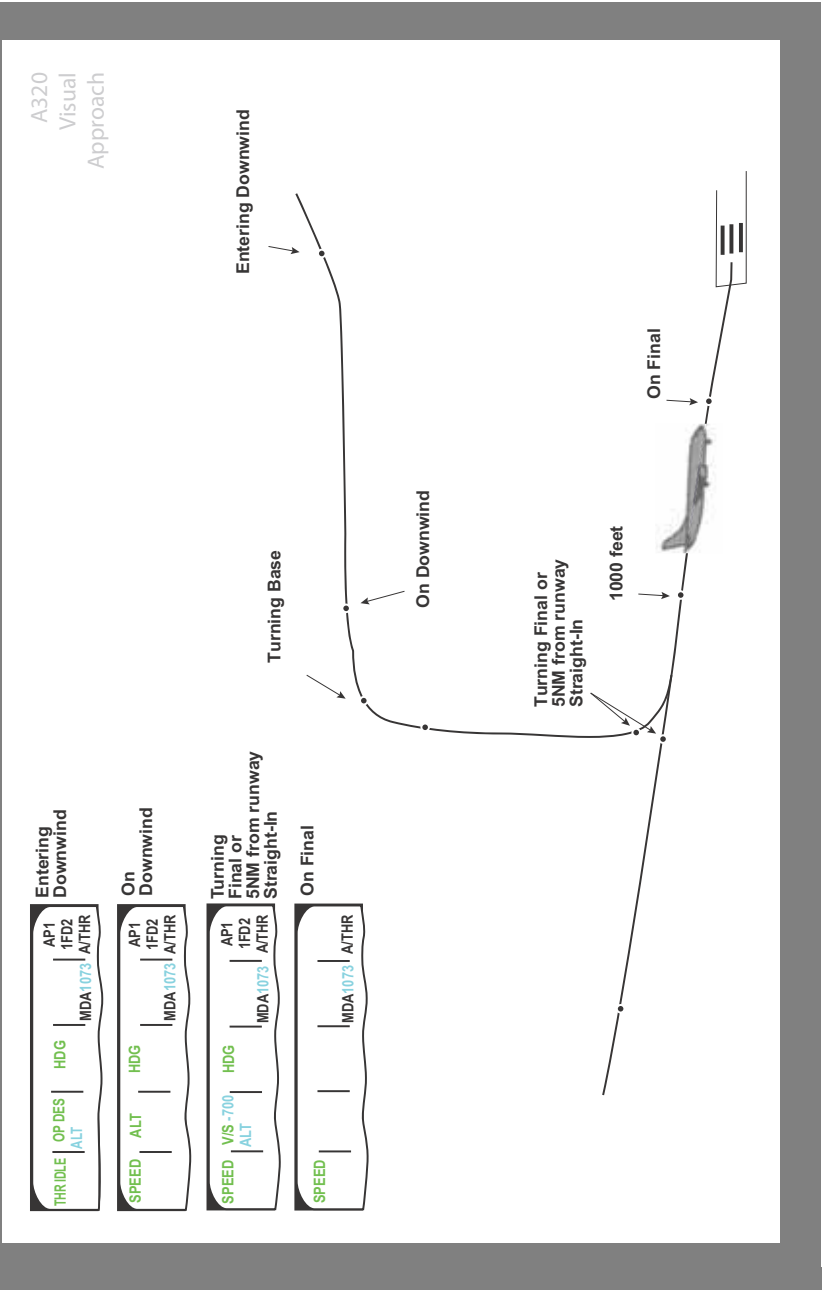


Visual Approach

Visual Approach Profile



FMA Progression





Approach Guide

Refer to Vol. 1, NOI.3 for charted visual approach guidance.

Visual Approach - General

The recommended landing approach path is approximately 3°. Once the final approach is established, the aircraft configuration remains fixed and only small adjustments to the glide path and approach speed are necessary. This results in the same approach profile under all conditions.

Downwind and Base Leg

When entering the traffic pattern, airspeed should be “S” speed, Flaps 1. If a slower speed is required, select Flaps 2 and maintain “F” speed. Turn off the flight directors if not being followed.

If possible, maintain 1,500’ AFE on downwind. Turn base leg so as to have a final of no less than three miles. Begin descent so as to intercept a 3° descent path to the runway. If the downwind leg is extended, maintain 1,500’ AFE until intercepting the 3° descent path, using the 300 feet per mile rule of thumb. If the final approach is five miles long, for example, leave 1,500’ AFE at the point in the base turn that allows the aircraft to rollout on final at 1,500’ AFE.

The landing configuration should normally be established by five miles from touchdown. Unless a long final is anticipated, this may require completing the flaps and gear sequence while in the base turn. If the aircraft does not arrive on final on the desired glide path, make the necessary adjustments back to the profile as early as possible to comply with the stabilized approach criteria.

Internal Visual Cues

Select the ILS or VFR approach to the intended runway. Make the runway (or other appropriate point on final) the active waypoint and set the intercept course. Use the cross track indication to establish the desired downwind leg displacement. Use the glideslope or donut to reference the vertical path to the runway. Reference the RWY symbol on the ND in rose nav mode (10 mile scale) for the turn to base leg. Initiate the turn to final when the cross-track error is approximately 1.5.

Final Approach

Once established on final approach and on glide path, select the flight directors back on and arm the APPR pb and use the ILS for guidance on final if available. If there is no ILS to the runway, visually maneuver to the runway using all available cues (e.g., VASI, PFD, descent path indicator). Turn off the flight directors if not being followed, select FPA if desired.



High Energy Approach

The efficiency of the A319/320/321's wing combined with the autopilot/autothrust relationship make it difficult to “go down” and “slow down” at the same time. To expedite traffic flow, ATC often clears aircraft for a visual approach when the aircraft is high and/or fast in relation to its distance from the airport. There are varying extremes of “slam-dunks” and, therefore, a variety of methods a pilot can employ to successfully execute a stabilized approach.

The technique detailed below is by no means a substitute for adequate planning or lack of situational awareness. In the most extreme “slam-dunk” situations, the best rate of descent (approx. 3,000'/min. and 1,000'/nm) can be achieved with the gear down, flaps 3 (flaps 2 A321), and full speed brakes (autopilot must be off for an A320) at a speed of 170-180 knots with idle thrust. Though the initial portion of this technique is performed with the A/P and F/Ds on, there may be situations where keeping this automation engaged throughout the entire maneuver may not be desirable. In such cases, the pilot may simply continue to the “If a more aggressive descent desired” section.

Assuming the approach phase has been activated, a technique that works well is: “Slow Down ”2” (flaps 2) Go Down.”

Procedure:

- Select 170 KIAS.
- Extend the landing gear at 240 knots or below.
- Set a target altitude (typically FAF altitude, but no lower than 1,500 feet HAT).
- Extend the flaps to 1 & 2 on schedule.
- At 190 (A321 205 knots) knots, pull OP DES.
- Extend the flaps to 3 at 175 knots. (A319/320 only; A321 leave flaps 2).
- Extend speed brakes - FULL (1/2 on A320).
- Maintain VFE -10 knots using SEL SPD.
- Arm the APPR p/b if applicable.

If a more aggressive descent desired (A320 only):

- Disconnect A/P and extend speedbrakes FULL.
- If maneuvering without referencing FD's; command them off and activate managed speed (to keep thrust at idle).
- Descend, at VFE -10 knots (approximately 5° nose down).

Upon intercepting the vertical path:

- Select managed speed.
- Stow the Speed Brakes when extra drag is no longer required. It may be necessary to leave the speed brakes extended until reaching VAPP in order to lose the last 15 knots and achieve the stabilized approach criteria.

**A319/320/321 Flight Crew Training Manual**

-
- Turn on the F/Ds and select the APPR pb (if an instrument approach is available) or select FPA if desired..
 - Ensure landing flaps set.

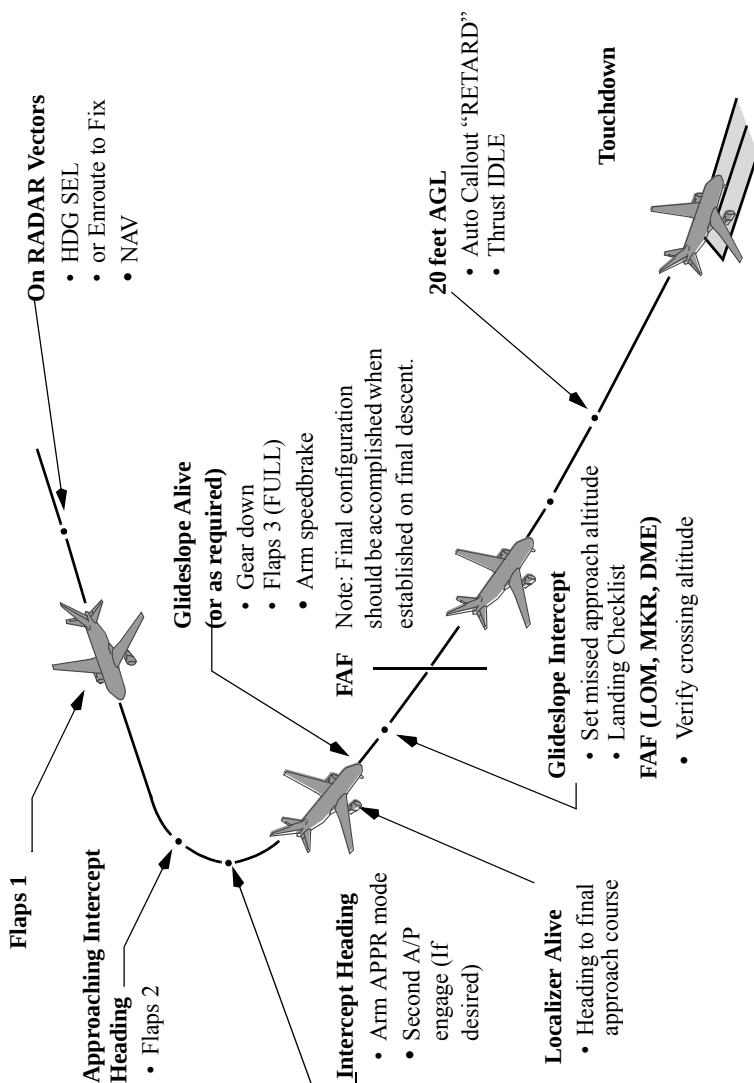
At this point, autothrust will maintain VAPP and the flight directors will be in HDG-V/S until capturing the ILS.

This profile requires approximately 13 nm in a no wind environment to lose 7,000 feet. More specifically:

- Slowing from 250 KIAS to 175 KIAS in level flight at 10,000 feet with landing gear down, full speedbrakes, and extending the flaps to 3 will take approximately 4 nm.
- The descent from 10,000 feet to 3,000 feet at 175 KIAS in Open Descent will result in an average descent rate of 3,000 fpm and will take approximately 8 nm.
- Slowing from 175 KIAS to VAPP in level flight at 3,000 feet with gear down, full speedbrakes, and Flaps FULL will take approximately 1 nm.

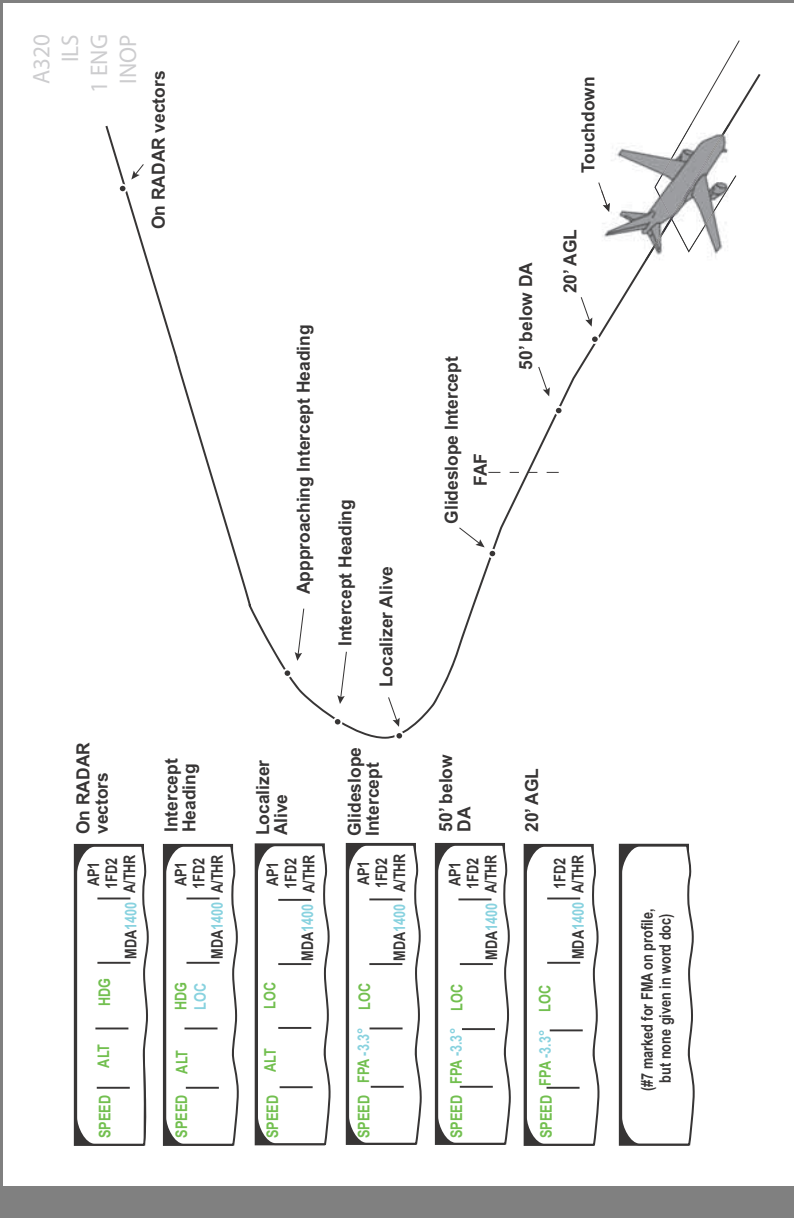
Engine Inoperative Approach Operations

ILS Approach Profile - One Engine Inoperative





FMA Progression



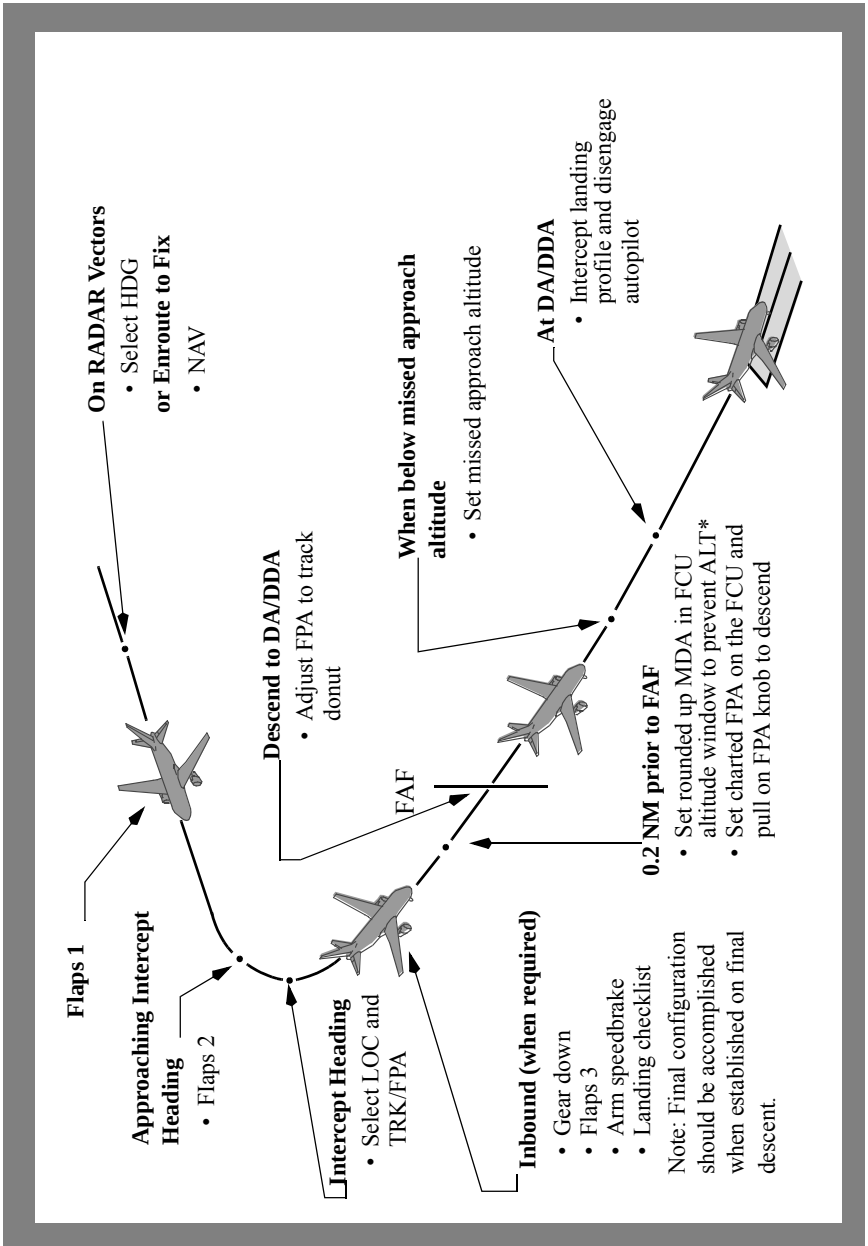


ILS Approach - Engine Inoperative

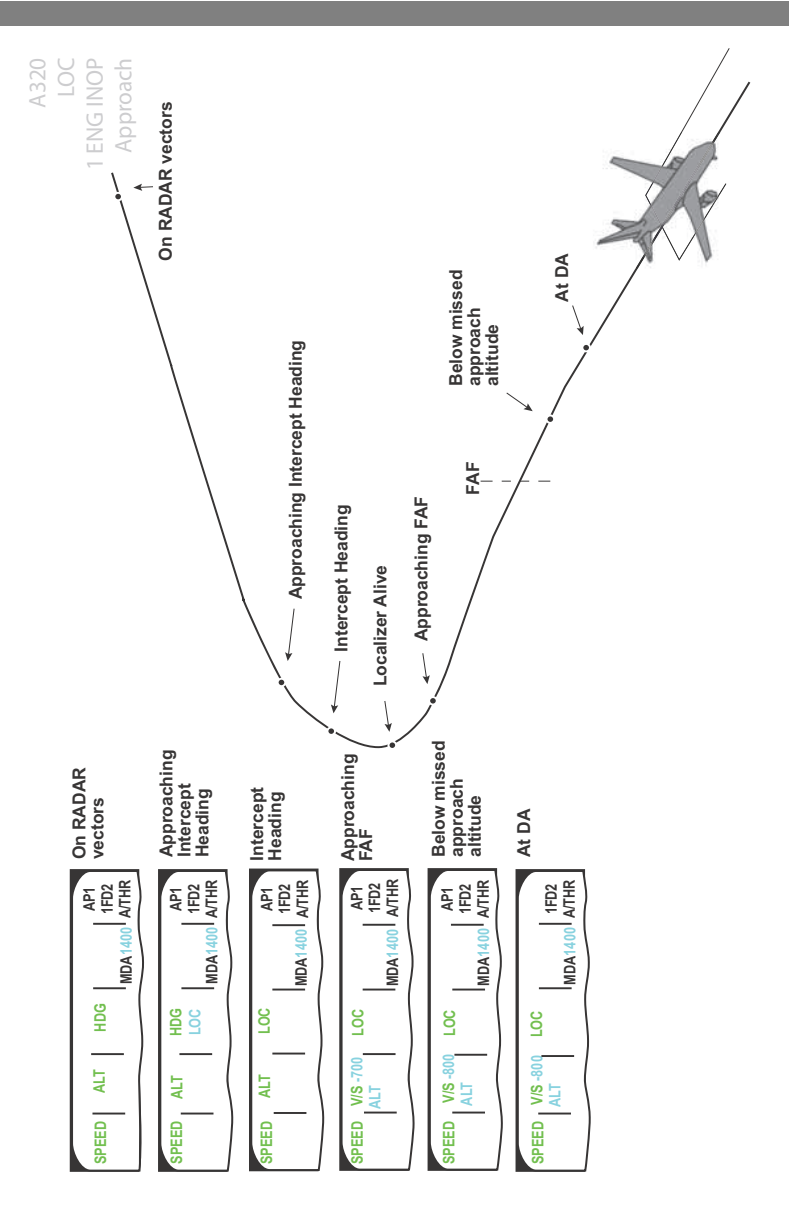
Maneuvering before and after the final approach fix with one engine inoperative is the same as for an all-engine ILS approach, with the exception that the crew should delay final configuration until established on the glide slope for performance reasons. Either Flaps 3 or FULL may be used for landing.



Non-ILS Instrument Approach Profile Using LOC & FPA Mode - One Engine Inoperative



FMA Progression

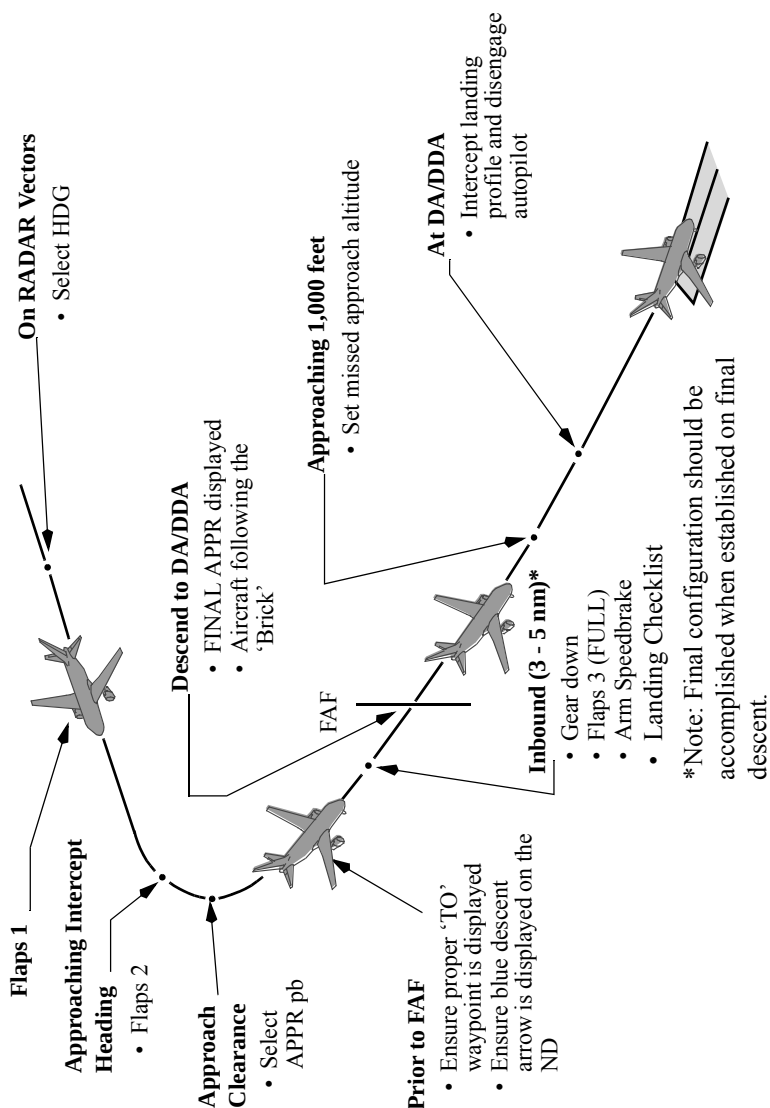




Non-ILS Approach - One Engine Inoperative

Maneuvering before and after the final approach fix with one engine inoperative is the same as for an all engine non-ILS approach, except that the crew should delay final configuration until established on final descent to landing for performance reasons. Either Flaps 3 or FULL may be used for landing.

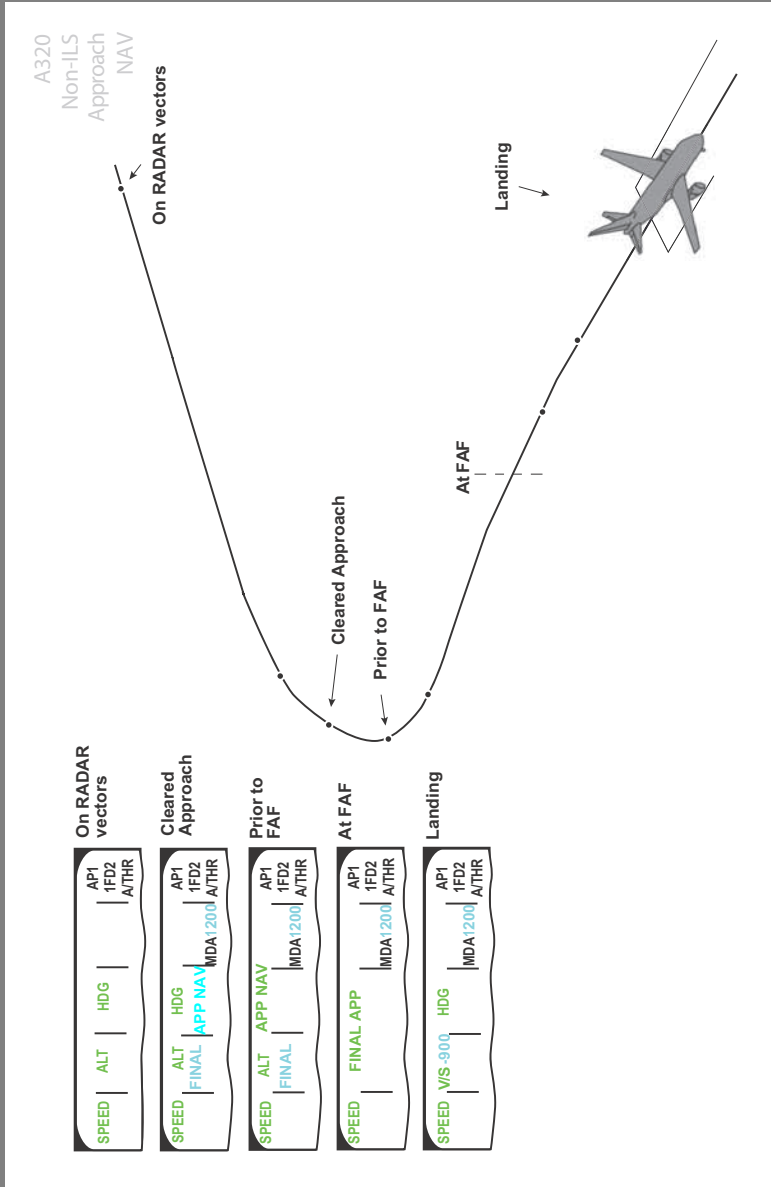
Non-ILS Approach Profile Using Approach Nav Mode - One Engine Inoperative



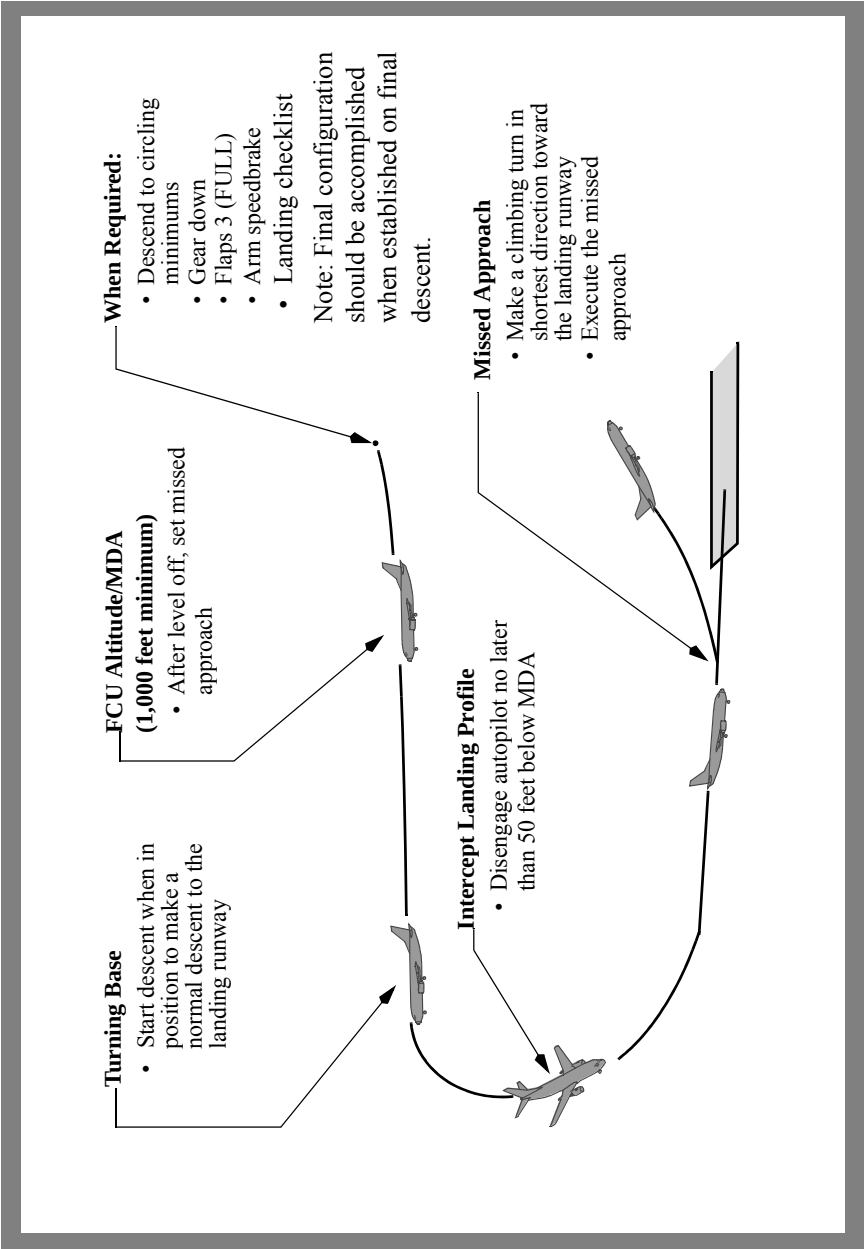


A319/320/321 Flight Crew Training Manual

FMA Progression

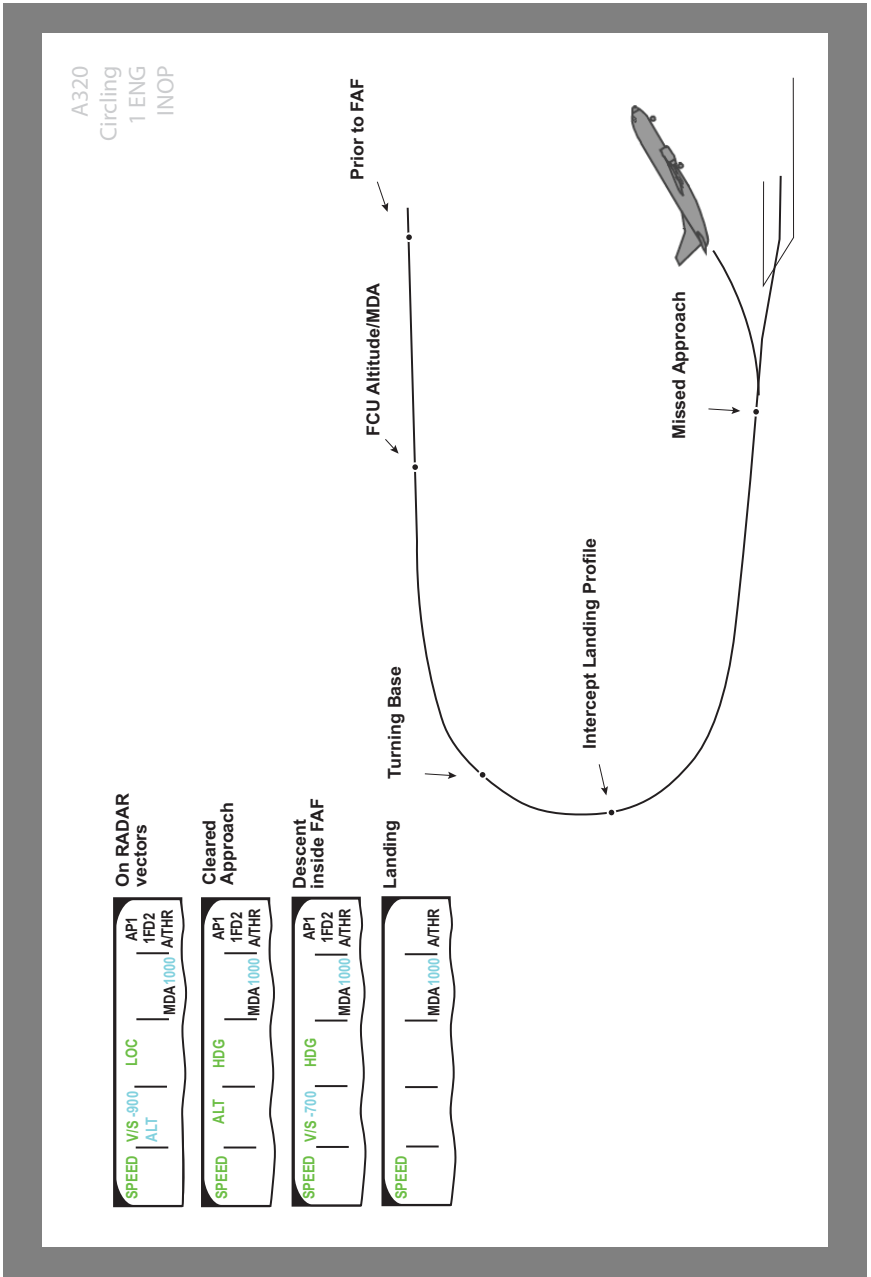


Circling Maneuver Profile - One Engine Inoperative





FMA Progression





Circling Maneuver - One Engine Inoperative

Maneuvering before and after the final approach fix with one engine inoperative is the same as for an all-engine circling maneuver, except the crew should delay final configuration until established on final descent to landing for performance reasons. Either flaps 3 or FULL may be used for landing.

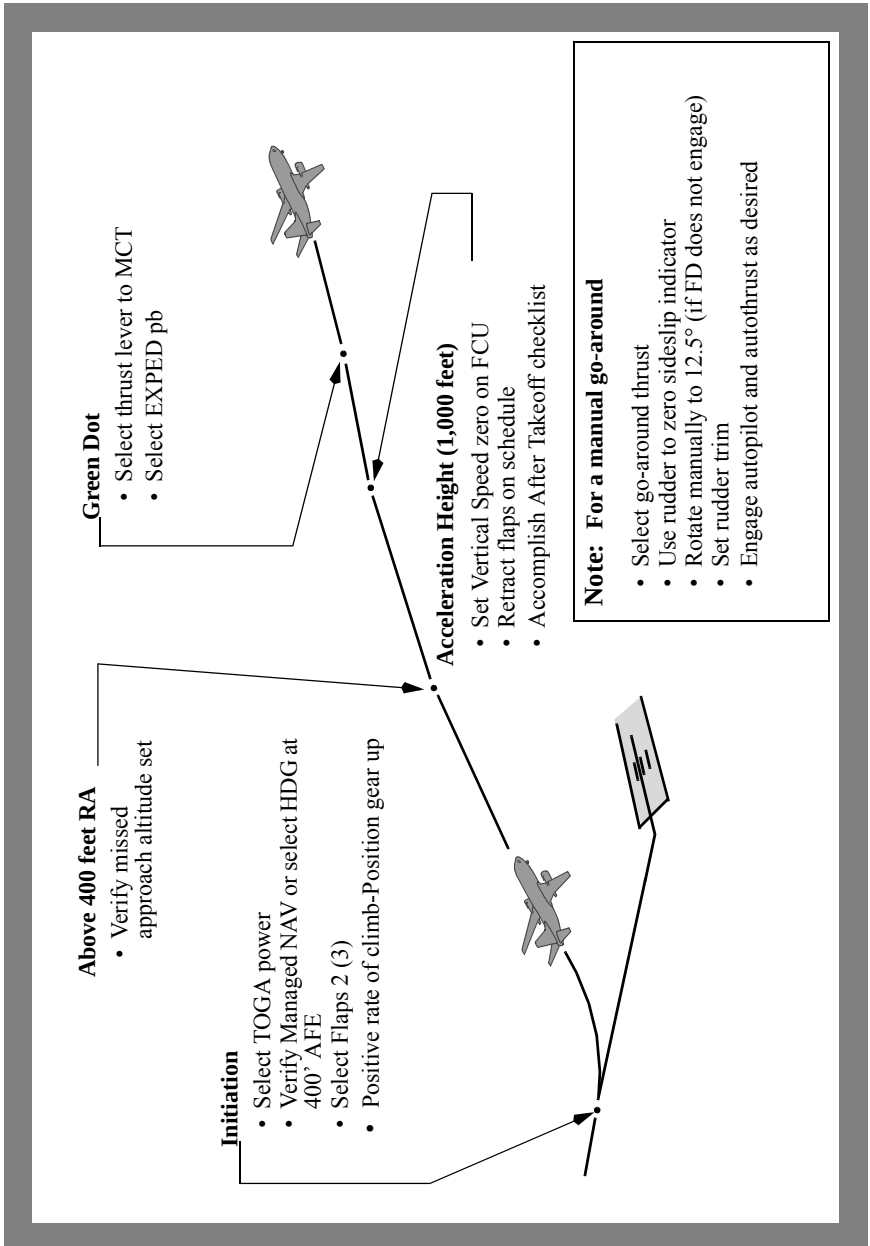
Engine Failure On Final Approach

In the event that an engine should fail while on final approach, the captain must decide either to go-around and assess the situation or to continue the approach and land.

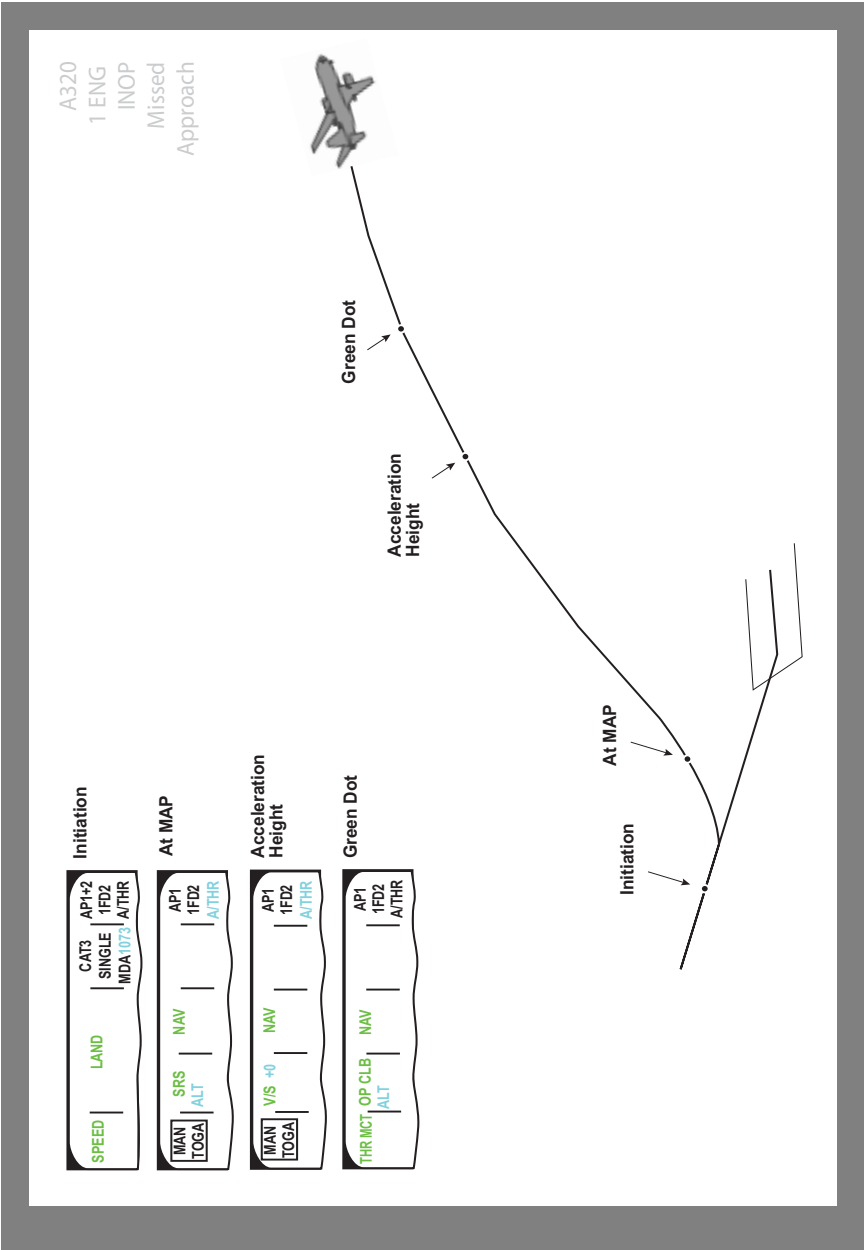
In the event the decision is to continue the approach, the current landing configuration (either Flaps 3 or FULL) can be maintained to touchdown.



Go-Around and Missed Approach Profile - One Engine Inoperative



FMA Progression





Go-Around and Missed Approach - One Engine Inoperative

Should a missed approach be necessary, the following actions are required:

- Any decision to go-around should be made as early and as high as possible.
- Simultaneously advance the thrust lever to the forward limit and rotate to the go-around pitch angle commanded by the flight director. If the flight director is not in use, rotate to 12.5° nose up.
- Call for the flaps to be raised to the appropriate go around setting (Flaps 2 if at Flaps 3 or Flaps 3 if at Flaps FULL).
- When a positive rate of climb is achieved, call for the landing gear to be retracted.

CAUTION: Do not retract the landing gear until there is no chance of main gear touchdown.

- Maintain the target go-around speed. Check the validity of the guidance before relying on SRS commands.
- Request a straight out climb from ATC. If a straight out climb is not available due to traffic or terrain, limit the bank angle to 15° until reaching Green Dot speed.

Note: The flight director will automatically limit the bank angle to maximize aircraft performance.

- Acceleration and flap retraction will be in level flight at 1,000 feet AFE. (If performance allows, cleanup can be accomplished in a slight climb).
- Use normal clean up procedures and accelerate to Green Dot airspeed.
- To climb above 1,000 feet AFE, ensure a higher altitude is in the FCU ALT window and select the EXPED function after selecting the flap handle up.
- Select MCT thrust.

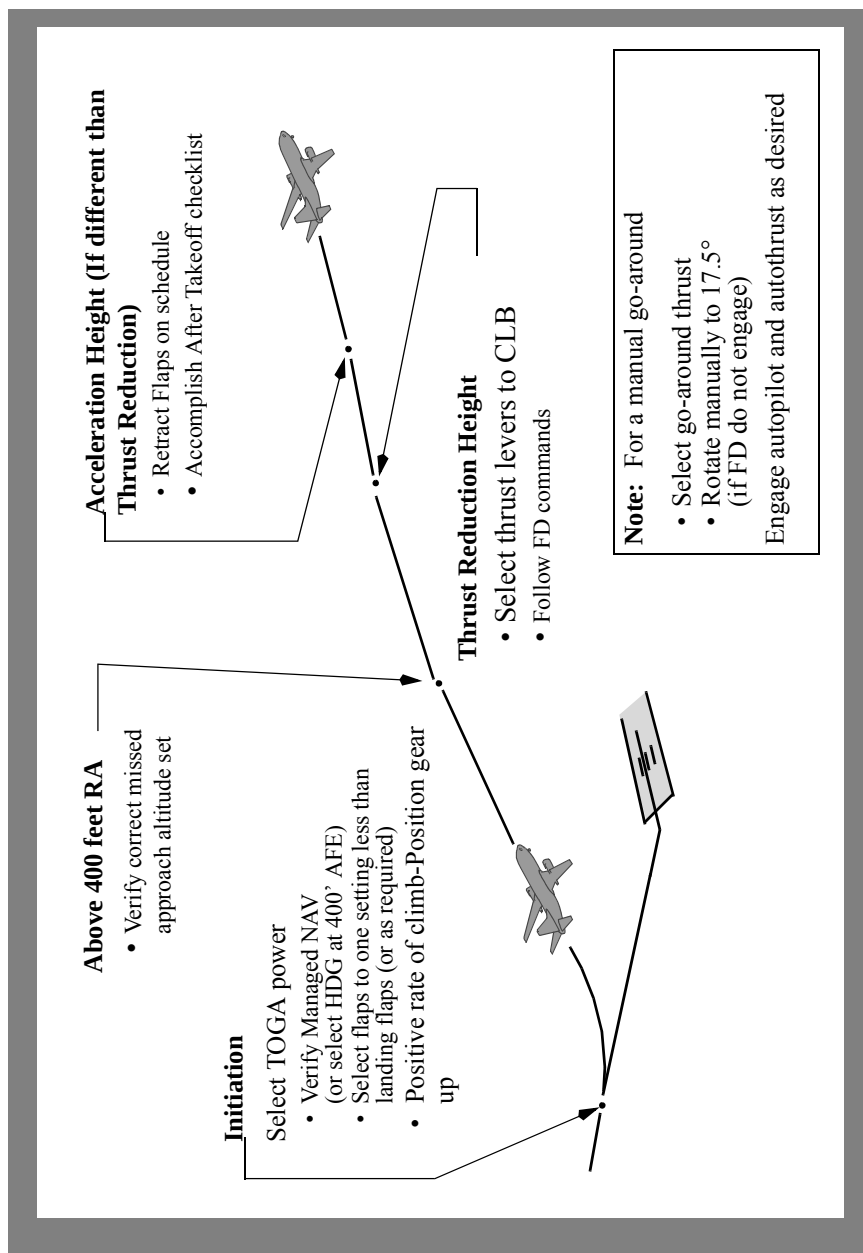
Engine Failure During Go-Around and Missed Approach

If an engine fails during a go-around, the situation should be treated as though it occurred during a takeoff. All procedures are the same as an engine failure on takeoff. To ensure directional control can be maintained, follow flight director guidance to maintain the commanded airspeed.

Note: Quick and simultaneous input of pitch and rudder is key to maintain control of the aircraft.

Go-Around and Missed Approach - All Approaches

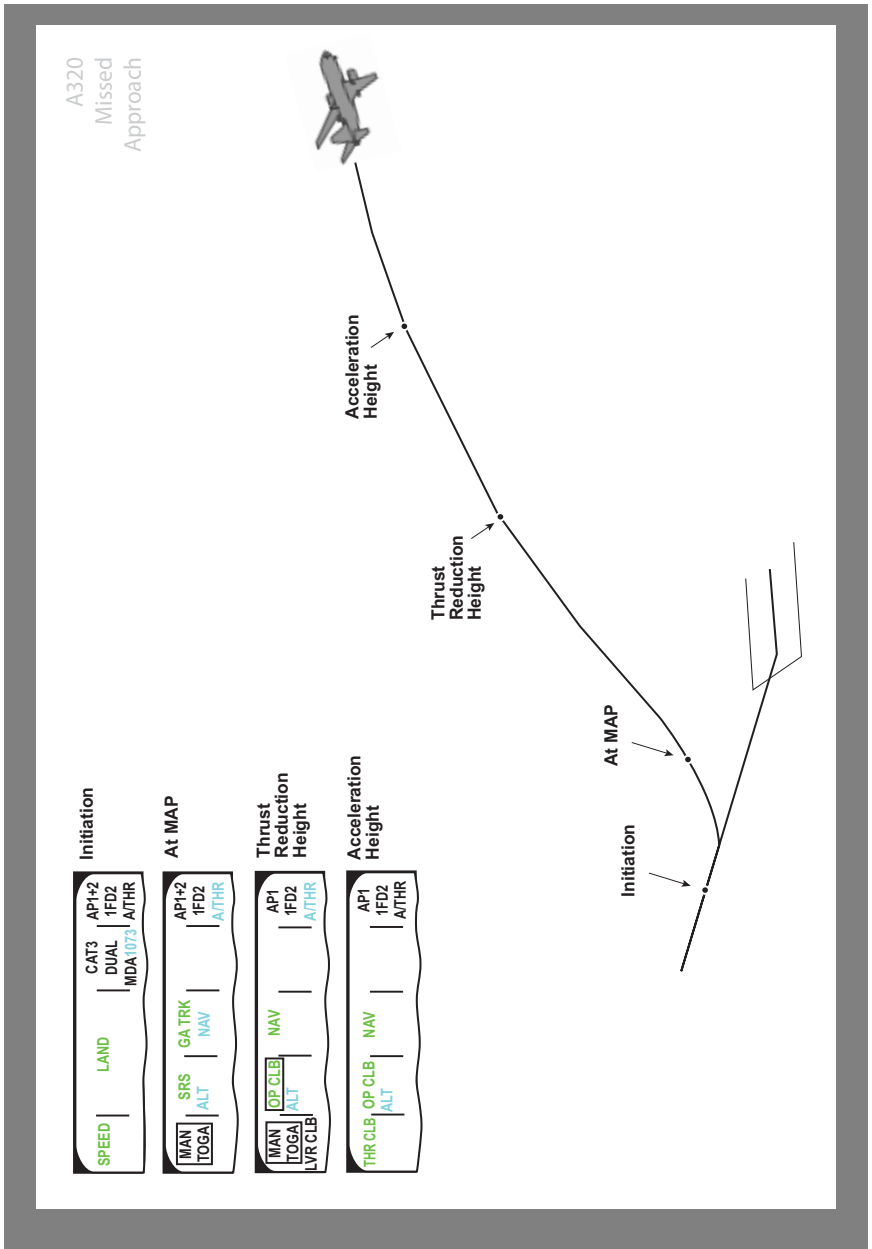
Go-Around and Missed Approach Profile - All Approaches





A319/320/321 Flight Crew Training Manual

FMA Progression



Go-Around and Missed Approach - All Engines Operating

The go-around and missed approach is generally performed in the same manner whether an instrument or visual approach was flown. The go-around and missed approach is flown using the Go-Around and Missed Approach procedure described in the Vol. 1, NP.20, Go-Around procedure. The discussion in this section supplements those procedures.

If a missed approach is required following an autopilot approach, leave the autopilot engaged.

Note: If slats or flaps are not extended and TOGA is selected, the FMS does not transition to the GO AROUND phase. Current lateral and vertical modes remain engaged (e.g., LOC & G/S) and thrust will increase to TOGA.

If a missed approach is required following a manual instrument approach, or a visual approach, follow the Vol. 1, NP.20 procedure and rotate smoothly toward 17° pitch attitude. Then follow flight director commands. If a missed approach is initiated with the autopilot, flight directors or autothrust off, the flight directors will automatically engage in the SRS/NAV mode (GA TRK if FMS missed approach unavailable) at TOGA selection and the autothrust will arm.

During an automatic go-around, if touchdown occurs, the go-around continues. Ensure that the autopilot is engaged and follow the procedure in Vol. 1.

When TOGA is selected:

- The lateral mode reverts to Go-Around Track (as indicated by GA TRK in column 3 of the FMA) with NAV armed. If a missed approach procedure is in the flight plan, NAV engages almost immediately unless heading is selected.
- The missed approach portion of the F-PLN becomes active (missed approach waypoints change from blue to green).
- The runway (or MAP, if the runway is not part of the F-PLN) is converted to an OVERFLY point so that no turns are made if managed nav is active before arriving at the missed approach point.
- The previous approach is automatically re-inserted into the F-PLN after the current missed approach procedure.

Note: FMS altitude constraints are not honored during the GO-AROUND phase. Conditional waypoints (e.g., “at 2800 turn left direct ABC”) are honored during the go-around phase.

The minimum altitude for flap retraction during a normal takeoff is not normally applicable to a missed approach procedure. However, obstacles in the missed approach flight path must be taken into consideration. Use 1,000 feet AGL to initiate acceleration for flap retraction. The target speed during SRS is VAPP or current speed, whichever is higher, and remains a managed speed. It is not possible to select a speed while in SRS.

**A319/320/321 Flight Crew Training Manual**

SRS remains active until the acceleration altitude or selection of a different pitch mode, at which time CLB or OP CLB engages and the target speed becomes Green Dot, permitting flap retraction as the aircraft accelerates through F and S speeds.

Note: If both APs were engaged at the time of the go-around, AP2 will disengage when the GA TRK mode is replaced by another lateral mode.

Note: FMS altitude constraints are not honored during the go-around phase. For example, if there is an altitude restriction associated with a missed approach waypoint, the aircraft will climb to the FCU altitude and ignore the altitude constraint in the MCDU. Instead, the FCU must be set to the constraint altitude until passing the waypoint. Conditional waypoints (e.g., “at 2800 turn left direct ABC”) are honored during the go-around phase.

Note: When rejecting a landing past the published missed approach point, pilots must be aware of any published special departure procedure for terrain clearance. Refer to the AM, Ops specs, Departure/Missed Approach/Rejected Landing Priorities and the Delta Special Pages (green pages).



Go-Around Maneuver - All Engine Operating

Pilot Flying	Pilot Monitoring
When a go-around is initiated:	
Select TO/GA thrust and verbalize "GO AROUND" - For a manual go-around: - rotate manually; follow the flight director - engage autopilot as needed - Assure go-around thrust	- Verify FMA pitch, roll, and AT. Verbalize pitch mode "SRS VERIFIED" - Verbalize FMA annunciations other than [GA - Input actual FMA] and callout any omissions - Assure go-around thrust
Verify: - rotation to SRS Pitch Command, - thrust setting, and - proper mode annunciation.	
Call "FLAPS 3(2)."	Set the FLAP lever as directed
	Monitor rotation, pitch and vertical speed Verify a positive rate of climb and announce "POSITIVE RATE"
Confirm a positive rate of climb on the altimeter and call "GEAR UP"	Position the landing gear lever to UP
	Verify missed approach altitude is set
Above 400 feet RA:	
Verify or call for NAV/HDG and verify FMA change*	Select or verify lateral mode*
When LVR CLB appears in column 1 of the FMA:	
Select CL thrust detent.	
At acceleration altitude:	
Call "FLAPS ____" according to the flap retraction schedule.	Set the FLAP lever as directed.



A319/320/321 Flight Crew Training Manual

Pilot Flying	Pilot Monitoring
If another approach is warranted at the destination airport:	
Select flaps to maintain appropriate maneuvering speed.	
When at the planned flap configuration:	
Call “AFTER TAKEOFF CHECKLIST.”	Accomplish the After Takeoff checklist.
	Call out any trend toward terrain contact, descending flight path, or significant airspeed changes.

**Go-Around Not Requiring a Climb
(Approach Cancellation Prior to Descent)**

At times, ATC may direct a missed approach that does not require a climb. In this case, DO NOT select the TOGA detent. Selecting TOGA with the flaps extended will initiate an unwanted climb using the SRS pitch mode.

To perform a missed approach when a climb is not required, simply use the FCU to manage the aircraft (e.g., select an appropriate speed, heading, etc.).

Since TOGA is not used, the FMS phase of flight remains in APPROACH.

Depending on the subsequent track of the aircraft, the MCDU F-PLN may completely sequence. In this case, the pilot must re-enter a destination and re-insert the desired approach.



Go-Around from an Altitude Above the Acceleration Height

This maneuver can be challenging and disorienting because a light weight aircraft climbs rapidly at TOGA thrust and not as much climb is required due to the missed approach being initiated at a higher altitude than normal. Use caution not to overspeed the landing gear and flaps or overshoot the MAP altitude.

If the missed approach is initiated at an altitude above the DA/MDA, but below the missed approach altitude:

- Select TOGA thrust. The amount of time at TOGA thrust will depend upon the aircraft weight and the amount of climb required to reach the missed approach altitude.

Note: The selection of TOGA, even momentarily, is important because it engages the FMS go-around phase, automatically re-enters the selected approach into the flight plan, prevents the FMS from erasing the destination airport when overflowed, engages the SRS vertical mode (which commands the appropriate airspeed for initial climb out and acceleration), and automatically arms autothrust if it was off.

- Place the thrust levers in the CL detent as required.
- Accomplish the rest of the missed approach procedure as previously described.

Go-Around from an Altitude Below the Acceleration Height

Should a go-around be initiated below the acceleration height, use normal go-around procedures.

Low Altitude Level Off - Low Gross Weight

When accomplishing a low altitude level off following a go-around at a low gross weight, the crew should consider the following factors:

- If full go-around thrust is used, altitude capture can occur just after the go-around is initiated due to the proximity of the level off altitude and the high climb rate of the aircraft.
- The flight control laws limit F/D and autopilot pitch commands for passenger comfort.
- There may not be enough altitude below the intended level-off altitude to complete the normal capture profile and an overshoot may occur unless crew action is taken.



Go-Around after Touchdown

WARNING: After reverse thrust is initiated, a full stop must be made.

If a go-around is initiated before touchdown and touchdown occurs, continue with normal go-around procedures. The F/D go-around mode will continue to provide go-around guidance commands throughout the maneuver.

If a go-around is initiated after touchdown but before thrust reverser selection, auto speedbrakes retract as thrust levers are advanced.

Once reverse thrust is initiated following touchdown, a full stop landing must be made. If an engine stays in reverse, safe flight is not possible.



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Landing**Table of Contents****Chapter 6****Section TOC**

Visual Approach Slope Indicator (VASI, and T-VASI)	6.1
Three Bar VASI, and T-VASI	6.2
VASI Landing Geometry	6.2
Precision Approach Path Indicator	6.6
PAPI Landing Geometry	6.6
Landing Geometry	6.7
Visual Aim Point	6.7
Runway Markings (Typical)	6.7
Threshold Height	6.9
Tail Strike	6.10
Landing Risk Factors	6.10
Flare and Touchdown	6.12
Airspeed Control	6.13
Landing Flare Profile	6.13
Pitch and Roll Limit Conditions	6.14
Bounced Landing Recovery	6.17
Rejected Landing	6.17
Landing Roll	6.18
Speedbrakes	6.19
Directional Control and Braking during Landing Roll	6.19
Factors Affecting Landing Distance	6.19
Wheel Brakes	6.21
Reverse Thrust Operation	6.25
Crosswind Landings	6.28
Landing Crosswind Guidelines	6.28



Crosswind Landing Techniques.	6.28
Overweight Landing	6.29
Overweight - General.	6.29
Overweight Autolands	6.30

Visual Approach Slope Indicator (VASI, and T-VASI)

The VASI is a system of lights arranged to provide visual descent guidance information during the approach. All VASI systems are visual projections of the approach path normally aligned to intersect the runway at a point 1,000 or 1,800 feet beyond the threshold. Flying the VASI glide slope to touchdown is the same as selecting a visual aim point on the runway adjacent to the VASI installation.

When using a two-bar VASI, the difference between the eye reference path and the gear path results in a normal approach and threshold height. It provides useful information in alerting the crew to low profile situations.

Some airports have three-bar VASI which provides two visual glide paths. The additional light bar is located upwind from a standard two-bar installation. When the aircraft is on the glide path, the pilot sees the two red bars over one white bar. Three-bar VASI may be safely used with respect to threshold height, but may result in landing further down the runway.

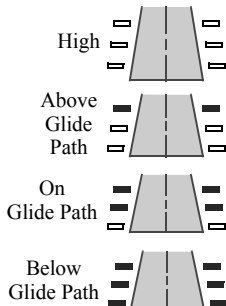
For a T-VASI, flying the approach with one additional white fly down light visible provides additional wheel clearance.

Three Bar VASI, and T-VASI

Visual Approach Slope Indicator (VASI)

■ Red VASI Lights
□ White VASI Lights

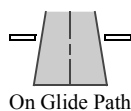
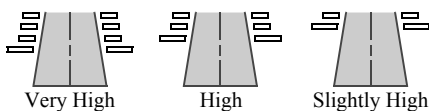
Standard (3-bar)



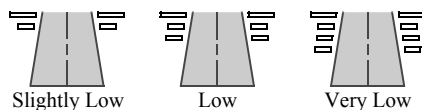
Visual Approach Slope Indicator (T-VASI)

■ Red T-VASI Lights
□ White T-VASI Lights

Fly Down Lights



Fly Up Lights



VASI Landing Geometry

Two-bar VASI installations provide one visual glide path which is normally set at 3° . Three-bar VASI installations provide two visual glide paths. The lower glide path is provided by the near and middle bars and is normally set at 3° while the upper glide path, provided by the middle and far bars, is normally $1/4^\circ$ higher (3.25°). This higher glide path is intended for use only by high cockpit (long wheelbase) aircraft to provide a sufficient threshold crossing height.

Two Bar/Three Bar VASI Landing Geometry

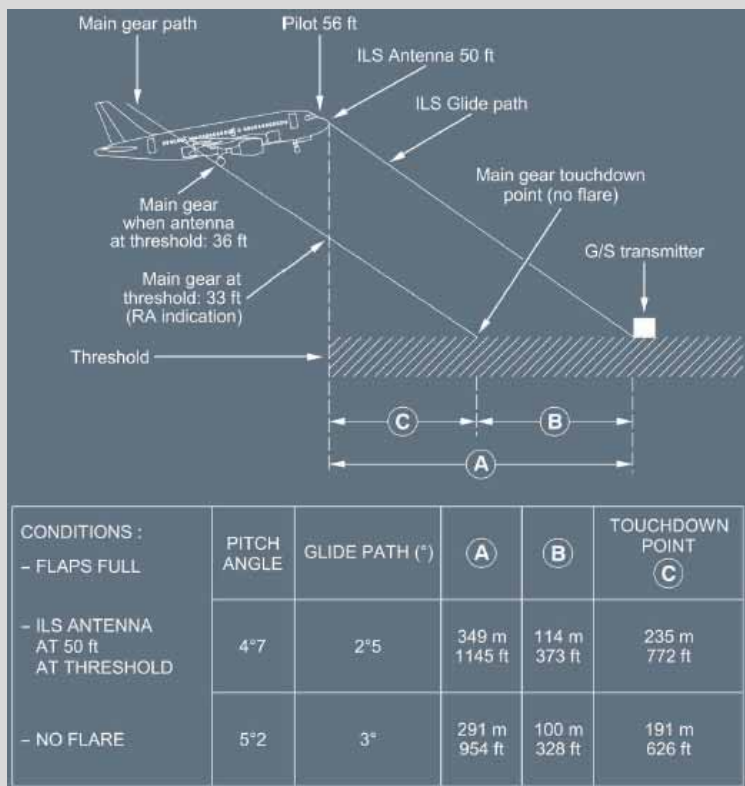
The following diagrams use these conditions:

- data is based upon typical landing weight
- pilot eye height is measured when the main gear is over the threshold.



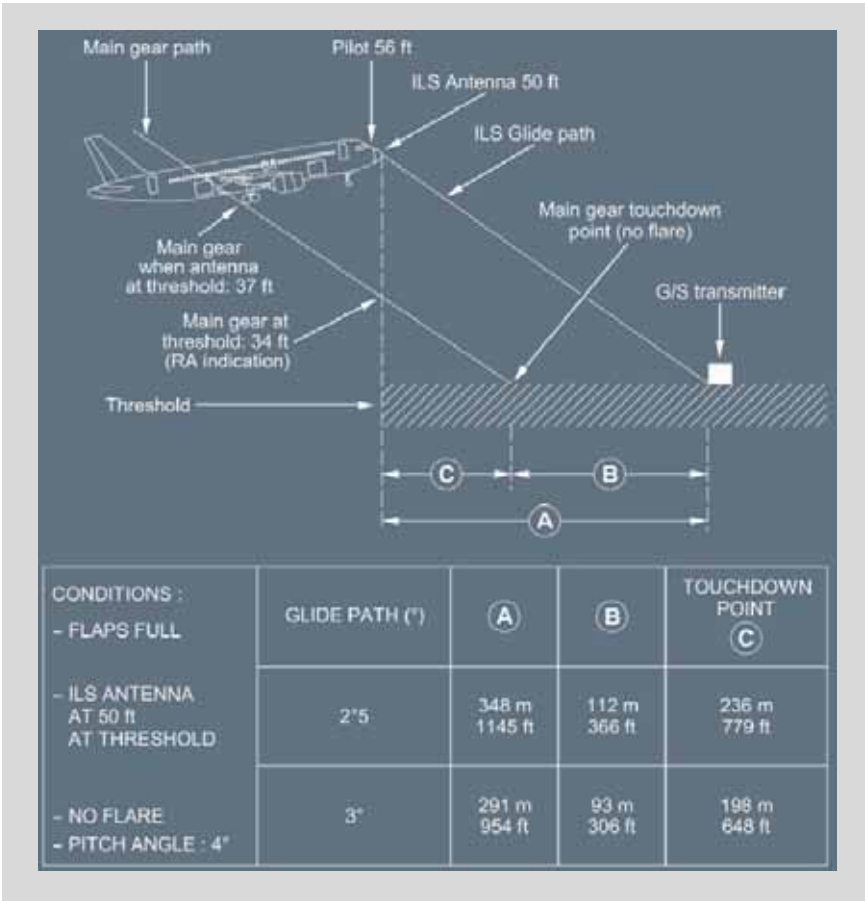
A319/320/321 Flight Crew Training Manual

A319



A319 Model	Flaps Full		Main Gear over Threshold		Threshold to Main Gear Touchdown Point-No Flare (feet)
	Visual Glide Path (degrees)	Aircraft Body Attitude (degrees)	Pilot Eye Height (feet)	Main Gear Height (feet)	
	3.0	5.2	56	36	626

A320

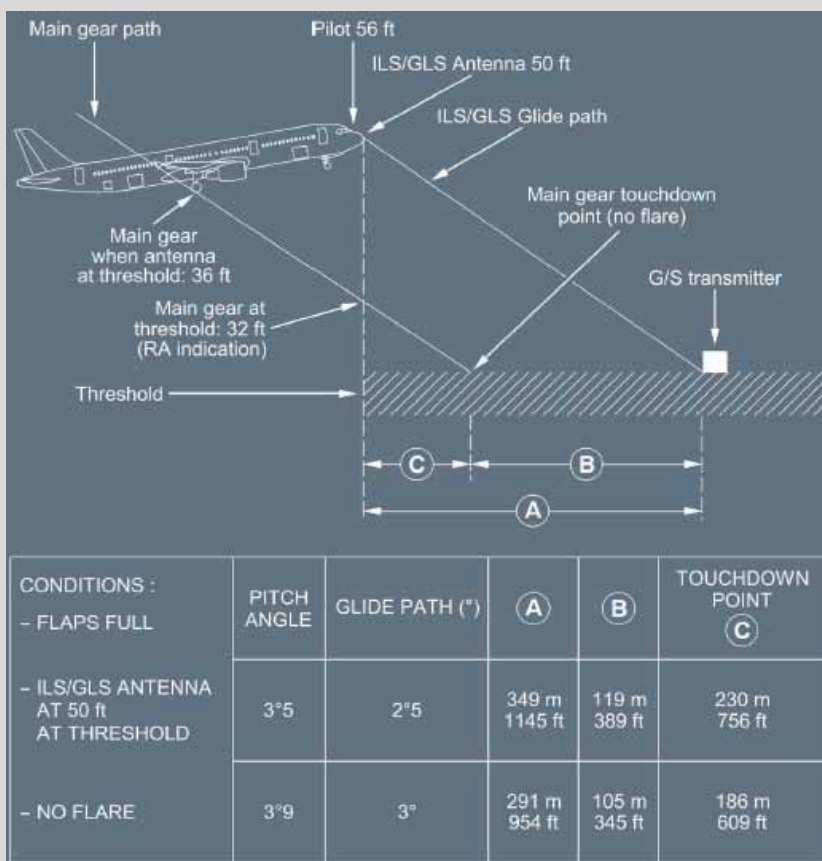


A320 Model	Flaps Full		Main Gear over Threshold		Threshold to Main Gear Touchdown Point-No Flare (feet)
	Visual Glide Path (degrees)	Aircraft Body Attitude (degrees)	Pilot Eye Height (feet)	Main Gear Height (feet)	
	3.0	4.0	56	37	648



A319/320/321 Flight Crew Training Manual

A321



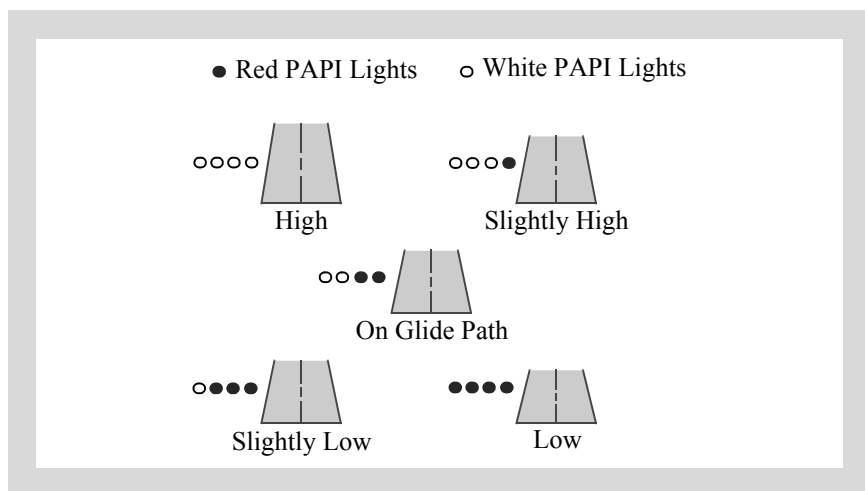
A321 Model	Flaps Full		Main Gear over Threshold		Threshold to Main Gear Touchdown Point-No Flare (feet)
	Visual Glide Path (degrees)	Aircraft Body Attitude (degrees)	Pilot Eye Height (feet)	Main Gear Height (feet)	
	3.0	3.9	56	36	609

Precision Approach Path Indicator

The Precision Approach Path Indicator (PAPI) uses lights which are normally on the left side of the runway. They are similar to the VASI, but are installed in a single row of light units.

When the aircraft is on a normal 3° glide path, the pilot sees two white lights on the left and two red lights on the right. The PAPI may be safely used with respect to threshold height, but may result in landing further down the runway. The PAPI is normally aligned to intersect the runway 1,000 to 1,500 feet beyond the threshold.

PAPI Landing Geometry





Landing Geometry

Visual Aim Point

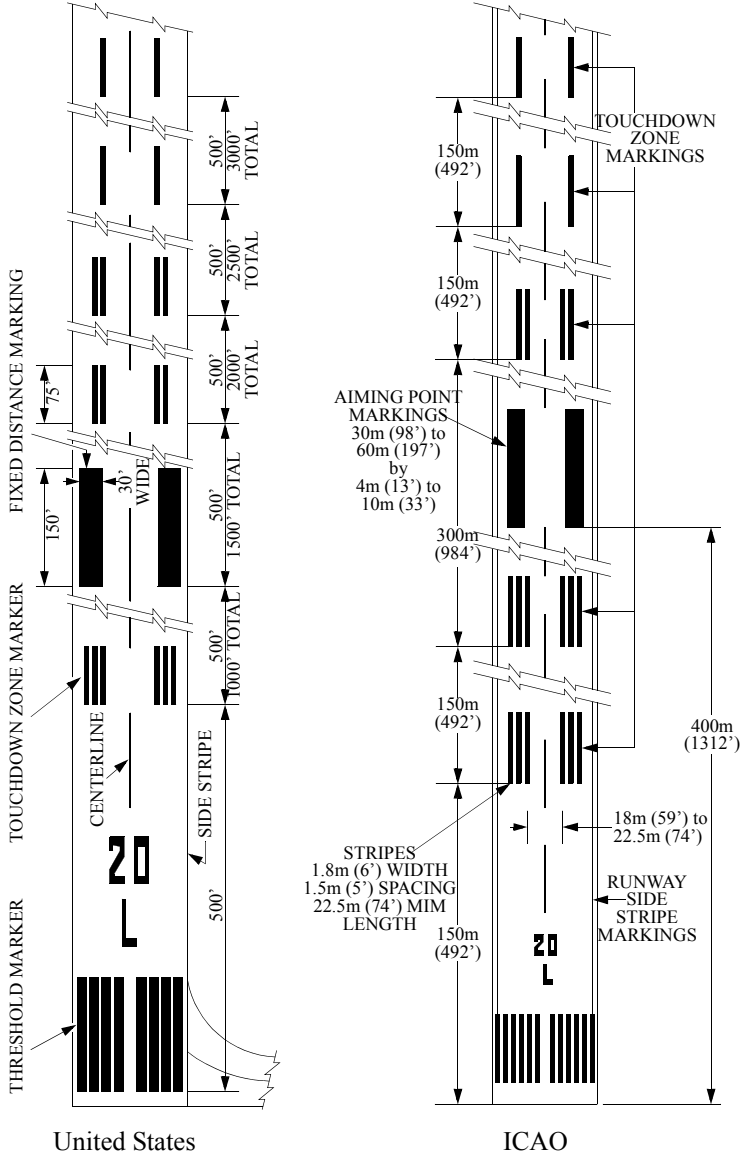
During visual approaches many techniques and methods are used to ensure main landing gear touchdown at the desired point on the runway. One of the most common methods used is to aim at the desired gear touchdown point on the runway, then adjust the final approach glide path until the selected point appears stationary in relation to the aircraft (the point does not move up or down in the pilot's field of view during the approach).

This method is acceptable in smaller aircraft because of the small difference between landing gear path and eye level path. Flare distance accounts for the small difference in paths. Gear touchdown occurs very near the visual aim point. However, in larger airplanes, the difference in gear path and eye-level path has increased because of the longer wheelbase and the increased flight deck height. Consequently, the main gear do not touch down on the runway at the selected visual aim point.

The gear touchdown point versus the visual aim point varies with the angle of the approach. For example on a low angle or flat approach, the gear will touch down much closer to the approach end of the runway given the same visual aim point on the runway. This difference between gear path and eye level path must be accounted for by the pilot.

Runway Markings (Typical)

The following runway markings are for runways served by a precision approach.





Threshold Height

Threshold height is a function of glide path angle and landing gear touchdown target. Threshold height for main gear and pilot eye level is shown in the Two Bar/Three Bar VASI Landing Geometry tables in this chapter. Special attention must be given to establishing a final approach that assures safe threshold clearance and gear touchdown at least 1,000 feet down the runway. If automatic callouts are not available, the radio altimeter should be used to assist the pilot in judging terrain clearance, threshold height, and flare initiation height.

Tail Strike

Tail strike occurs when the lower aft fuselage contacts the runway during takeoff or landing. A significant factor that appears to be common is the lack of flight crew experience in the model being flown. Understanding the factors that contribute to a tail strike can reduce the possibility of a tail strike occurrence.

Note: Any time fuselage contact is suspected or known to have occurred, accomplish the appropriate NNC.

Landing Risk Factors

A tail strike on landing tends to cause more serious damage than the same event during takeoff and is usually more expensive and time consuming to repair. The risk of tailstrike on landing is twice that during takeoff. In the worst case, the tail can strike the runway before the landing gear, thus absorbing large amounts of energy for which it is not designed. The aft pressure bulkhead is often damaged as a result.

Any one of the following landing risk factors may precede a tail strike:

Unstabilized Approach

An unstabilized approach is the biggest single cause of tail strike. Flight crews will comply with the stabilized approach criteria or a go-around should be conducted.

Flight recorder data show that flight crews who continue with an unstabilized condition below 500 feet seldom stabilize the approach. When the airplane arrives in the flare, it often has either excessive or insufficient airspeed. The result is a tendency toward large thrust and pitch corrections in the flare, often culminating in a vigorous pitch change at touchdown resulting in tail strike shortly thereafter. If the pitch is increased rapidly when touchdown occurs as ground spoilers deploy, the spoilers add additional nose up pitch force, reducing pitch authority, which increases the possibility of tail strike. If the airplane is slow, increasing the pitch attitude in the flare does not effectively reduce the sink rate, and in some cases may increase it.

A firm touchdown on the main gear is often preferable to a soft touchdown with the nose rising rapidly. Refer to Bounced Landing Recovery, this chapter.



Holding Off in the Flare

The second most common cause of a landing tail strike is an extended flare, with a loss in airspeed that results in a rapid loss of altitude, (a dropped-in touchdown). This can also be caused by flaring high. This condition is often precipitated by a desire to achieve an extremely smooth/soft landing. A very smooth/soft touchdown is not essential, nor even desired, particularly if the runway is wet. During the flare, the pilot should not concentrate on airspeed, but on aircraft attitude using external cues. Do not allow the pitch angle to exceed 10° during the flare and landing.

Mishandling of Crosswinds

The combined effects of high closure rate, shifting winds with the potential for a quartering tail wind, can result in a sudden drop in wind velocity commonly found below 100 feet. Combining this with turbulence can make the timing of the flare very difficult. The pilot flying can best handle the situation by using an appropriate pitch change to keep the descent rate stable until initiation of the flare. Flight crews should clearly understand the criteria for initiating a go-around and plan to use this avoidance maneuver when needed.

Over-Rotation during Go-Around

Go-arounds initiated very late in the approach, such as during the landing flare or after touching down, are a common cause of tail strikes. Another contributing factor in tail strikes may be a strong desire by the flight crew to avoid landing gear contact after initiating a late go-around when the airplane is still over the runway. In general, this concern is not warranted because a brief landing gear touchdown during a late go-around is acceptable. This had been demonstrated during autoland and go-around certification programs.

Flare and Touchdown

The techniques discussed here are applicable to all landings including one engine inoperative landings, crosswind landings, and landings on slippery runways. Unless an unexpected or sudden event occurs, such as windshear or collision avoidance situation, it is not appropriate to use sudden, violent, or abrupt control inputs during landing. Begin with a stabilized approach on speed, on glide path.

Note: When a manual landing is planned from an approach with the autopilot connected, the transition to manual flight should be planned early enough to allow the pilot time to establish aircraft control before beginning the flare. The PF should consider disengaging the autopilot and disconnecting the autothrust no later than 1 to 2 nm before the threshold, or approximately 300 to 600 feet above field elevation.

When the threshold passes under the aircraft nose and out of sight, shift the visual sighting point to the far end of the runway. Shifting the visual sighting point assists in controlling the pitch attitude during the flare. Maintaining a constant airspeed and descent rate assists in determining the flare point.

The flight control law changes to the landing mode at 50 feet RA. Below 30 feet, the flight control system blends in a nose down command which helps the pilot to “feel” the flare. Begin the flare at approximately 30 feet AGL by gently increasing the pitch angle with back stick pressure which counteracts the tendency for the nose to drop. When the pilot hears the “thirty” callout, he should raise the pitch attitude approximately 2° to slow the rate of descent. This should be done smoothly and slowly to prevent the aircraft from inadvertently leveling off or climbing.

Conditions permitting, reduce the thrust levers to idle at about 20 feet when the pilot hears “retard”. Hold sufficient back pressure on the side stick to keep the pitch constant. Avoid the tendency to float and land long. Make small pitch attitude adjustments to maintain the desired descent rate to the runway, but do not allow the aircraft speed to decay appreciably or the pitch attitude to increase above approximately 8° nose-up. The PM should make awareness calls if the pitch attitude approaches 10°. Fly the aircraft onto the runway.

A321

A "PITCH-PITCH" synthetic voice sounds when the pitch attitude becomes excessive and a tail strike pitch limit indicator appears on the PFD to indicate the maximum pitch attitude to avoid a tail strike.



A319/320/321 Flight Crew Training Manual

After touch down, the pilot must “fly” the nosewheel smoothly, but without delay, on to the runway, and must be ready to counteract any residual pitch up effect of the ground spoilers. However, the main part of the spoiler pitch up effect is compensated by the flight control law itself. A small nose down trim on the elevators is introduced by the control law, which compensates the pitch up tendency with ground spoiler extension.

Prolonged flare increases aircraft pitch attitude 2° to 3° . When prolonged flare is coupled with a misjudged height above the runway, a tail strike is possible. Do not prolong the flare in an attempt to achieve a perfectly smooth touchdown. A smooth touchdown is not the criterion for a safe landing.

Airspeed Control

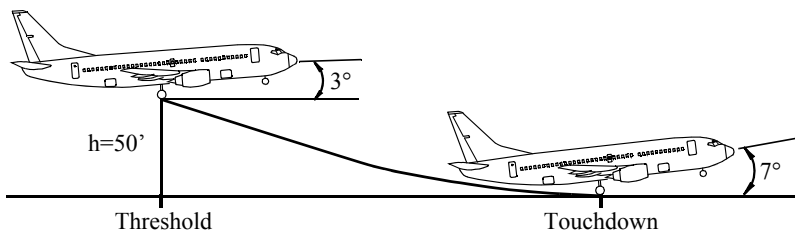
During an automatic landing, a “RETARD” callout is made at 10 feet RA as a reminder to retard the thrust levers to idle to match the A/THR commanded thrust and place the thrust levers in a position where reverse thrust can be activated. During manual landings, the SPEED mode remains active and the callout is generated at 20 feet RA as a reminder that the thrust levers should have already been retarded to idle for landing.

The autothrust system is normally used for all landings. Because thrust required during the approach is less than climb thrust, the initial movement of the thrust levers from the climb detent to the idle detent will have no effect on thrust. When the autothrust system is not used for landing (to maintain proficiency for instance) the initial movement of the thrust levers toward idle will have an immediate effect on thrust.

Landing Flare Profile

The following diagram uses these conditions:

- 3° approach glide path,
- flare distance is approximately 1,000 to 2,000 feet beyond the threshold,
- typical landing flare times range from 4 to 8 seconds and are a function of approach speed, and
- aircraft body attitudes are based upon typical landing weights, flaps FULL and VAPP (approach) and VLS (touchdown)



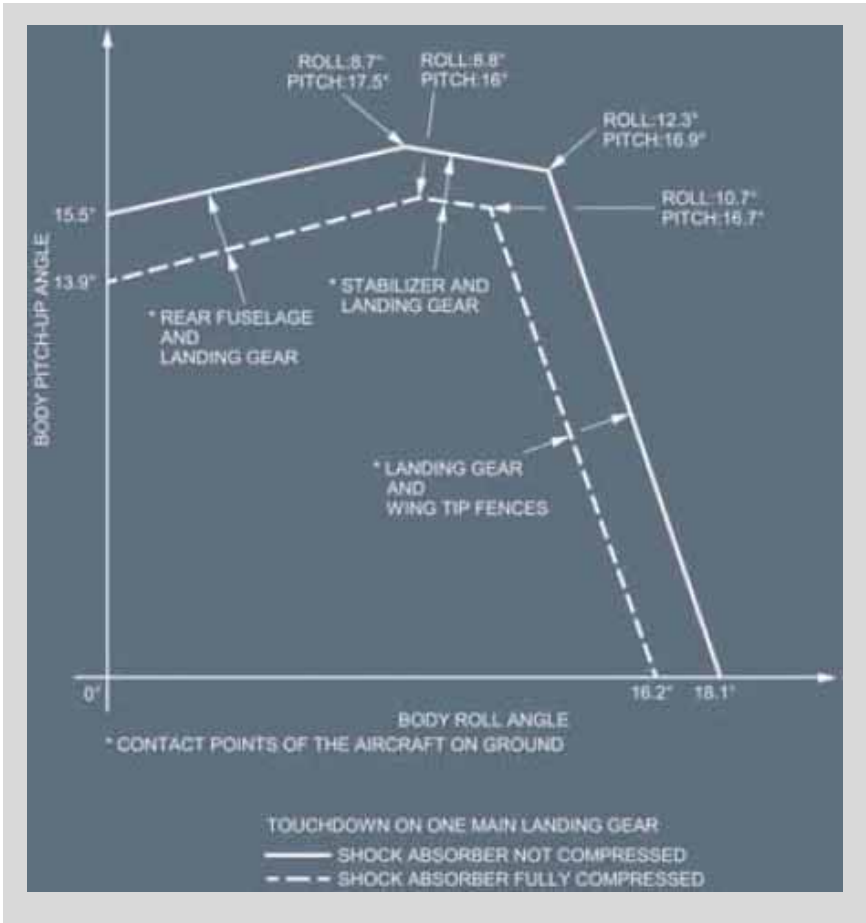
Pitch and Roll Limit Conditions

The Ground Contact Angles - Normal Landing figures illustrate body roll/pitch angles at which the aircraft structure contacts the runway.

Note: The figures are based on a rigid wing, however, dynamic maneuvering can reduce this envelope due to structural flexing of the airframe. Therefore, body roll/pitch angles within the envelope shown on the figures can result in aircraft structure contacting the runway.

Ground Contact Angles - Normal Landing

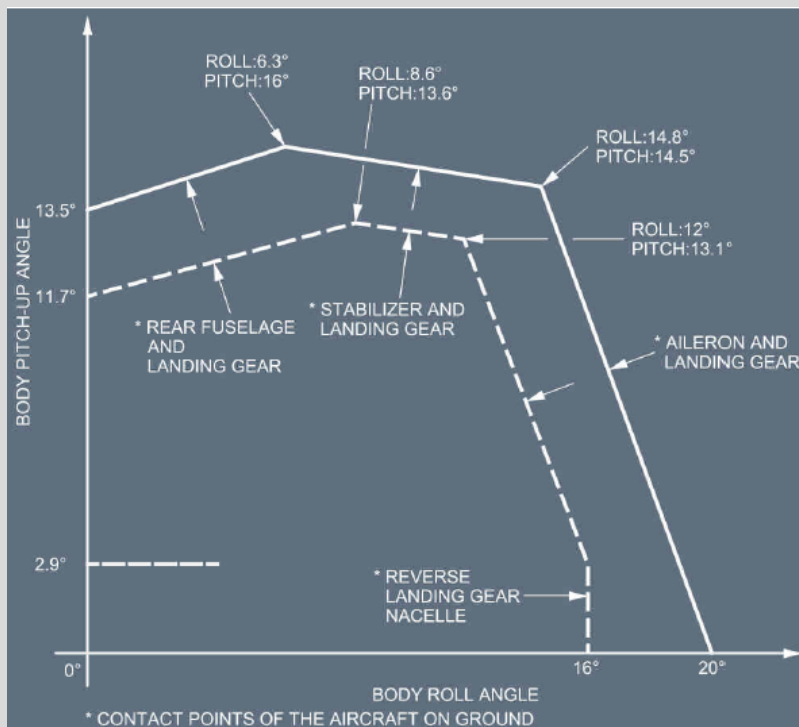
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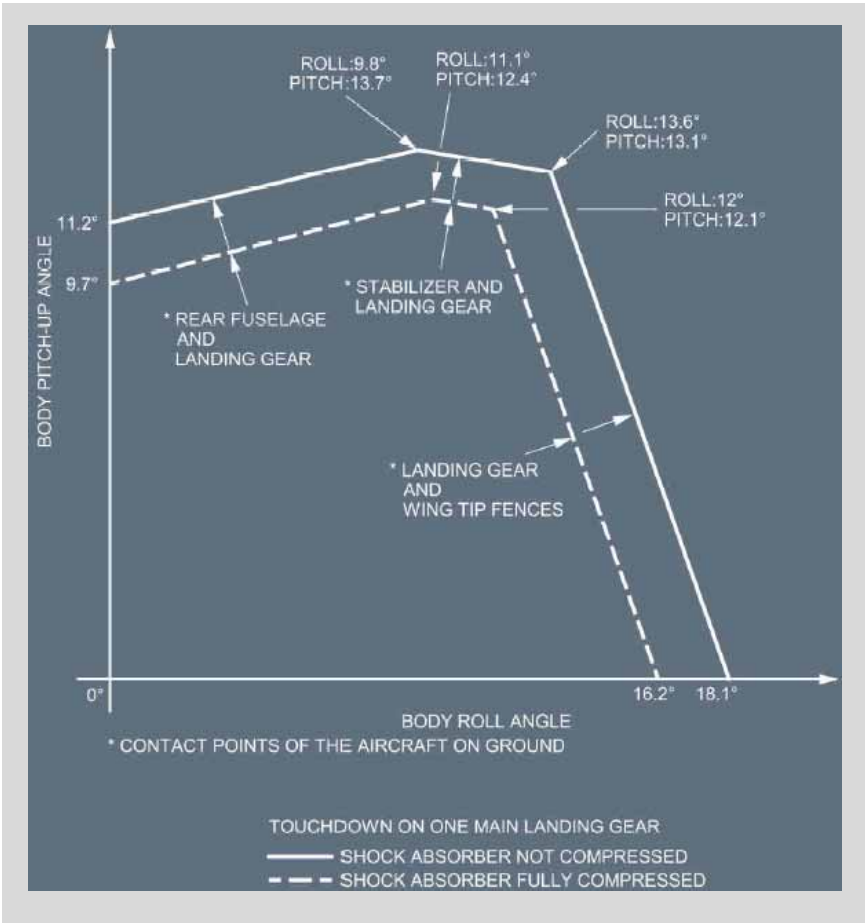


A319/320/321 Flight Crew Training Manual

A320



A321





Bounced Landing Recovery

Tailstrikes are most common following a firm landing with the thrust levers not at idle (because the spoilers do not deploy). If the aircraft should bounce, hold or re-establish a normal landing attitude and add thrust as necessary to control the rate of descent. Thrust need not be added for a shallow bounce or skip. When a high, hard bounce occurs, initiate a go-around. Apply TOGA thrust and use normal go-around procedures. Do not allow the pitch attitude to increase, particularly following a firm touchdown with a high pitch rate. Do not retract the landing gear until a positive rate of climb is established because a second touchdown may occur during the go-around.

Rejected Landing

A rejected landing is defined as a go-around initiated after the MAP or below MDA/DA. Refer to chapter 5, Go-Around and Missed Approach and Go-Around after Touchdown, for more information on this subject.

If the go-around is initiated below 50 feet RA, the initial sidestick “nose up” input forces will be greater than normal due to the fact that the flight controls have reverted to the landing mode of normal law. These forces will normalize above 50 feet RA as the flight controls transition back to the flight mode of normal law.

Landing Roll

Avoid touching down with thrust above idle since this will prevent spoiler deployment and may establish an aircraft nose up pitch tendency and increases landing roll.

Fly the nose wheels smoothly onto the runway without delay. Do not attempt to hold the nose wheels off the runway. Holding the nose up after touchdown for aerodynamic braking is not an effective braking technique and results in high nose gear sink rates upon brake application and reduced braking effectiveness.

To avoid the risk of a tail strike, do not allow the pitch attitude to increase after touchdown. After touchdown, when autobraking is no longer desired, manually apply wheel brakes smoothly with steadily increasing pedal pressure as required for runway condition and runway length available. Maintain deceleration rate with constant or increasing brake pressure as required until stopped or desired taxi speed is reached.

After main gear touchdown, fly the nose gear smoothly to the runway without delay. Normally, there is no need to apply forward stick pressure to bring the nose to the runway, but be prepared to immediately counteract any pitch up effect as the spoilers deploy. Slight forward stick may be necessary during the landing roll.

After main gear touchdown, select at least idle reverse thrust to activate partial spoiler extension (panels 1-5). Selecting reverse thrust activates the partial spoiler extension regardless of the position of the ground spoiler handle. Partial spoiler extension ensures that the aircraft settles on both main landing gear and allows the ground spoilers to fully deploy.

CAUTION: Not selecting reverse thrust on at least one engine may delay the weight on wheels signal which may in turn delay the deployment of automatic ground spoilers and activation of autobrakes.



Speedbrakes

Monitor the operation of the autobrakes, ground spoilers and reversers.

Normally, speedbrakes are armed to extend automatically. Both pilots should monitor speedbrake extension after touchdown. Manual extension of the ground spoilers will extend fewer spoiler panels than auto extension and is normally not recommended.

The position of the speedbrakes should be announced during the landing phase by the PM. This improves the crew's situational awareness of the position of the spoilers during landing and builds good habit patterns which can prevent failure to observe a malfunctioned or disarmed spoiler system.

Directional Control and Braking during Landing Roll

If the nose wheels are not promptly lowered to the runway, braking and steering capabilities are significantly degraded and no drag benefit is gained. Rudder control is effective to approximately 60 knots. Rudder pedal steering is sufficient for maintaining directional control during the rollout. Do not use the nose wheel steering wheel until reaching taxi speed. Perform the landing roll procedure immediately after touchdown. Any delay markedly increases the stopping distance.

Stopping distance varies with wind conditions and any deviation from recommended approach speeds.

Factors Affecting Landing Distance

Advisory information for normal and non-normal configuration landing distances is contained in the ODM. Actual stopping distances for a maximum effort stop are approximately 60% of the dry runway field length requirement. Factors that affect stopping distance include: height and speed over the threshold, glide slope angle, landing flare, lowering the nose to the runway, use of reverse thrust, ground spoilers, wheel brakes, and surface conditions of the runway.

Note: Reverse thrust and ground spoiler drag are most effective during the high-speed portion of the landing. Activate reverse thrust with as little time delay as possible.

Note: Ground spoilers fully deployed, in conjunction with maximum reverse thrust and maximum manual antiskid braking provides the minimum stopping distance.

Floating above the runway before touchdown must be avoided because it uses a large portion of the available runway. The aircraft should be landed as near the normal touchdown point as possible. Deceleration rate on the runway is approximately three times greater than in the air.



Height of the aircraft over the runway threshold also has a significant effect on total landing distance. For example, on a 3° glide path, passing over the runway threshold at 100 feet altitude rather than 50 feet could increase the total landing distance by approximately 950 feet. This is due to the increased runway used before the aircraft actually touches down.

Reduced flaps landing marginally increases landing distance. Landing distance assumptions and performance can be determined by referencing the ODM.

Glide path angle also affects total landing distance. As the approach path becomes flatter, even while maintaining proper height over the end of the runway, total landing distance is increased.

Non-Normal Landing Distance

Because of the higher approach speeds and the possible degraded capability of deceleration devices (spoiler, brakes, reversers) associated with the non-normal landing condition, the actual landing distance is increased. The Abnormal Configuration Actual Landing Distances table in the ODM shows landing distances for various non-normal landing configurations and runway conditions.

Slippery Runway Landing Performance

When landing on slippery runways contaminated with ice, snow, slush, or standing water, the reported braking action must be considered. Stopping distances for the LO and MED autobrake settings and for non-normal configurations are provided in the ODM. Pilots should use extreme caution to ensure adequate runway length is available when poor braking action is reported.

Slippery/contaminated runway performance data is based on an assumption of uniform conditions over the entire runway. This means a uniform depth for slush/standing water for a contaminated runway or a fixed braking coefficient for a slippery runway. The data cannot cover all possible slippery/contaminated runway combinations and does not consider factors such as rubber deposits or heavily painted surfaces near the end of most runways.

Refer to the Vol. 1, SP.16 and the AM, OPS-4WX.3.



Wheel Brakes

Braking force is proportional to the force of the tires on the runway and the coefficient of friction between the tires and the runway. The contact area normally changes little during the braking cycle. The perpendicular force comes from aircraft weight and any downward aerodynamic force such as speedbrakes.

The coefficient of friction depends on the tire condition and runway surface, (e.g. concrete, asphalt, dry, wet, or icy).

Automatic Brakes

CAUTION: The MAX selection is used for takeoff only.

Use of the autobrake system in LO or MED is required for landing, if operable.

Experience with various runway conditions and the related aircraft handling characteristics provide initial guidance for the level of deceleration to be selected.

Immediate initiation of reverse thrust at main gear touchdown and full reverse thrust allow the autobrake system to reduce brake pressure to the minimum level. Since the autobrake system senses deceleration and modulates brake pressure accordingly, the proper application of reverse thrust results in reduced braking for a large portion of the landing roll.

The importance of establishing the desired reverse thrust level as soon as possible after touchdown cannot be overemphasized. This minimizes brake temperatures and tire and brake wear, and reduces stopping distance on very slippery runways.

The use of minimum reverse thrust as compared to maximum reverse thrust can double the brake energy requirements and result in brake temperatures much higher than normal.

After touchdown, crewmembers should be alert for autobrake disengagement annunciations. The PM should notify the PF any time the autobrakes disengage.

If stopping distance is not assured with autobrakes engaged, the PF should immediately apply manual braking sufficient to ensure deceleration to a safe taxi speed within the remaining runway.

The Operational Landing Distance tables in the ODM shows the stopping capabilities of the available autobrake selections.

Transition to Manual Braking

The speed at which the transition from autobrakes to manual braking is made depends on aircraft deceleration rate, runway conditions, and stopping requirements. Normally the spoilers remain deployed until clearing the runway. The use of spoilers and reverse thrust is especially important when nearing the end of the runway where rubber deposits affect stopping ability.



When transitioning from the autobrake system to manual braking, the PF should notify the PM. Transition to manual brakes any time the selected autobrake deceleration rate is determined to be insufficient for the runway remaining. Transition to manual brakes by applying gradually increasing pressure to the brake pedals. Disarming the autobrakes before coming out of reverse thrust provides a smooth transition to manual braking. Techniques for release of autobrakes can affect passenger comfort and stopping distance.

Manual Braking

The following technique for manual braking provides optimum braking for all runway conditions:

The pilot's seat and rudder pedals should be adjusted so that it is possible to apply maximum braking with full rudder deflection.

Immediately after main gear touchdown, smoothly apply a constant brake pedal pressure for the desired braking. For short or slippery runways, use full brake pedal pressure.

- Do not attempt to modulate, pump, or improve the braking by any other special techniques
- Do not release the brake pedal pressure until the aircraft speed has been reduced to a safe taxi speed
- The antiskid system stops the aircraft for all runway conditions in a shorter distance than is possible with either antiskid off or brake pedal modulation.

The antiskid system adapts pilot-applied brake pressure to runway conditions by sensing an impending skid condition and adjusting the brake pressure to each individual wheel for maximum braking. When brakes are applied on a slippery runway, several skid cycles occur before the antiskid system establishes the right amount of brake pressure for the most effective braking.

If the pilot modulates the brake pedals, the antiskid system is forced to readjust the brake pressure to establish optimum braking. During this readjustment time, braking efficiency is lost.

Low available braking coefficient of friction on extremely slippery runways at high speeds may be interpreted as a total antiskid failure. Pumping the brakes degrades braking effectiveness. Maintain steadily increasing brake pressure, allowing the antiskid system to function at its optimum.



Carbon Brake Life

Carbon brake wear is primarily dependent upon the number of brake applications. For example, one firm brake application causes less wear than several light applications. Continuous light applications of the brakes to keep the aircraft from accelerating over a long period of time (riding the brakes) to maintain a constant taxi speed produces more wear than proper brake application.

During taxi, proper braking involves a steady application of the brakes to decelerate the aircraft. Release the brakes as lower speed is achieved. After the aircraft accelerates, repeat the braking sequence.

During landing, one hard, high energy, long-duration brake application produces the same amount of wear as a light, low-energy, short application. This is different from steel brakes that wear as a function of the energy input during the stop.

Brake Cooling

A series of taxi-back or stop-and-go landings without additional in-flight brake cooling can cause excessive brake temperatures. The energy absorbed by the brakes from each landing is cumulative.

Extending the gear a few minutes early in the approach normally provides sufficient cooling for a landing.

Note: The ECAM wheels page may be used for assessing brake temperatures.

Close adherence to recommended landing roll procedures ensures minimum brake temperature buildup.

Note: (A321) After landing the use of brake fans could increase oxidation of the brake surface hot spots if brakes are not thermally equalized, leading to the rapid degradation of the brakes. For this reason, selection of brake fans should be delayed until approximately 5 min after touchdown or just prior to stopping at the gate (whichever occurs first). Selecting brake fans before reaching the gate prevents blowing carbon brake dust on ground personnel.

Minimizing Brake Heat Build Up

Consider using the following technique if landing overweight or other factors exist that may lead to excessive brake temperatures. A normal landing, at weights up to maximum landing weight, does not require special landing techniques.

Note: Autolands are not recommended for overweight landings.

To minimize brake temperature buildup, use the following landing techniques:

- complete the overweight landing checklist, if applicable (refer to QRH);
- select the longest runway available but avoid landing downwind;
- use flaps FULL unless limited by a non-normal procedure;
- use an autobrake setting, consistent with reported runway conditions, that will result in the use of all available runway length. A stopping distance safety margin should be used. Although the autobrakes initially increase brake temperature, the brake contribution is minimized after reverser deployment;
- use managed speed for landing to avoid landing with excessive airspeed;
- use a normal gear touchdown aim point;
- do not allow the aircraft to float;
- ensure the spoilers deploy immediately after touchdown;
- select maximum reverse thrust as soon as possible after main gear touchdown. Do not wait for nose wheel touchdown. The intention is to use reverse thrust as the major force that stops the aircraft. The use of maximum reverse thrust further minimizes brake heating;
- as soon as stopping is assured in the remaining runway, turn the autobrakes off and continue slowing the aircraft with reverse thrust;
- if stopping in the remaining runway is in doubt, continue use of autobrakes or take over manually and apply up to maximum braking as needed;
- consider extending the landing gear early to provide maximum brake cooling as needed.



Reverse Thrust Operation

WARNING: After reverse thrust is initiated, a full stop must be made.

Awareness of the position of the forward and reverse thrust levers must be maintained during the landing phase. Improper seat position as well as long sleeved apparel may cause inadvertent advancement of the forward thrust levers, preventing movement of the reverse thrust levers.

Note: Reverse thrust is most effective at high speeds.

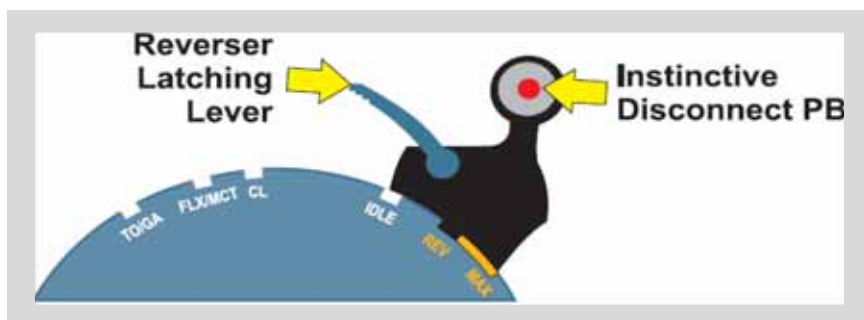
After touchdown, with the thrust levers at idle, rapidly raise the reverse thrust levers up and aft to the reverse idle position, then apply reverse thrust as required. Although the FADEC will control the maximum thrust, the PM should monitor engine operating limits and call out any engine operational limits being approached or exceeded, any thrust reverser failure, or any other abnormalities.

Maintain reverse thrust as required, up to maximum, until 80 knots. At this point start reducing the reverse thrust so that the reverse thrust levers are moving down at a rate commensurate with the deceleration rate of the aircraft. The thrust levers should be positioned to reverse idle by taxi speed, then to forward idle thrust after the engines have decelerated to idle. Reverse thrust is reduced to idle between 80 knots and taxi speed, unless required for adverse conditions, to prevent engine exhaust re-ingestion and to reduce the risk of FOD. It also helps the pilot maintain directional control in the event a reverser becomes inoperative. The use of high levels of reverse thrust at low airspeeds and/or the rapid forward movement of reverse thrust levers when deselecting reverse thrust may cause engine stalls (surges).

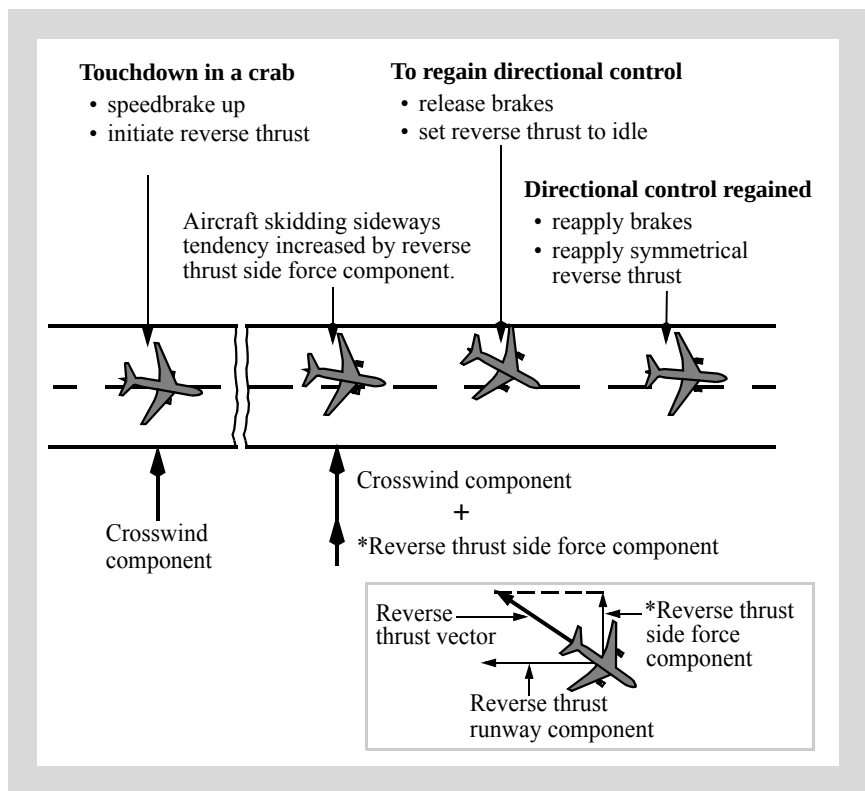
Note: If an engine surges during reverse thrust operation, quickly select reverse idle on both engines.

The PM should call out 80 knots to assist the PF in scheduling the reverse thrust. The PM should also call out any inadvertent selection of forward thrust as reverse thrust is cancelled.

Reverse Thrust Operations



Reverse Thrust and Crosswind (All Engines)



This figure shows a directional control problem during a landing rollout on a slippery runway with a crosswind. As the aircraft starts to weathervane into the wind, the reverse thrust side force component adds to the crosswind component and drifts the aircraft to the downwind side of the runway. Also, high braking forces reduce the capability of the tires to corner.

To correct back to the centerline, release the brakes and reduce reverse thrust to reverse idle. Releasing the brakes increases the tire-cornering capability and contributes to maintaining or regaining directional control. Setting reverse idle reduces the reverse thrust side force component without the requirement to go through a full reverser actuation cycle. Use rudder pedal steering and differential braking as required to prevent over correcting past the runway centerline. When directional control is regained and the aircraft is correcting toward the runway centerline, apply maximum braking and symmetrical reverse thrust to stop the aircraft.

Note: Use of this technique increases the required landing distance.

**Reverse Thrust - Engine Inoperative**

Asymmetrical reverse thrust may be used with one engine inoperative. After touchdown, the PF should move both thrust levers to reverse idle. If directional control becomes a problem during deceleration, return the thrust lever to the reverse idle detent.

Asymmetrical reverse thrust may be used with one engine inoperative. There are no appreciable adverse characteristics with using only one thrust reverser (unless the runway is deemed to be slippery and/or high crosswinds exist).

Crosswind Landings

Note: For additional information on crosswind guidelines, refer to Vol. 1, SP.16, Guidelines for Contaminated Runways.

Landing Crosswind Guidelines

The crosswind guidelines were derived through flight test data, engineering analysis, and flight simulator evaluations. These crosswind guidelines are based on steady wind (no gust) conditions and include all engines operating and engine inoperative. Gust effects were evaluated and tend to increase pilot workload without significantly affecting the recommended guidelines.

Crosswind Landing Techniques

CAUTION: During landings with strong crosswinds and one reverser inoperative, asymmetric reverse thrust above idle may cause directional control problems. Performance permitting, limiting reverse thrust to idle with the operative reverser may aid in maintaining directional control.

Crosswind capability is a function of runway surface conditions, aircraft loading, pilot technique, and any inoperative equipment on the aircraft.

Note: Gusty crosswind conditions can create a tendency for the pilot to overcontrol or rapidly move the sidestick, potentially causing a Pilot Induced Oscillation (PIO). If a PIO is encountered on final approach, the best course of action is a momentary “freeze” of the sidestick to eliminate oscillations, then execute a go-around.

The “crab” method is the preferred technique to use on final approach when landing in crosswind conditions. In the flare, smoothly use rudder to align the aircraft fuselage to the runway centerline. Routine use of sidestick into the wind before touchdown is not recommended because sidestick deflection commands roll rate. In strong crosswind conditions, a small amount of lateral control may be used to maintain wings level. After touchdown, the control law transfers from the flight mode to the ground mode, and there is a direct relationship between the sidestick position and the aileron position. In strong crosswinds, sidestick input may be required to both assist in directional control and keep the wings level during the initial stages of the landing rollout. Sidestick inputs should be removed progressively as the aircraft decelerates, with directional control maintained with the rudder.

After main gear touchdown, select at least idle reverse thrust to ensure proper ground spoiler operation.



Overweight Landing

Overweight - General

Overweight landings may be safely accomplished by using normal landing procedures and techniques. There are no adverse handling characteristics associated with overweight landings. However, wet or slippery runway field length requirements should be verified from the landing distance charts in the ODM.

If stopping distance is a concern, reduce the landing weight as much as possible. At the captain's discretion, reduce weight by holding at low altitude with a high drag configuration (gear down) to achieve maximum fuel burn-off.

When landing at high gross weights at speeds associated with non-normal procedures requiring flaps set at 3 or less, maximum effort stops may exceed the brake energy limits. The gross weights where this condition can occur are well above maximum landing weights. For these non-normal landings, maximize use of the available runway for stopping.

Observe VFE maximum indications on the PFD during flap extension and on final approach. In the holding and approach patterns, maneuvers should be flown at the normal maneuver speeds.

Note: (A321 only): At very high weights, VFE Flaps 1 is close to VLS clean. To select Flaps 1, deselect A/THR, decelerate to (or slightly below) VLS and select CONF 1 when below VFE. When established at Flaps 1 the crew can reengage A/THR and use managed speed again.

Use the longest available runway, and consider wind and slope effects. Where possible avoid landing in tailwinds, on runways with negative slope, or on runways with less than normal braking conditions. Do not carry excess airspeed on final. This is especially important when landing during an engine inoperative or other non-normal condition.

Fly a normal profile. Ensure that a higher than normal rate of descent does not develop. Do not hold the aircraft off waiting for a smooth landing. Fly the aircraft onto the runway at the normal touchdown point. If a long landing is likely to occur, go-around. After touchdown, immediately apply maximum reverse thrust using all of the available runway for stopping to minimize brake temperatures. Do not attempt to make an early runway turnoff.

Autobrake stopping distance guidance is contained in the ODM. If adequate stopping distance is available based upon approach speed, runway conditions, and runway length, the recommended autobrake setting should be used.



Overweight Autolands

Overweight autolands are not authorized by the manufacturer, the landing is flown manually in order to control the rate of descent at touchdown.

In an emergency, should the pilot determine that an overweight autoland is the safest course of action, the approach and landing should be closely monitored by the pilot and the following factors considered:

- touchdown may be beyond the normal touchdown zone; allow for additional landing distance;
- touchdown at higher than normal sink rates may result in exceeding structural limits; and
- plan for a go-around or manual landing if autoland performance is unsatisfactory; automatic go-arounds can be initiated until just prior to touchdown, and can be continued even if the aircraft touches down after initiation of the go-around.



Maneuvers

Table of Contents

Chapter 7

Section TOC

Abnormal Alpha Protection	7.1
Abnormal AOA Indications Requiring Action	7.2
Overspeed Protection	7.3
Engine Out Familiarization	7.4
Rudder and Lateral Control	7.4
Thrust and Airspeed	7.4
High Altitude Maneuvering, "G" Buffet	7.5
Emergency Descent	7.6
Autopilot Entry and Level Off	7.7
Manual Entry and Level Off	7.8
Landing Gear Extended Descent	7.8
After Level Off	7.8
Erroneous Radio Altimeter Indications	7.9
Erroneous RA Procedure	7.10
Flight Control Effectiveness	7.11
Normal Law	7.11
Alternate Law	7.11
Direct Law	7.12
Abnormal Attitude Law	7.12
Backup Law	7.12
Stall or Approach to Stall	7.13
Stall or Approach to Stall Recovery Maneuver	7.13
Stall or Approach to Stall Characteristics	7.14
Stall or Approach to Stall Recovery	7.15
Low Energy Warning	7.16

Alpha Floor Recovery	7.17
Steep Turns and Bank Angle Protection.....	7.19
Entry.....	7.19
During Turn.....	7.19
Attitude Indicator.....	7.19
Vertical Speed Indicator	7.20
Altimeter	7.20
Airspeed.....	7.20
Rollout	7.20
Bank Angle Protection.....	7.20
Terrain Avoidance	7.21
Terrain Avoidance Maneuver	7.21
Terrain Avoidance - RNAV (RNP) AR.....	7.23
Traffic Alert and Collision Avoidance System.....	7.23
TCAS Maneuver	7.23
Use of TA/RA, TA Only, and Transponder Only Modes	7.25
Traffic Advisory	7.25
Resolution Advisory	7.25
Upset Recovery	7.27
Nose High Recovery	7.27
Nose Low Recovery.....	7.28
General.....	7.28
Upset Recovery Techniques	7.31
Windshear	7.32
General.....	7.32
Avoidance	7.32
Precautions.....	7.32
Aircraft Performance in Windshear.....	7.34
Windshear Encounter Recognition	7.34



A319/320/321 Flight Crew Training Manual

Windshear Escape Maneuver	7.35
Windshear During Takeoff Roll	7.35
Windshear In Flight.	7.36
Post Windshear Considerations.	7.36

Intentionally
Blank

Abnormal Alpha Protection

Internal water buildup in the AOA sensors can freeze during climb, resulting in AOA vane sticking. If two probes become stuck in a similar setting, they override the remaining (correct reading) probe. As the aircraft climbs and its Mach number increases, the acceptable range of AOA decreases.

In two Airbus documented incidents, an A330 and A321 had vanes become fixed at 4 to 5 degrees during climb-out. As the aircraft climbed through FL200 to FL300 feet, the FACs interpreted the faulty AOA data as an approaching stall. Alpha Protection (active in Normal Law) took over, by disconnecting the autopilot and pitching the aircraft nose down to reduce AOA. This protection overrode the pilot's aft sidestick input and resulted in a steep descent rate.

Airbus has developed the Abnormal Alpha Protection non-normal procedure (Ref. QRH Section 11) in response to these incidents. Pilots must be prepared to apply the memory item if speed is above VLS and the aircraft goes into a continuous nose down pitch rate, which cannot be recovered using the sidestick.

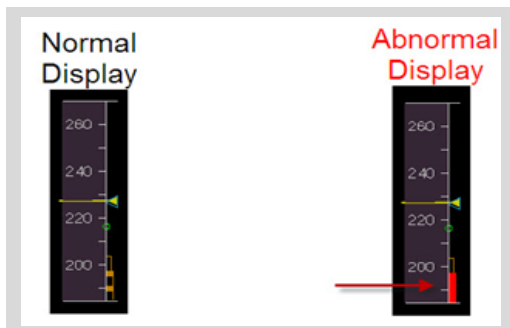
Early indications of a possible AOA blockage include:

- **Slow Climb Speed:** Airbus testing has determined the first indication of stuck or "blocked" AOA probes may be the aircraft climbing at a speed approximately 10 knots below the managed or selected speed target. While not by itself definitive, a slower than commanded speed during climb should raise the crew's awareness for other indications.
- **'CHECK WEIGHT' Scratchpad Message:** A 'CHECK WEIGHT' FMS scratchpad message may also provide an early indication of an AOA issue. This message indicates a discrepancy between the FMGC and FAC estimated weight of more than 15,000 pounds and usually results from an AOA error. If the message appears during flight, the crew should consult the QRH NNC (Ref. QRH Section 11) and heighten awareness of possible AOA sticking.

Abnormal AOA Indications Requiring Action

Abnormal Increase in Alpha Max:

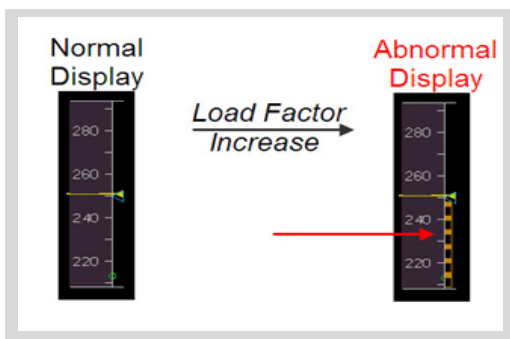
Normal indication on the left with the abnormal on the right, with the difference being the red Alpha Max strip overrunning the amber and black Alpha Prot strip. If observed during stable flight conditions, the Abnormal Alpha Protection QRH procedure should be consulted.



Note that this part of the QRH procedure is not a memory item, rather a read and do non-normal checklist with verification prior to selecting the two ADR pushbuttons to OFF. When this occurs, the autopilot disconnects, the flight directors disappear, and the aircraft transitions to alternate law. This is done as precautionary step in this case and the ADRs are left off for the duration of the flight. As both the AP and FDs are unavailable, Flight Path Vector (the "bird") is referenced as an option to help with altitude control. When the ADRs are selected off, the ECAM for the appropriate ADRs (1+2, 1+3, 2+3) off appears. This should be completed using normal ECAM/QRH procedures.

Abnormal "Jump" in Alpha Prot:

The unusual display here is the Alpha Prot band jumping by more than 30 knots during normal maneuvering (AP on and speedbrakes retracted). This again is not a memory item and the Abnormal Alpha Protection procedure should be used.





Overspeed Protection

The object of the overspeed maneuver is to familiarize the pilot with aircraft handling characteristics at and above VMO. It is not intended that the pilot should ever fly at airspeeds in excess of VMO.

While descending, select the V/S mode and increase the descent rate to 5,000 fpm. As the airspeed increases above VMO, forward sidestick pressure must be maintained to remain above VMO. Release pressure and the airplane pitch increases to reduce the airspeed to VMO.

When flying beyond maximum design speeds (which are greater than VMO/MMO), there is an increased potential for aircraft control difficulties and structural concerns, due to high air loads.

High speed protection is activated at/or above VMO/MMO (it is displayed on the speed tape as two green bars at VMO+4).

When high speed protection is activated:

- The autopilot disconnects.
- If there is no sidestick input, the aircraft will slightly overshoot VMO/MMO, the sidestick nose-down authority will be progressively reduced, and a nose-up order will be applied to aid recovery to normal flight conditions.
- If the sidestick is maintained full forward, the aircraft will significantly overshoot VMO/MMO. At approximately VMO +16 / MMO +0.04, the pitch nose-down authority smoothly reduces to zero (which does not mean that the aircraft stabilizes at that speed).
- Positive spiral static stability is introduced to 0° bank angle (instead of 33° in normal law), so that with the sidestick released, the aircraft always returns to a bank angle of 0°.
- The bank angle limit is reduced from 67° to 45°.

Note: This maneuver is for demonstration purposes only and is performed in the simulator only.

Engine Out Familiarization

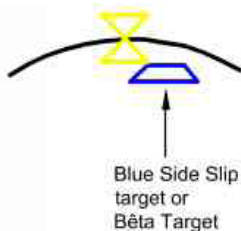
One engine out controllability is excellent during takeoff roll and after lift-off. Minimum control speed in the air is below VR and VLS.

Engine out familiarization is performed to demonstrate that an engine failure requires pilot input to control the yaw produced by the asymmetrical thrust condition.

Rudder and Lateral Control

In flight with the autopilot disengaged, if an engine failure occurs, and no input is applied on the sidestick, the aircraft will reach an approximate 5° constant bank angle, a constant sideslip, and slowly diverge from heading. While the lateral behavior of the aircraft is safe, from a performance standpoint the most effective flying technique is to fly a constant heading with little or no aileron or spoiler input.

When an engine fails either on takeoff or in flight, the sideslip index or beta target indicator on the PFD turns blue, instead of the normal yellow, and shows a skid indication toward the operating engine. If the rudder pedal is pressed to center the index, the aircraft will fly at optimum performance with the ailerons and spoiler at the neutral position. If the autopilot is engaged, the rudder is automatically trimmed but the aircraft may diverge from heading momentarily as the autopilot rudder trim rate attempts to keep up with large power changes.



Thrust and Airspeed

If not thrust limited, apply additional thrust, if required, to control the airspeed. If performance limited (high altitude), adjust aircraft attitude to maintain airspeed while setting maximum continuous thrust.

Note: Autothrottle can be used effectively with an engine inoperative.



High Altitude Maneuvering, "G" Buffet

Aircraft buffet reached as a result of aircraft maneuvering is commonly referred to as "g" buffet. During turbulent flight conditions, it is possible to experience high altitude "g" buffet at speeds less than MMO. In training, buffet is induced to demonstrate the aircraft's response to control inputs during flight in buffet.

Establish an airspeed of 0.81M to 0.84M. Induce "g" buffet by smoothly increasing the bank angle until the buffet is noticeable. Increase the rate of descent while increasing the bank angle to maintain airspeed. Do not exceed 30° of bank. If buffet does not occur by 30° of bank, increase sidestick back pressure until buffet occurs. When buffet is felt, relax back pressure and smoothly roll out to straight and level. Notice that the controls are fully effective at all times.

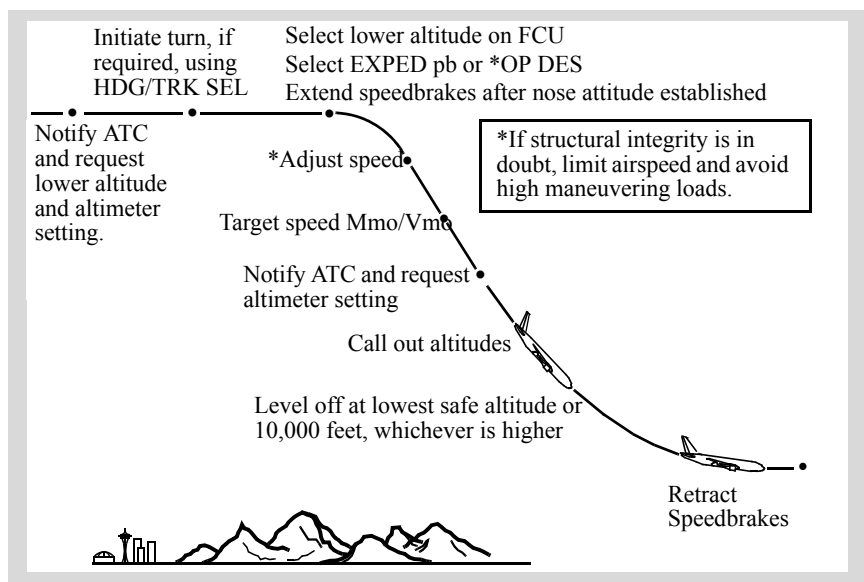
Emergency Descent

This section addresses basic techniques and procedures for an emergency descent. Some routes over mountainous terrain require careful planning to include carrying additional oxygen, special procedures, higher initial level off altitudes, and emergency routes in the event a depressurization is experienced.

This maneuver is designed to bring the aircraft down smoothly to a safe altitude, in the minimum time, with the least possible passenger discomfort.

Note: Use of the autopilot is recommended.

Rapid Descent Profile



If the descent is performed because of a rapid loss of cabin pressure, crewmembers should place oxygen masks on and establish communication at the first indication of a loss of cabin pressurization. Verify cabin pressure is uncontrollable, and if so, begin descent. If structural damage exists or is suspected, limit airspeed to current speed or less. Avoid high maneuvering loads.

Perform the maneuver deliberately and methodically. Do not be distracted from flying the aircraft. If icing conditions are entered, use anti-ice as required.

In airspace/airways with reduced vertical separation coupled with improved navigation accuracy, due to the close lateral separation of airplanes below cruise altitude, descending before turning may not be practical. In this case an immediate turn may be appropriate.

Note: Emergency descents are normally made with the landing gear up.



A319/320/321 Flight Crew Training Manual

The PF should notify ATC of the emergency descent, check for the lowest safe altitude and, obtain the local altimeter setting (QNH). The PM completes any ECAM procedure and the CAB PR EXCESS CAB ALT or Emergency Descent procedures in the QRH while the PF performs this maneuver. The PM calls out 2,000 feet and 1,000 feet above the level-off altitude.

Level off at the lowest safe altitude or 10,000 feet, whichever is higher. Lowest safe altitude is the Minimum Enroute Altitude (MEA), Minimum Off Route Altitude (MORA), or any other altitude based on terrain clearance, navigation aid reception, or other appropriate criteria.

If severe turbulent air is encountered or expected, reduce to the turbulent air penetration speed.

Autopilot Entry and Level Off

Open Descent or Expedite Descent

Because of airspeed and altitude protection and reduced crew workload, use of the autopilot with EXP DES or OP DES mode is the recommended technique for rapid descents. Use of the V/S or FPA mode is not recommended.

Initiate a turn, if required, using HDG/TRK SEL. Set a lower altitude in the FCU, then select the EXPED pb or OP DES, retard the thrust levers to idle if autothrust is not engaged and smoothly extend the speedbrakes after a nose down pitch attitude has been established.

Note: Pulling the select knob disengages Expedite mode; aircraft will revert to Open descent mode.

Note: Pushing an illuminated EXPED pb has no effect.

Deploy the speed brakes only after the nose is lowered to avoid the alpha inhibit function of the speedbrakes. The speedbrakes on the A320 are limited to the half position with the autopilot engaged (A319 does not have this restriction) so higher descent rates can be achieved on the A320 by turning off the autopilot and deploying full speedbrakes. Adjust the speed as needed and ensure the altitude window is correctly set for the level off.

When descending at speeds near VMO/MMO with the autopilot engaged, short-term airspeed increases above VMO/MMO may occur. These are most often due to wind and temperature changes. These short-term increases are acceptable for this maneuver and the autopilot should adjust the pitch to correct the airspeed to below VMO/MMO. Do not disconnect the autopilot unless autopilot operation is clearly unacceptable. Any airspeed above VMO/MMO should be documented in the aircraft logbook.

Note: For more complete information on recommendations if VMO/MMO is exceeded, see the section titled “Overspeed” in chapter 8 of this manual.



When approaching the target altitude, ensure the altitude is set in the FCU altitude select window, and the command speed is set to LRC or approximately 300 knots before level-off is initiated. This aids in a smooth transition to level flight. When the speedbrakes are retracted during altitude capture near VMO/MMO, a momentary overspeed condition may occur. To avoid this condition, smoothly and slowly retract the speedbrakes to allow the autopilot sufficient time to adjust the pitch attitude to maintain the airspeed within limits.

Manual Entry and Level Off

The entry may be accomplished on heading or a turn may be made to clear the airway or controlled track. However, since extending the speedbrakes initially reduces the maneuver margin, monitor the airspeed display and bank angle to ensure that at least minimum maneuver speed is maintained when turning.

To manually fly the maneuver, disconnect the autothrust and retard thrust levers to idle. Extend the speedbrakes, disengage the autopilot and smoothly lower the nose to initial descent attitude (approximately 10°- 15° nose down). A simultaneous 15° to 25° bank turn will reduce the negative Gs and may be needed to clear the airway or controlled track.

About 10 knots before reaching target speed, slowly raise the pitch attitude to maintain target speed. If MMO/VMO is inadvertently exceeded, change pitch smoothly to decrease speed.

Approaching the level off altitude, smoothly adjust the pitch attitude to reduce the rate of descent. The speedbrake lever should be returned to the down detent when approaching the desired level off altitude. After reaching level flight add thrust to maintain speed as required, verify the autothrust is engaged and select the desired airspeed.

Landing Gear Extended Descent

The rapid descent is normally made with the landing gear up. However, when structural integrity is in doubt and airspeed must be limited, when below FL 250 extension of the landing gear may provide a more satisfactory rate of descent.

If the landing gear is to be used during the descent, comply with the landing gear placard speeds.

After Level Off

Recheck the pressurization system and evaluate the situation. Do not remove the crew oxygen masks if cabin altitude remains above 10,000 feet.

Note: Determine the new course of action based on weather, oxygen, fuel remaining, medical condition of crew and passengers, terrain and available airports. Obtain a new ATC clearance.



Erroneous Radio Altimeter Indications

Erroneous RA indications can result in changes to the flight mode, incorrect PFD indications and untimely terrain/autoland warnings with some possible indications described below:

- Early or multiple "RETARD" callout(s).

Note: Selecting both APs ON for an ILS approach increases the probability of the "RETARD" callout should the anomaly occur.

- Differences between RA indications and FD commands on the CA's PFD versus the FO's PFD.
- Rapid cycling of a single RA indication from 0 to actual altitude.
- Activation of the L/G GEAR NOT DOWN ECAM warning above 750' AGL.
- Early engagement of the 'LAND' mode in columns 2 and 3 of the FMA during an ILS approach.
- Early engagement of the 'FLARE' mode in columns 2 and 3 of the FMA at 50' AGL during an ILS approach. Pitch increases during the FLARE mode.
- Early engagement of 'THR IDLE' in column 1 of the FMA. Thrust is commanded to IDLE during the THR IDLE mode even with the T/Ls at the CL detent.
- Activation of the AUTOLAND warning light above 200' AGL (even if an autoland is not planned).
- Inability to engage NAV, TRK, or HDG during the go-around (FMA indicates FLARE or ROLLOUT during a go-around).
- Amber RA indications on the PFD (possibly negative or frozen).
- Inappropriate terrain alerts and warnings.
- A 'NAV RA DEGRADED' ECAM message after landing (indicates a significant difference between the CA's and FO's RAs was encountered during flight).

Erroneous RA Procedure

Vigilance, continual instrument crosscheck, and situational awareness are the best tools for dealing with this anomaly. Increased FMA awareness is essential in identifying unwanted mode changes.

An Erroneous RA is of most concern when established on an ILS approach (aircraft armed for an autoland). If a RA malfunctions, triggering a false FLARE or IDLE, the pilot should be prepared to either go-around, or accomplish up to all of the following:

- (1) AP: OFF (prevents the aircraft from flaring to land).
- (2) A/THR: OFF (prevents thrust from being automatically retarded to idle).
- (3) FDs: OFF (FDs may provide flare guidance, ignoring the G/S resulting in an unsafe approach).

Note: In the case of a manual go-around, if the RA is frozen, NAV, HDG or TRK lateral modes may not be selectable and ALT* and ALT may not engage at the FCU altitude. Recycling both FDs OFF and then ON should enable engagement of HDG mode and allow a normal altitude capture. LVR CLB may not be displayed at the THR RED ALT.

Following any suspected Erroneous RA event, a detailed logbook write-up is essential to ensure maintenance inspects the proper equipment. Include which autopilot was engaged, what instruments were affected (CA's or FO's) along with the erroneous FMA indications and callouts ("RETARD", "TERRAIN", etc.) that were experienced. Use of the keywords ERRONEOUS or RETARD highlights the fault in the maintenance Sceptre system, ensuring a high level response.



Flight Control Effectiveness

If certain flight control or other system failures will not allow the flight control system to operate in normal law, a degraded flight control law may become active. These maneuvers are performed in the full flight simulator and are for demonstration purposes only. Refer to Vol. 2, chapter 27, for a full description of Flight Control Laws.

Normal Law

The sidesticks are used to fly the aircraft in pitch and roll (and in yaw, indirectly, through turn coordination). Computers interpret pilot input and move the flight control surfaces, as necessary, to follow these commands. In normal law, regardless of the pilot's input, the computers will prevent excessive maneuvers and exceedance of the safe maneuver envelope in pitch and roll axes. However, as on conventional aircraft, the rudder must be used with caution as large rudder inputs, and reversals, may exceed the structural design limits of the aircraft.

Pitch

The normal law flight mode is a load factor demand law with auto trim and full flight envelope protection. With the sidestick at neutral and the wings level, the system maintains 1 g in pitch corrected for pitch attitude. There is no need for the pilot to trim with speed or configuration changes.

Roll

The roll rate requested by the pilot during flight is proportional to the sidestick deflection. With the sidestick in neutral, the system maintains zero roll rate. 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° and no further.

Alternate Law

Alternate law provides a degraded mode of operation with some normal law flight characteristics and protections retained. Depending on the failure, the autopilot may not be available. Alternate law has variations in roll control and available protections depending on the failure, though the indications to the pilot are identical. Alternate law has reduced protections compared to normal law.

Stabilities replace some normal law limits and protections. While a protection would prohibit exceeding a limit, a stability is an overridable command by the flight control computers to return the aircraft to normal limits. Continuous sidestick force is required to override a stability. Flight control in alternate law will vary depending on the specific malfunction that caused alternate law. It is possible to stall the aircraft in alternate law.



Direct Law

Direct law provides a direct relationship between sidestick and rudder pedal deflection and flight control surface movement. All protections and stabilities are lost in direct law. Aircraft pitch, roll, and yaw rates for any given flight control input will change depending on the speed and configuration of the aircraft (just as in non fly-by-wire aircraft). Though pitch control provides for a direct sidestick to elevator relationship, the maximum elevator deflection is automatically limited depending on CG. This allows for adequate controllability at forward CGs, yet prevents overly sensitive controls at aft CGs.

Automatic pitch trim is inoperative and the THS must be trimmed manually using the pitch trim wheels. Overspeed and stall warnings are still available. Flight control in direct law is similar to flight control in conventional aircraft. It is possible to stall the aircraft in direct law.

Abnormal Attitude Law

If the defined flight envelope limits are exceeded for any reason (e.g., severe turbulence), abnormal attitude law becomes active. Abnormal attitude law ensures that the flight control laws do not prevent or interfere with recovery from an abnormal flight condition. Recoveries can be made from such attitudes as inverted flight, and vertical climbs or dives. After the recovery is complete, pitch control upgrades to alternate law with low and high speed stabilities and automatic pitch trim is restored. Roll control remains in direct law and yaw control remains in alternate law. The flight control law will not upgrade to normal law for the remainder of the flight. It is possible to stall the aircraft in abnormal attitude law.

Backup Law

Backup flight control provides a means to control the aircraft even during a complete loss of flight control computers or electrical power. Backup control is accomplished using the manual pitch trim wheel and the rudder pedals. Backup control is intended to be used only until a higher level of computerized control is restored. Hydraulic pressure must be available for backup control to function. In backup law pitch is maintained using the pitch trim wheel and thrust application. Roll control is maintained by rudder pedal input and asymmetric thrust. It is possible to stall the aircraft in backup law.



Stall or Approach to Stall

Stall or Approach to Stall Recovery Maneuver

The following is immediately accomplished at the first indication of an impending stall. This may be aircraft buffet or the aural stall warning.

Pilot Flying	Pilot Monitoring
- Simultaneously: - Apply nose down pitch control. - Disengage autopilot and autothrust. - Level the wings (do not change flaps or landing gear configuration).	- Monitor altitude and airspeed. - Verify all required actions have been done and call out any omissions. - Call out any trend toward terrain contact.
- When out of stall (no stall indication): - Increase thrust smoothly as needed. - Verify speedbrakes are retracted. - Adjust pitch attitude to accelerate while minimizing altitude loss. - In clean configuration and below FL200: - Call "Flaps 1"	- Monitor altitude and airspeed. - Verify speedbrakes are retracted. - Verify all required actions have been completed and call out any omissions. - Call out any trend toward terrain contact. - Set the FLAP lever as directed.
- Complete the recovery: - Check airspeed and adjust thrust as needed - Return to the desired flight path. - Re-engage the autopilot and autothrottle if desired.	- Monitor altitude and airspeed. - Verify all required actions have been completed and call out any omissions. - Call out any trend toward terrain contact.

Note: If clean up is required, do not change the configuration of the aircraft until the airspeed is at VLS and accelerating. When above VLS and a positive climb is indicated, the gear may be retracted. Retract the flaps on the normal schedule, and when in a clean configuration retard the thrust levers to maintain level flight and Green Dot airspeed.



Note: At high altitude, the stall warning indicates the aircraft is approaching the angle of attack for the onset of buffet. To recover the pilot must relax the back pressure and reduce the bank angle. When the warning stops back stick pressure may again be applied.

Note: The purpose of configuring to flaps 1 below FL200 is to prevent another stall from occurring.

Stall or Approach to Stall Characteristics

An approach to a stall is a controlled flight maneuver; a stall is an out-of-control, but recoverable, condition.

Most approach to stall incidents have occurred where there was altitude available for recovery. The incidents that progressed into accidents often occurred because the crew failed to make a positive recovery when the stall warning occurred, the condition progressed to a full stall, and the aircraft impacted the ground in a stalled condition. For this reason, emphasis has shifted from a recovery with minimum loss of altitude to reducing the angle of attack below the wing stalling angle to complete a positive and efficient recovery.

A stall warning should be readily identifiable by the pilot, either by initial buffet or an artificial voice (“STALL, STALL”). During the initial stages of a stall, local airflow separation results in buffeting (initial buffet), giving a natural warning of an approach to stall. Recovery from an approach to stall should be initiated at the earliest recognizable stall warning, either initial buffet or stall warning.

An aircraft may be stalled in any attitude (nose high, nose low, high or low angle of bank) or any airspeed (turning, accelerated stall). It is not always intuitively obvious that the aircraft is stalled.

An aircraft stall is characterized by one or more of the following conditions:

- stall warning;
- buffeting, which could be heavy;
- lack of pitch authority;
- lack of roll control; and
- inability to arrest descent rate.

In normal law the flight control system is designed to prevent stall conditions. In alternate law, stall warning is considered to be a warning readily identifiable by the pilot, either by initial buffet or artificial voice (“STALL, STALL”). During initial stages of stall, local airflow separation results in buffeting (initial buffet), giving natural warning of an approach to stall. Initiate recovery from an approach to stall at the earliest recognizable stall warning, either initial buffet or stall warning.



Stall or Approach to Stall Recovery

To initiate the recovery, the angle of attack must be reduced below the wing stalling angle. Nose down pitch control must be applied and maintained until the wings are unstalled. Application of forward control stick (as much as full forward may be required) should provide sufficient elevator control to produce a nose-down pitch rate.

Note: With high thrust engines, low airspeed coupled with high thrust settings may result in a condition where elevator authority is not adequate. This is because aircraft with underwing-mounted engines have a nose-up pitch moment relative to increased thrust.

Note: If clean up is required, do not change the configuration of the aircraft until the airspeed is at VLS and accelerating. When above VLS and a positive climb is indicated, the gear may be retracted. Retract the flaps on the normal schedule, and when in a clean configuration retard the thrust levers to maintain level flight and Green Dot airspeed.

The Stall or Approach to Stall Recovery maneuver calls for the crew to advance the thrust levers as needed. Under certain conditions, where high thrust settings are already applied such as during takeoff or go-around, it may be necessary to reduce thrust in order to prevent the angle of attack from continuing to increase. This is because aircraft with underwing-mounted engines have a nose-up pitch moment relative to increased thrust.

Note: Use care during recovery from a nose low attitude after the buffet and/or stall warning have stopped. If the pull up is too aggressive, a “secondary” stall or sustained stick shaker may result.

If pitch control inputs do not stop an increasing pitch rate in a nose high situation, rolling the airplane to a bank angle that starts the nose down may be effective. Bank angles of about 45°, up to a maximum of 60°, could be needed. Normal roll controls, up to full deflection of ailerons and spoilers, may be used. Unloading the wing by maintaining continuous nose-down elevator pressure keeps the wing angle of attack as low as possible, making the normal roll controls as effective as possible.

Finally, if normal pitch control then roll control is ineffective, careful rudder input in the direction of the desired roll may be required to initiate a rolling maneuver recovery.

Do not change gear or flap configuration during the recovery, unless a stall warning indication is encountered during liftoff and the flaps were inadvertently positioned up for takeoff. In this case, extend flaps 1 as directed in the Stall or Approach to Stall Recovery maneuver.



High Altitude Recovery

At higher altitudes, normally above 20,000 feet, the aircraft becomes increasingly thrust limited. If an approach to stall indication is experienced, forward side stick is required to decrease the angle of attack and initiate a descent while accelerating. This is because when the aircraft is thrust limited, altitude needs to be traded for airspeed. Therefore a recovery at high altitude results in a greater altitude loss than a recovery at low altitudes.

Stall Protection Demonstration

Begin the stall protection demonstration in level flight with flaps up at Green Dot speed. To demonstrate autopilot stall protection, select a speed in the IAS/MACH window that is below the minimum speed indication on the speed tape. Disengage autothrust by retarding the thrust levers to idle and ensure the pitch mode is ALT.

As the airplane slows to alpha PROT (the top of the black and amber barber poll on the speed tape) high AOA protection engages. High AOA protection enables the PF to pull the sidestick full aft in dangerous situations, and thus consistently achieve the best possible aircraft lift. This action on the sidestick is instinctive, and the high AOA protection minimizes the risk of stalls or control loss.

When high AOA protection is active:

- The autopilot will disconnect.
- Elevator control switches to a protection mode in which the angle-of-attack is proportional to the sidestick deflection.
- The PF will notice if the normal flight envelope is exceeded for any reason, because the auto pitch trim will stop, the aircraft will sink to maintain its current AOA (alpha PROT, strong static stability), and a significant change in aircraft behavior will occur.
- If the PF then pulls the sidestick full aft, a maximum AOA (approximately corresponding to CLMAX) is commanded. In addition, the speedbrakes will automatically retract, if extended.

If level flight is held, and the airplane continues to slow, alpha MAX may be reached. In normal law the airplane will not fly slower than alpha MAX even if the sidestick is held fully aft.

Low Energy Warning

The “SPEED, SPEED, SPEED” aural warning is a low energy alert that considers aircraft configuration, deceleration rate, and flight path angle. It is triggered prior to alpha floor, and indicates that it is not possible to recover a positive flight path (i.e., level off) with pitch control alone. The warning is repeated every 5 seconds as long as thrust has not been sufficiently increased.



A319/320/321 Flight Crew Training Manual

The warning is available in Normal law in the following situations:

- below 2000 feet.
- above 100 ft RA.
- in CONF 2, 3, and full.

If this warning activates:

Pilot Flying	Pilot Monitoring
Immediately decrease sink rate, increase thrust, or perform a go-around.	

Alpha Floor Recovery

To aid in recovering from high angle-of-attack conditions, an autothrust mode, alpha floor, is provided. Alpha floor provides TOGA thrust automatically under the following conditions:

- an excessively high angle of attack (alpha),
- excessively high nose up attitudes combined with specific sidestick inputs, or
- indirectly, as a result of windshear.

Under most flight regimes, the pilot can expect an alpha floor engagement to occur approximately half way between Alpha Prot and Alpha Max.

Alpha floor can be activated any time above 100 feet AGL when in normal law regardless of the status of the A/THR system (assuming it is functioning) or position of the thrust levers.



Indications

Indications that alpha floor has been activated are:

- Thrust goes to TOGA,
- A. FLOOR appears in column 1 of the FMA,
- A. FLOOR appears on the E/WD, and
- A/THR appears in blue in column 5 indicating that the A/THR is armed.

Delta Air Lines’ operating procedures are designed to keep the aircraft well away from the threshold where alpha floor becomes active. The exception may be a clean wing approach where maneuvering margins are small.

Should the situation arise where alpha floor protection is activated, pilots must realize that the aircraft is making thrust inputs independently. Autothrust automatically engages and the thrust goes to TOGA. Once the unsafe condition abates, the pilot must take immediate and positive steps to return the aircraft to its normal flight envelope.

If alpha floor is activated (A. FLOOR in column one of the FMA and in the upper right corner of the E/WD) the aircraft is independently commanding TOGA thrust. Once the ‘unsafe’ condition abates, the pilot must take immediate and positive steps to return the aircraft to its normal flight envelope.

Pilot Flying	Pilot Monitoring
• Advance thrust levers to TOGA. • Simultaneously adjust pitch attitude as necessary. • Level the wings. • Depress the ‘instinctive’ disconnect pb to disconnect autothrust. • When the aircraft has been returned to normal conditions manually retard the thrust levers to maintain desired airspeed. • Reengage the autothrust (if desired) and place the thrust levers in the CL detent.	• Confirm the airspeed is above alpha protection and increasing. • Confirm the airspeed is above VLS before initiating any configuration changes. • Confirm a positive climb before retracting the gear.



Steep Turns and Bank Angle Protection

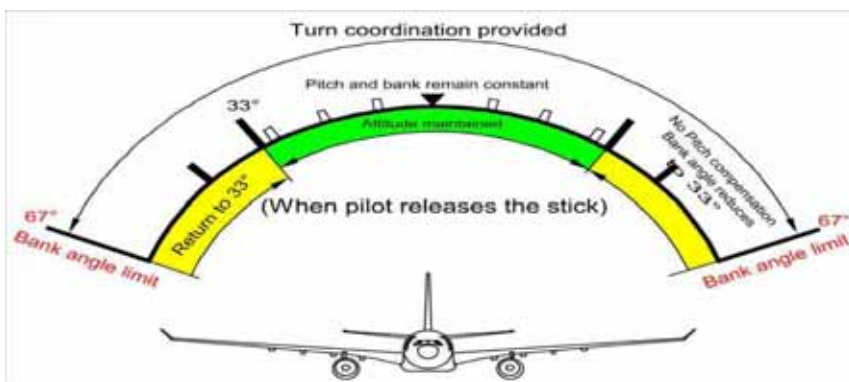
The objective of the steep turn maneuver is to familiarize the pilot with aircraft handling characteristics beyond 33° of bank, build confidence in hand flying the aircraft, and improve the instrument crosscheck. During training, 45° of bank is used for this maneuver. It is not intended that the pilot should ever be required to bank greater than 25° to 30° in any normal or non-normal condition.

Entry

Use the autothrust to stabilize at a selected speed of 250 knots and on a selected heading and altitude. Disconnect the autothrust and autoflight systems and turn off flight directors. Roll into the turn using the same techniques as a normal turn entry.

During Turn

For up to 33° of bank, the aircraft uses normal control laws to maintain trim for 1g flight. Beyond 33° of bank, the automatic pitch trim stops working and the flight control laws attempt to roll the wings back to a 33° bank angle. The stick forces becomes progressively stronger as the bank angle increases. Maintain a 45° of bank and 250 knots in level flight. As drag increases from the increased pitch angle, a slight increase in thrust is needed to maintain airspeed. In practical terms, the 45° bank turn will require approximately a 2° to 3° increase in pitch and an additional 8% to 10% N1.



Attitude Indicator

The attitude indicator is reliable for accurate pitch and bank information throughout the turn. Precession error does not exist because the ADIRS is the source of attitude information. If desired, the flight path vector (FPV) may be used to assist in positive aircraft control. Since the symbol is the aircraft's velocity vector, center the FPV circle on the horizon line of the PFD to maintain level flight.

Vertical Speed Indicator

ADIRS vertical speed indications provide immediate trend information.

Altimeter

Crosscheck the direction and rate of change, and make smooth minor adjustments to the pitch attitude for corrections.

Airspeed

Airspeed changes very slowly because of small changes in thrust and drag. Anticipate thrust changes and apply them at the first indication of change on the airspeed indicator speed tape and trend arrow. An increase in thrust is required as bank angle increases.

Rollout

Roll out at the same rate as used during normal turns. Normally rollout should begin 15° to 20° prior to the desired heading. A decrease in pitch is required as the bank angle is decreased to maintain constant altitude. As the aircraft returns to less than 33° of bank the sidestick commands 1g flight and the trim returns to normal. Reducing below 33° of bank simply requires bank input to return to wings level flight. When the aircraft has returned to normal flight and stabilized on the desired heading, restore the autoflight systems as desired. A decrease in thrust is required to maintain constant airspeed.

Bank Angle Protection

With the autopilot OFF, initiate a turn beyond 33° of bank. Release the roll input and the protection system returns the airplane back to 33° of bank or less.

Note: When flying with bank angle more than 33° the pilot must add control stick back pressure to maintain level flight.



Terrain Avoidance

The Ground Proximity Warning System (GPWS) PULL UP Warning occurs when an unsafe distance or closure rate is detected with terrain below the aircraft. The EGPWS/Look-ahead terrain alerting also provides an aural warning when an unsafe distance is detected from terrain ahead of the aircraft. If either of these occur, immediately accomplish the Terrain Avoidance maneuver.

Do not attempt to engage the autopilot and/or autothrust until terrain clearance is assured.

Terrain Avoidance Maneuver

Ground Proximity Caution

Accomplish the following maneuver for any of these aural alerts:

- SINK RATE
- TERRAIN AHEAD
- DON'T SINK
- TOO LOW FLAPS
- TOO LOW GEAR
- TOO LOW TERRAIN
- GLIDESLOPE
- AVOID TERRAIN
- TERRAIN, TERRAIN

Pilot Flying	Pilot Monitoring
Immediately adjust the flight path or initiate a go-around.	

The below glideslope deviation alert may be cancelled or inhibited for:

- localizer or LDA without glideslope approach
- circling approach from an ILS
- when conditions require a deliberate approach below glideslope
- unreliable glideslope signal.

Note: If a terrain caution occurs when flying under daylight VMC, and positive visual verification is made that no obstacle or terrain hazard exists, the alert may be regarded as cautionary and the approach may be continued.



Ground Proximity Warning

Accomplish the following maneuver for any of these conditions:

- Activation of "TERRAIN, TERRAIN PULL UP" or "WHOOPEE, PULL UP" warning.
- Other situations resulting in unacceptable flight toward terrain.

Pilot Flying	Pilot Monitoring
Disconnect autopilot. Pitch up using full back stick. Disregard the flight directors. CAUTION: Use caution when in degraded flight control law, stall protection is lost. Advance the thrust levers to their forward limit (TOGA). Ensure speedbrakes are retracted. Level the wings CAUTION: Bank may be adjusted to avoid the terrain displayed on the ND for a "TERRAIN AHEAD" warning only.	Verify maximum thrust. Verify all required actions have been completed and call out any omissions. Verify speedbrakes are retracted.
Do not change gear or flap configuration until terrain separation is assured. Monitor radio altimeter for sustained or increasing terrain separation. When terrain clearance is assured, return the thrust levers to the CL detent and restore the autoflight systems as desired. If the GPWS recovery occurred at flaps 1 or greater, the FMS will be in the go-around phase.	Monitor vertical speed and altitude (radio altitude for terrain clearance and barometric altitude for a minimum safe altitude.) Call out any trend toward terrain contact. Call out "ALPHA FLOOR" if alpha floor activates.

Note: If positive visual verification is made that no obstacle or terrain hazard exists when flying under daylight VMC conditions prior to a terrain or obstacle warning, the alert may be regarded as cautionary and the approach may be continued.



Terrain Avoidance - RNAV (RNP) AR

During RNAV (RNP) AR operations in close proximity to terrain on departure or approach, crews may experience occasional momentary terrain caution-level alerts. If these alerts are of short duration and have ceased, crews should verify they are on the required path and consider continuing the procedure. Depending upon where initiation occurs, the risks of terrain contact while executing a terrain avoidance maneuver may be higher than continuing on the required track.

Terrain warning-level alerts always require immediate action. The most appropriate crew actions regarding aircraft bank angle and track during a terrain avoidance maneuver depend on where the maneuver is initiated.

Traffic Alert and Collision Avoidance System

The Traffic Alert and Collision Avoidance System (TCAS) is designed to enhance crew awareness of nearby traffic and issue advisories for timely visual acquisition or appropriate vertical flight path maneuvers to avoid potential collisions. It is intended as a backup to visual collision avoidance, application of right-of-way rules, and ATC separation.

TCAS Maneuver

Immediately accomplish the following by recall whenever a TCAS traffic advisory (TA) or resolution advisory (RA) occurs.

WARNING: Comply with RA if there is conflict between RA and air traffic control. Inform ATC of “TCAS RA” as soon as practicable after responding to the RA. When the RA is clear, the flight crew should advise ATC they are CLEAR OF CONFLICT, RETURNING TO (assigned clearance) or CLEAR OF CONFLICT, (assigned clearance) RESUMED.

WARNING: Once an RA has been issued, safe separation could be compromised if current vertical speed is changed, except as necessary to comply with the RA. This is because TCAS II-to-TCAS II coordination may be in progress with the intruder aircraft, and any change in vertical speed that does not comply with the RA may negate the effectiveness of the others aircraft’s compliance with the RA.

Note: Maneuvers based solely on a TA may result in reduced separation and are not recommended.

Note: Turn off both flight directors until clear of conflict for an RA only if maneuvering is required. For a TA, the flight directors do not need to be turned off.



A319/320/321 Flight Crew Training Manual

For TA:

Pilot Flying	Pilot Monitoring
Look for traffic using traffic display as a guide. Call out any conflicting traffic.	
If traffic is sighted, maneuver as required.	

For RA, except a climb in landing configuration:

Pilot Flying	Pilot Monitoring
Both pilots visually clear the airspace in the direction of the maneuver.	
If maneuvering is required, Disconnect the autopilot. Command the PM to turn off both flight directors if maneuvering is required. Note: Turning off both flight directors places the autothrust in the SPEED mode. Smoothly adjust pitch (and thrust, if necessary) to satisfy the RA commands. Continue to follow the planned lateral flight path unless visual contact with the conflicting traffic requires other action. When TCAS advises "CLEAR OF CONFLICT", smoothly maneuver back to the ATC cleared altitude. Re-establish the autopilot, flight director and autothrust, as desired.	Turn off both flight directors if maneuvering is required. Notify ATC of the RA maneuver as soon as possible. If necessary, coordinate with ATC for further clearance.
Attempt visual contact. Call out any conflicting traffic. Visual acquisition of traffic may be misleading and does not guarantee separation. Pilots shall comply with RA guidance until clear of conflict unless doing so would clearly impose a greater risk.	



Use of TA/RA, TA Only, and Transponder Only Modes

TCAS operation should be initiated in accordance with local policy or just before takeoff and continued until just after landing. Whenever practical, the system should be operated in the TA/RA mode to maximize system benefits. Operations in the Traffic Advisory (TA) Only or TCAS Off (Transponder Only) modes, to prevent nuisance advisories and display clutter, should be in accordance with published normal or non-normal procedures.

The responsibility for avoiding collisions still remains with the flight crew and ATC. Pilots should not become preoccupied with TCAS advisories and displays at the expense of basic aircraft control, normal visual lookout, and other crew duties.

Traffic Advisory

A Traffic Advisory (TA) occurs when nearby traffic meets system minimum separation criteria, and is indicated aurally and visually on the TCAS traffic display. A goal of the TA is to alert the pilot of the possibility of an RA. If a TA is received, immediately accomplish the TCAS Maneuver.

Maneuvers based solely on a TA may result in reduced separation and are not recommended.

The TA ONLY mode is appropriate under the following circumstances:

- when directed by a Delta Special Page, or
- when directed by an NNC.
- when directed by flight plan remark.

Resolution Advisory

When TCAS determines that separation from approaching traffic may not be sufficient, TCAS issues a Resolution Advisory (RA) aural warning and a pitch command. Maneuvering is required whenever the vertical velocity indicator is in the red region on the PFD vertical speed tape. Flight crews should follow RA commands using established procedures unless doing so would jeopardize the safe operation of the aircraft. If an RA is received, immediately accomplish the TCAS maneuver.

Note: Pilots are authorized to deviate from their current ATC clearance to the extent necessary to comply with a TCAS resolution advisory.

Resolution advisories are known to occur more frequently at locations where traffic frequently converges (e.g. waypoints). This is especially true in RVSM airspace. Climb or descent profiles should not be modified in anticipation of avoiding an RA unless specifically requested by ATC.



RA maneuvers require only small pitch attitude changes which should be accomplished smoothly and without delay. Properly executed, the RA maneuver is mild and does not require large or abrupt control movements. Remember that the passengers and flight attendants may not all be seated during this maneuver. The flight director is not affected by TCAS guidance. Therefore, when complying with an RA that requires maneuvering, flight director will be selected off.

There have been reports of some flight crews responding incorrectly to the RA “MONITOR VERTICAL SPEED” by increasing rather than decreasing vertical speed. Flight crews should be aware that a “MONITOR VERTICAL SPEED” always requires a reduction in vertical speed.

During the RA maneuver, the aircrew attempts to establish visual contact with the target. However, visual perception of the encounter can be misleading, particularly at night. The traffic acquired visually may not be the same traffic causing the RA.

Note: Comply with any TCAS RA guidance even when visual contact with the “intruder” aircraft has been established, unless doing so would clearly impose a greater risk.

Pilots should maintain situational awareness since TCAS may issue RAs in conflict with terrain considerations, such as during approaches into rising terrain or during an obstacle limited climb. Continue to follow the planned lateral flight path unless visual contact with the conflicting traffic requires other action. Windshear, EGPWS, and stall warnings take precedence over TCAS advisories. Complying with RAs may result in brief exceedance of altitude and/or placard limits. However, even at the limits of the operating envelope, in most cases sufficient performance is available to safely maneuver the aircraft. Smoothly and expeditiously return to appropriate altitudes and speeds when clear of conflict. Maneuvering opposite to an RA command is not recommended since TCAS may be coordinating maneuvers with other aircraft.



Upset Recovery

An upset can generally be defined as unintentionally exceeding the following conditions:

- pitch attitude greater than 25° nose up, or
- pitch attitude greater than 10° nose down, or
- bank angle greater than 45°, or
- within above parameters but flying at airspeeds inappropriate for the conditions.

The following techniques represent a logical progression for recovering the airplane. The sequence of actions is for guidance only and represents a series of options to be considered and used depending on the situation. Not all actions may be necessary once recovery is under way. Careful use of rudder to aid roll control should be considered only if roll control is ineffective and the airplane is not stalled.

These techniques assume that the airplane is not stalled. A stalled condition can exist at any attitude and may be recognized by one or more of the following:

- buffeting which could be heavy at times,
- lack of pitch authority and/or roll control, and
- inability to arrest descent rate.

If the airplane is stalled, recovery from the stall must be accomplished first by applying and maintaining nose down elevator until stall recovery is complete.

Nose High Recovery

Pilot Flying	Pilot Monitoring
• Recognize and confirm the situation.	
• Disconnect autopilot and autothrust. • Apply as much as full forward sidestick. • Adjust thrust as necessary. • Roll (adjust bank angle) to obtain a nose down pitch rate • Complete the recovery: - When approaching the horizon, roll to wings level - Check airspeed and adjust thrust - Establish pitch attitude.	• Call out attitude, airspeed and altitude throughout the recovery • Verify all required actions have been completed and call out any omissions.



Nose Low Recovery

Pilot Flying	Pilot Monitoring
Recognize and confirm the situation.	
- Disconnect autopilot and autothrust. - Reduce thrust, if required. - Roll in shortest direction to wings level - Recover to level flight: - Adjust thrust and drag as required.	- Call out attitude, airspeed and altitude throughout the recovery - Verify all required actions have been completed and call out any omissions.

WARNING: * Excessive use of rudder may aggravate an upset situation or may result in loss of control and/or high structural loads.

General

Though flight crews in line operation rarely, if ever, encounter an upset situation, understanding how to apply aerodynamic fundamentals in such a situation helps them control the aircraft. Normal law's protections attempt to limit pitch and bank, but if these limits are exceeded due to outside forces, abnormal attitude law becomes active. Abnormal attitude law ensures that flight control laws do not prevent or interfere with the recovery from unusual attitudes. Automatic pitch trim and yaw damping is inhibited until the aircraft is restored to a normal attitude. Stick forces may be higher than normal during the recovery. The flight control laws will remain in alternate law even after the landing gear is extended. Several techniques are available for recovering from an upset. In most situations, if a technique is effective, it is not recommended that pilots use additional techniques. Several of these techniques are discussed in the example scenarios below:

- nose high, wings level
- nose low, wings level
- high bank angles
- nose high, high bank angles, and
- nose low, high bank angles.

Note: Higher than normal control forces may be required to control the aircraft attitude when recovering from upset situations. Be prepared to use a firm and continuous force on the sidestick to complete the recovery.

**A319/320/321 Flight Crew Training Manual**

Nose High, Wings Level

In a situation where the aircraft pitch attitude is unintentionally more than 25° nose high and increasing, the airspeed is decreasing rapidly. As airspeed decreases, the pilot's ability to maneuver the aircraft also decreases. Further complicating this situation, as the airspeed decreases, the pilot could intuitively make a large thrust increase. This causes an additional pitch up. At full thrust settings and very low airspeeds, the elevator, working in opposition to the stabilizer, has limited control to reduce the pitch attitude.

In this situation the pilot should trade altitude for airspeed, and maneuver the aircraft's flight path back toward the horizon. This is accomplished by the input of up to full forward sidestick. These actions should provide sufficient elevator control power to produce a nose-down pitch rate. Because a large nose-down pitch rate results in a condition of less than 1 g, at this point the pitch rate should be controlled by modifying control inputs to maintain between 0 g and 1 g. If altitude permits, flight tests have determined that an effective way to achieve a nose-down pitch rate is to reduce some thrust.

If normal pitch control inputs do not stop an increasing pitch rate, rolling the aircraft to a bank angle that starts the nose down should work. Bank angles of about 45°, up to a maximum of 60°, could be needed. Unloading the wing by maintaining continuous nose-down elevator pressure keeps the wing angle of attack as low as possible, making the normal roll controls as effective as possible. The rolling maneuver changes the pitch rate into a turning maneuver, allowing the pitch to decrease. Finally, if normal pitch control then roll control is ineffective, careful rudder input in the direction of the desired roll may be required to induce a rolling maneuver for recovery.

Only a small amount of rudder is needed. Too much rudder applied too quickly or held too long may result in loss of lateral and directional control. Because of the low energy condition, pilots should exercise caution when applying rudder.

The reduced pitch attitude allows airspeed to increase, thereby improving elevator and aileron control effectiveness. After the pitch attitude and airspeed return to a desired range the pilot can reduce angle of bank with normal lateral flight controls and return the aircraft to normal flight.



Nose Low, Wings Level

In a situation where the aircraft pitch attitude is unintentionally more than 10° nose low and going lower, the airspeed is increasing rapidly. A pilot would likely reduce thrust and extend the speedbrakes. Thrust reduction causes an additional nose-down pitching moment. Speedbrake extension causes a nose-up pitching moment, an increase in drag, and a decrease in lift for the same angle of attack. At airspeeds well above VMO/MMO, the ability to command a nose-up pitch rate with elevator may be reduced because of the extreme aerodynamic loads on the elevator.

Again, it is necessary to maneuver the aircraft's flight path back toward the horizon. At moderate pitch attitudes, applying up to full back sidestick, reducing thrust, and extending speedbrakes, if necessary, changes the pitch attitude to a desired range.

High Bank Angles

A high bank angle is one beyond that necessary for normal flight. Though the bank angle for an upset has been defined as unintentionally more than 45°, it is possible to experience bank angles greater than 90°.

Any time the aircraft is not in “zero-angle-of-bank” flight, lift created by the wings is not being fully applied against gravity, and more than 1 g is required for level flight. At bank angles greater than 67°, level flight cannot be maintained within AFM load factor limits. In high bank angle increasing airspeed situations, the primary objective is to maneuver the lift of the aircraft to directly oppose the force of gravity by rolling in the shortest direction to wings level. Applying nose-up elevator at bank angles above 60° causes no appreciable change in pitch attitude and may exceed normal structure load limits as well as the wing angle of attack for stall. The closer the lift vector is to vertical (wings level), the more effective the applied g is in recovering the aircraft.

A smooth application of up to full lateral control should provide enough roll control power to establish a very positive recovery roll rate. If full roll control application is not satisfactory, it may even be necessary to apply some rudder in the direction of the desired roll.

Only a small amount of rudder is needed. Too much rudder applied too quickly or held too long may result in loss of lateral and directional control or structural failure.



Nose High, High Bank Angles

A nose high, high angle of bank upset requires deliberate flight control inputs. A large bank angle is helpful in reducing excessively high pitch attitudes. The pilot must apply nose-down elevator and adjust the bank angle to achieve the desired rate of pitch reduction while considering energy management. Once the pitch attitude has been reduced to the desired level, it is necessary only to reduce the bank angle, ensure that sufficient airspeed has been achieved, and return the aircraft to level flight.

Nose Low, High Bank Angles

The nose low, high angle of bank upset requires prompt action by the pilot as altitude is rapidly being exchanged for airspeed. Even if the aircraft is at a high enough altitude that ground impact is not an immediate concern, airspeed can rapidly increase beyond aircraft design limits. Simultaneous application of roll and adjustment of thrust may be necessary. It may be necessary to apply nose-down elevator to limit the amount of lift, which will be acting toward the ground if the bank angle exceeds 90°. This also reduces wing angle of attack to improve roll capability. Full aileron and spoiler input should be used if necessary to smoothly establish a recovery roll rate toward the nearest horizon. It is important to not increase g force or use nose-up elevator or stabilizer until approaching wings level. The pilot should also extend the speedbrakes as needed.

Upset Recovery Techniques

It is possible to consolidate and incorporate recovery techniques into two basic scenarios, nose high and nose low, and to acknowledge the potential for high bank angles in each scenario described above. Other crew actions such as recognizing the upset, reducing automation, and completing the recovery are included in these techniques. The recommended techniques provide a logical progression for recovering an aircraft.

If an upset situation is recognized, immediately accomplish the Upset Recovery maneuver.

Windshear

General

Windshear is a change of wind speed and/or direction over a short distance along the flight path.

Improper or ineffective vertical flight path control has been one of the primary factors in many cases of flight into terrain. Low-altitude windshear encounters are especially significant because windshear can place the crew in a situation which requires the maximum performance capability of the aircraft. Windshear encounters near the ground are the most threatening because there is very little time or altitude to respond to and recover from an encounter.

Avoidance

The flight crew should search for any clues to the presence of windshear along the intended flight path. Presence of windshear may be indicated by:

- thunderstorm activity
- virga (rain that evaporates before reaching the ground)
- pilot reports
- low level windshear alerting system (LLWAS) warnings.

Stay clear of thunderstorm cells and heavy precipitation and areas of known windshear. If the presence of windshear is confirmed, delay takeoff or do not continue an approach.

Precautions

If windshear is suspected, be alert to any of the danger signals and be prepared for the possibility of an inadvertent encounter. The following precautionary actions are recommended:

Takeoff

- Use TOGA thrust.
- Use the longest suitable runway provided it is clear of areas of known windshear.
- Be alert for any airspeed fluctuations during takeoff and initial climb. Such fluctuations may be the first indication of windshear.



A319/320/321 Flight Crew Training Manual

- Know the all-engine initial climb pitch attitude (17.5°). Rotate at normal rate to this attitude for all non-engine failure takeoffs. Follow flight director guidance when available. Refer to chapter 3, Gusty Wind and Strong Crosswind Conditions for additional guidance.
- Crew coordination and awareness are very important. Develop an awareness of normal values of airspeed, attitude, vertical speed, and airspeed build-up. Closely monitor vertical flight path instruments such as vertical speed and altimeters. The PM should be especially aware of vertical flight path instruments and call out any deviations from normal.

Approach and Landing

- Consider a flaps 3 landing.
- Establish a stabilized approach no lower than 1,000 feet above the airport to improve windshear recognition capability.
- Use the most suitable runway that avoids the areas of suspected windshear and is compatible with crosswind or tailwind limitations. Use ILS G/S, G/P, VDEV path or VASI/PAPI indications to detect flight path deviations and help with timely detection of windshear.
- If the autothrust is disengaged, avoid large thrust reductions in response to sudden airspeed increases as these may be followed by airspeed decreases.
- Crosscheck F/D commands using vertical flight path instruments
- Crew coordination and awareness are very important, particularly at night or in marginal weather conditions. Closely monitor the vertical flight path instruments such as vertical speed, altimeters, and glideslope displacement. The pilot monitoring should call out any deviations from normal. Use of autopilot and autothrust for the approach may provide more monitoring and recognition time.

Recovery

Accomplish the windshear escape maneuver.



Aircraft Performance in Windshear

Knowledge of how windshear affects aircraft performance can be essential to the successful application of the proper vertical flight path control techniques during a windshear encounter.

The wind component is mostly horizontal at altitudes below 500 feet. Horizontal windshear may improve or degrade vertical flight path performance. Windshear that improves performance is first indicated in the flight deck by an increasing airspeed. This type of windshear may be a precursor of a shear that decreases airspeed and degrades vertical flight path performance.

Airspeed decreases if the tailwind increases, or headwind decreases, faster than the aircraft is accelerating. As the airspeed decreases, the aircraft normally tends to pitch down to maintain or regain the in-trim speed. The magnitude of pitch change is a function of the encountered airspeed change. If the pilot attempts to regain lost airspeed by lowering the nose, the combination of decreasing airspeed and decreasing pitch attitude produces a high rate of descent. Unless this is countered by the pilot, a critical flight path control situation may develop very rapidly. As little as 5 seconds may be available to recognize and react to a degrading vertical flight path.

In critical low altitude situations, trade airspeed for altitude, if possible. An increase in pitch attitude, even though the airspeed may be decreasing, increases the lifting force and improves the flight path angle. Proper pitch control, combined with maximum available thrust, utilizes the total aircraft performance capability. In normal law the sidestick can be held full aft and the aircraft will not stall.

Windshear Encounter Recognition

Note: The following are indications the airplane is encountering a windshear:

- Windshear Warning (WINDSHEAR message will appear in red on both PFDs along with “WINDSHEAR, WINDSHEAR, WINDSHEAR”)
- unacceptable flight path deviations.

Note: Unacceptable flight path deviations are recognized as uncontrolled changes from normal steady state flight conditions below 1,000 feet AGL, in excess of any of the following:

- 15 knots indicated airspeed
- 500 fpm vertical speed
- 5° pitch attitude
- 1 dot displacement from the glideslope
- unusual engine thrust setting for a significant period of time.



Windshear Escape Maneuver

Pilot Flying	Pilot Monitoring
- Advance the thrust levers to their forward limits (TOGA). - Disconnect Autopilot - Follow the SRS commands. Use full back stick, if necessary to follow the pitch commands. Note: If SRS is unavailable, use pitch attitude up to 17.5°, with full back stick, if necessary.	- Assure TOGA thrust. - Verify all required actions have been completed and call out any omissions. - Monitor and call out the vertical flight path indications (IVSI, radio altimeter).
- Do not change flap or gear configuration until windshear is no longer a factor. - Monitor vertical speed and altitude. - Do not attempt to regain lost airspeed until windshear is no longer a factor.	- Monitor vertical speed and altitude. - Call out any trend toward terrain contact, descending flight path, or significant airspeed changes.

Windshear During Takeoff Roll

Prior to V1

A321

Predictive windshear ("WINDSHEAR AHEAD" aural warning).

- Reject takeoff. (The aural warning is inhibited at speeds greater than 100kts).

At or Near V1

If windshear is encountered prior to V1, there may not be sufficient runway remaining to stop if an RTO is initiated at V1. If the decision is made to continue the takeoff, apply maximum thrust. At VR, rotate at a normal rate following the SRS commands. Once airborne, perform the Windshear Escape Maneuver.

If windshear is encountered near the normal rotation speed and airspeed suddenly decreases, there may not be sufficient runway left to accelerate back to normal takeoff speed. If there is insufficient runway left to stop, ensure maximum thrust, initiate a normal rotation following the SRS commands at least 2,000 feet before the end of the runway even if airspeed is low. Higher than normal attitudes may be required to lift off in the remaining runway. Once airborne, perform the Windshear Escape Maneuver.



Windshear In Flight

After Takeoff

All Aircraft:

If windshear encountered OR reactive "WINDSHEAR, WINDSHEAR" warning:

- Perform Windshear Escape Maneuver

A321:

If Predictive windshear "WINDSHEAR AHEAD" aural warning:

- Select TOGA.
- Closely monitor speed and speed trend.
- Consider changing course to avoid shear.

Note: Configuration change is permitted as long as reactive warning does not occur.

On Approach

All Aircraft:

If windshear encountered OR reactive "WINDSHEAR, WINDSHEAR" warning:

- Perform Windshear Escape Maneuver

A321

If predictive "GO AROUND WINDSHEAR AHEAD" aural warning:

- Go around using TOGA.
- Closely monitor speed and speed trend.

Note: Configuration change is permitted as long as reactive warning does not occur



Post Windshear Considerations

Recover from the Windshear Escape Maneuver when windshear is no longer a factor and terrain clearance is assured, then:

- set thrust and pitch for phase of flight,
- establish aircraft configuration for phase of flight,
- reestablish automation,
- make a Windshear PIREP to ATC, and
- complete the normal checklist (After Takeoff).



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Non-Normal Operations**Table of Contents****Chapter 8****Section TOC**

Non-Normal Situation Guidelines	8.1
Troubleshooting	8.1
Approach and Landing	8.2
Landing at the Nearest Suitable Airport	8.3
Ditching	8.5
Send Distress Signals	8.5
Coast Guard Ditching Recommendations	8.5
Advise Crew and Passengers	8.5
Fuel Burn-Off	8.6
Passenger Cabin Preparation	8.6
Ditching Final	8.6
Initiate Evacuation	8.6
Electrical	8.7
Approach and Landing with Electrical Emergency Configuration	8.7
Engines, APU	8.8
Engine Failure versus Engine Fire After Takeoff	8.8
Engine Tailpipe Fire	8.8
Loss of Engine Thrust Control	8.9
Dual Engine Failure	8.9
High Engine Vibration	8.10
Recommended Technique for an In-Flight Engine Shutdown	8.10
Bird Strikes	8.11
EGT OVERLIMIT (Exceedance) During Takeoff	8.12
Evacuation	8.13
Method of Evacuation	8.13
Discharging Fire Bottles during an Evacuation	8.14

Emergency Landing Preparation	8.14
Flight Crew Duties Summary For Emergency Landing/ Ditching Evacuation.	8.15
Flight Controls.	8.16
Leading Edge or Trailing Edge Device Malfunctions	8.16
Jammed Stabilizer	8.18
Flight Instruments, Displays	8.19
Airspeed Unreliable	8.19
Fuel	8.21
Fuel Balance	8.21
Fuel Leak	8.22
Low Fuel	8.23
Hydraulics	8.24
Single Hydraulic System Failure	8.24
Dual Hydraulic System Failure	8.24
Landing Gear.	8.26
Braking with Antiskid Inoperative	8.26
Brake Malfunctions	8.26
Tire Failure during or after Takeoff.	8.26
Landing on a Flat Tire	8.27
Landing with Abnormal Landing Gear	8.28
Overspeed	8.29
Smoke/Fumes Principles.	8.31
General	8.31
Known Source	8.31
Unknown Source	8.31

A319/320/321 Flight Crew Training Manual

Smoke/Fumes Priorities	8.32
General	8.32
Priorities	8.32
Warning Systems	8.33
Windows	8.33
Window Damage	8.33
Flight with the Side Window(s) Open	8.33
Situations Beyond the Scope of Non-Normal Checklists	8.34
Basic Aerodynamics and Systems Knowledge	8.34
Flight Path Control	8.35
Checklists with Memory Steps	8.36
Communications	8.36
Damage Assessment and Aircraft Handling Evaluation	8.36
Landing Airport	8.37

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Non-Normal Situation Guidelines

When a non-normal situation occurs, the following guidelines apply:

- **NON-NORMAL RECOGNITION:** The crewmember recognizing the malfunction calls it out clearly and precisely.
- **MAINTAIN AIRCRAFT CONTROL:** It is mandatory that the Pilot Flying (PF) fly the aircraft while the Pilot Monitoring (PM) accomplishes the ECAM and QRH. Maximum use of the autoflight system is recommended to reduce crew workload.
- **ANALYZE THE SITUATION:** NNCs should be accomplished, time permitting, only after the ECAM procedure has been completed. Review all ECAM messages to positively identify the malfunctioning system(s).

Note: Pilots should don oxygen masks and establish crew communications any time oxygen deprivation or air contamination is suspected, even though an associated warning has not occurred.

- **TAKE THE PROPER ACTION:** Although some in-flight non-normal situations require immediate corrective action, difficulties can be compounded by the rate the PF issues commands and the speed of execution by the PM. Commands must be clear and concise, allowing time for acknowledgment of each command prior to issuing further commands. The PF must exercise positive control by allowing time for acknowledgment and execution. The other crewmembers must be certain their reports to the PF are clear and concise, neither exaggerating nor understating the nature of the non-normal situation. This eliminates confusion and ensures efficient, effective, and expeditious handling of the non-normal situation.
- **EVALUATE THE NEED TO LAND:** If the ECAM directs the crew to “LAND ASAP” in red, plan on landing at the nearest suitable airport where a safe landing can be accomplished. If the NNC or the Non-Normal Checklist Instructions do not direct landing at the nearest suitable airport, the pilot must determine if continued flight to destination may compromise safety.

Refer to FOM, chapter 12.

Troubleshooting

Troubleshooting can be defined as:

- taking steps beyond a published NNC in an effort to improve or correct a non-normal condition,
- initiating an annunciated checklist without an ECAM message to improve or correct a perceived non-normal condition, and
- initiating diagnostic actions.

Examples of troubleshooting are:

- attempting to reset a system by cycling a system control or circuit breaker when not directed by the NNC,
- using maintenance-level information to diagnose or take action, and
- using switches or controls intended only for maintenance.

Troubleshooting beyond checklist directed actions is rarely helpful and has caused further loss of system function or failure. In some cases, accidents and incidents have resulted. The crew should consider additional actions beyond the checklist only when completion of the published checklist steps clearly results in an unacceptable situation. In the case of aircraft controllability problems when a safe landing is considered unlikely, aircraft handling evaluations with gear, flaps, or speedbrakes extended may be appropriate. In the case of jammed flight controls, do not attempt troubleshooting beyond the actions directed in the NNC unless the aircraft cannot be safely landed with the existing condition. Always comply with NNC actions to the extent possible.

Crew distraction, caused by preoccupation with troubleshooting, has been a key factor in several fuel starvation and CFIT accidents. Complete the NNC as published whenever possible, in particular for flight control malfunctions that are addressed by an NNC. Guidance for situations beyond the scope of the non-normal checklist is provided later in this chapter.

Approach and Landing

When a non-normal situation occurs, a rushed approach can often complicate the situation. Unless circumstances require an immediate landing, complete all corrective actions before beginning the final approach.

For some non-normal situations, the possibility of higher airspeed on approach, longer landing distance, a different flare profile, or a different landing technique should be considered.

Plan an extended straight-in approach with time allocated for the completion of any lengthy NNC steps such as for a flap or slat malfunction. Arm autobrakes and speedbrakes unless precluded by the NNC.

Note: The use of autobrakes is recommended because autobraking may be more effective than maximum manual braking due to timely application upon touchdown and symmetrical braking. When used properly, maximum manual braking provides the shortest stopping distance.

Fly a normal glide path and attempt to land in the normal touchdown zone. After landing, use available deceleration measures to bring the aircraft to a complete stop on the runway. The captain must determine if an immediate evacuation should be accomplished or if the aircraft can be safely taxied off the runway.



Non-Normal Approach Speeds

Occasionally, a non-normal checklist instructs the flight crew to use a speed additive for the approach. To apply the additive, add it to the VLS displayed on the MCDU PERF APPR page (VREF = VLS (FULL)).

The speed additive is always applied to the VAPP with flaps FULL as the selected landing flap configuration. This is true even if the ECAM/QRH guidance indicates that a FLAPS 3 landing is to be performed.

Landing at the Nearest Suitable Airport

“Plan to land at the nearest suitable airport” is a phrase used in the QRH. This section explains the basis for that statement and how it is applied.

In a non-normal situation, the pilot in command, having the authority and responsibility for operation and safety of the flight, must make the decision to continue the flight as planned or divert. In an emergency situation, this authority may include necessary deviations from any regulation to meet the emergency. In all cases, the pilot in command is expected to take a safe course of action.

The QRH and ECAM assists flight crews in the decision making process by displaying the “LAND ASAP” message on the ECAM during some non-normal procedures. If the “LAND ASAP” message is in red, the crew must always consider landing at the nearest suitable airport. If the message is in amber, consideration should be given to landing at the nearest suitable airport. The QRH also has “Land As Soon As Possible” in the non-normal checklists where the situations require a “landing at the nearest suitable airport”.

The regulations regarding an engine failure are specific. Most regulatory agencies specify that the pilot in command of a twin-engine aircraft that has an engine failure or engine shutdown should land at the nearest suitable airport at which a safe landing can be made.

A suitable airport must have adequate facilities and meet certain minimum weather and field conditions. If required to divert to the nearest suitable airport (twin-engine aircraft with an engine failure), the pilot should select the nearest suitable airport “in point of time” or “in terms of time.” In selecting the nearest suitable airport, the pilot in command should consider the suitability of nearby airports in terms of facilities and weather and their proximity to the aircraft position. The pilot in command may determine, based on the nature of the situation and an examination of the relevant factors, that the safest course of action is to divert to a more distant airport than the nearest airport. For example, there is not necessarily a requirement to spiral down to the airport nearest the aircraft's present position if, in the judgment of the pilot in command, it would require equal or less time to continue to another nearby airport. Refer to FOM, chapter 10.1, Engine Failure/Stall/Surge, Considerations, Suitable Airport.



For persistent smoke or a fire which cannot positively be confirmed to be completely extinguished, the safest course of action typically requires the earliest possible descent, landing, and evacuation. This may dictate landing at the nearest airport appropriate for the aircraft type, rather than at the nearest suitable airport normally used for the route segment where the incident occurs.

The MCDU “CLOSEST AIRPORTS” page is a useful tool for determining the nearest airports by both distance and time.



Ditching

When the decision has been made to ditch, complete the Ditching NNC in the QRH.

Refer to the Flight Crew Duties Summary For Emergency Landing/Ditching Evacuation table, this chapter.

Send Distress Signals

Transmit Mayday, current position, course, speed, altitude, situation, intention, time and position of intended touchdown, and type of aircraft using existing air-to-ground frequency. Set transponder code 7700 and, if practical, determine the course to the nearest ship or landfall. Refer to AM, Jeppesen Pages, Distress and Urgency Procedures.

Coast Guard Ditching Recommendations

In a ditching situation, the captain should consider requesting a US Coast Guard Search and Rescue (SAR) aircraft to launch for intercept. Initial contact with SAR may be made on primary HF frequency or 121.5 MHz. To assist SAR aircraft, squawk 7700 unless assigned another code.

The SAR aircraft may intercept 1,000 feet below your aircraft in VFR or 1,000 feet above in IFR. Therefore, the altimeters of each aircraft must be compared prior to intercept to ensure safe vertical separation.

If ditching is unavoidable, the Coast Guard may be able to recommend a ditching heading either through the SAR aircraft or from a surface ship. If possible, ditch in the lee of an island, in a lagoon, or near a ship.

On primary HF, try to obtain information on ship location through USCG, Navy, AMVER, or RCC. If a merchant ship is nearby, attempt to communicate on 4125 or 2182 kHz. USCG and Navy vessels may be able to communicate on 121.5 MHz.

Coast Guard, Navy, and some merchant ships may have the capability of supplying homing signals, radar for intercept, flares for night ditching, and other aids. Standard low frequency homing signal is 410 kHz, giving the call sign, followed by 2 (two) 10 (ten) second dashes.

Advise Crew and Passengers

Alert the crew and the passengers to prepare for ditching. Assign life raft positions (as installed) and order all loose equipment in the aircraft secured. Put on life vests, shoulder harnesses, and seat belts. Do not inflate life vests until after exiting the aircraft.

Fuel Burn-Off

Consider burning off fuel prior to ditching, if the situation permits. This provides greater buoyancy and a lower approach speed. However, do not reduce fuel to a critical amount, as ditching with engine thrust available improves ability to properly control touchdown.

Passenger Cabin Preparation

Confer with cabin personnel either by interphone or by having them report to the flight deck in person to ensure passenger cabin preparations for ditching are complete.

Ditching Final

Transmit final position. Select maximum flaps appropriate for the existing conditions.

Advise the cabin crew of imminent touchdown. On final approach announce ditching is imminent and advise crew and passengers to brace for landing. Maintain airspeed at VAPP. Maintain 200 to 300 fpm rate of descent. Plan to touch down on the windward side and parallel to the waves or swells, if possible. To accomplish the flare and touchdown, rotate smoothly to touchdown attitude of 10° to 12°. Maintain airspeed and rate of descent with thrust.

Initiate Evacuation

After the aircraft has come to rest, proceed to assigned ditching stations and deploy slides/rafts. Evacuate as soon as possible, ensuring all passengers are out of the aircraft.

Note: Be careful not to rip or puncture the slides/rafts. Avoid drifting into or under parts of the aircraft. Remain clear of fuel-saturated water.



Electrical

Approach and Landing with Electrical Emergency Configuration

The probability of a total and unrecoverable AC power failure is remote.

The following guidelines should be considered if power to AC BUS 1 and 2 can not be restored.

When power is lost to both AC BUS 1 and 2, the RAT extends automatically. The RAT powers the blue hydraulic system which drives the emergency generator. The emergency generator supplies power to both AC and DC ESS Buses.

On A320 aircraft, when the landing gear is lowered, the emergency generator disconnects from the electrical network. The electrical network automatically transfers to battery power and power to the AC and DC ESS Shed Buses is lost. On A319 aircraft, the emergency generator remains connected to the network as long as the airspeed remains above 100 knots.

Only the captain's flight instruments and FMGC are powered during the emergency configuration. However, when the landing gear is extended on the A320, FMGC 1 loses electrical power. The QRH checklist prepares the crews for the loss of FMGC 1 by having the crew manually set the landing field elevation, RMP tune the nav aids, and directing the crew to calculate and maintain a selected speed for the approach. These items should be accomplished prior to lowering the landing gear.

The captain will be the PF and the aircraft will be flown without the use of autopilot, autothrust, or flight directors. The control laws will degrade to DIRECT LAW when the gear is lowered. It is important to maintain a stabilized approach with proper airspeeds and glidepath. Do not float in the landing flare since landing distances are increased to over two times normal because of higher approach speeds and lack of anti-skid braking. The crew should have a plan on how to communicate limiting brake pressure to 1,000 psi during landing roll out. The aircraft will have to be towed off the runway since nose wheel steering is inoperative.

Engines, APU

Engine Failure versus Engine Fire After Takeoff

The ECAM for an engine failure is normally accomplished after the flaps have been retracted and conditions permit.

An engine with a fire warning immediately after takeoff may still be producing thrust but is handled similar to an engine failure after V1.

- Engage the autopilot when above 100 AGL and at least five seconds after liftoff.
- At 1,000 feet AFE, select V/S to zero.
- Move both thrust levers to the CLB detent.
- Retract the flaps on schedule.
- At Green Dot, select EXPED CLB to initiate a climb.

The captain will then designate one pilot to complete the ENG FIRE ECAM procedure. When the engine is shutdown, move the other thrust lever to MCT when LVR MCT flashes in column one of the FMA.

If the captain deems it necessary, in case of an engine fire, when the aircraft is under control, the gear has been retracted, and a safe altitude has been attained (minimum 400 feet AGL) accomplish the ECAM steps. Due to asymmetric thrust considerations, the PF retards the affected thrust lever after the PM confirms that the PF has identified the correct engine. NNC items should be accomplished on a non-interfering basis with other normal duties after the flaps have been retracted and conditions permit.

Engine Tailpipe Fire

Engine tailpipe fires are typically caused by engine control malfunctions that result in the ignition of pooled fuel. These fires can be damaging to the engine and have caused unplanned evacuations.

If a tailpipe fire is reported, the crew should accomplish the NNC without delay. Flight crews should consider the following when dealing with this situation:

- Motoring the engine is the primary means of extinguishing the fire.
- To prevent an inappropriate evacuation, flight attendants should be notified without significant delay.
- Communications with ramp personnel and the tower are important to determine the status of the tailpipe fire and to request fire extinguishing assistance.
- The engine fire checklist is inappropriate because the engine fire extinguishing agent is not effective against a fire inside the tailpipe.



Loss of Engine Thrust Control

All turbo fan engines are susceptible to this malfunction whether engine control is hydro-mechanical, hydro-mechanical with supervisory electronics (e.g. PMC) or Full Authority Digital Engine Control (FADEC). Engine response to a loss of control varies from engine to engine. Malfunctions have occurred in-flight and on the ground. Engine thrust control malfunctions will be indicated on the ECAM. This condition can occur during any phase of flight.

Since recognition may be difficult, if a loss of engine control is suspected, the flight crew should continue the takeoff or remain airborne until the ECAM and NNC can be accomplished. This helps with directional control and may preclude an inadvertent shutdown of the wrong engine. In some conditions, such as during low speed ground operations, immediate engine shutdown may be necessary to maintain directional control.

Dual Engine Failure

The first indication of the failure of both engines may be the loss of electrical power. The ECAM may display the ELEC EMER CONFIG procedure above of the ENG DUAL FAILURE procedure as it prioritizes malfunctions. The aircraft is capable of gliding for a substantial period from cruise (it takes approximately 15 minutes to descend from FL350 to the ground).

The H2F5 Flight Warning Computer ECAM procedure directs the crew to accomplish either the ENG DUAL FAIL (Fuel Remaining) or the ENG DUAL FAIL (No Fuel Remaining) QRH procedures.

If fuel is available, the QRH assists the crew in restarting the engines. The optimum speed is 280 knots which will require a pitch of approximately 2.5° below the horizon on the PFD. Although the ECAM does not specifically say to start the APU, the QRH checklist directs the crew to start the APU when below FL250. After the APU bleed air is available, 280 knots airspeed is no longer necessary for windmill engines starts. Slowing to green dot speed will increase the time and distance of the gliding airplane. If neither engine is recovered, the remaining ECAM and QRH procedures prepare the aircraft for an emergency landing. Refer to the QRH "Emergency Landing" checklist if time permits.

If no fuel is available, the QRH procedure directs the crew to establish the optimum glide speed of Green Dot or 220 knots then continue to either the Ditching or Emergency Landing checklists.

High Engine Vibration

Certain engine failures, such as fan blade separation, can cause high levels of airframe vibration. Refer to the QRH, chapter 0, ECAM Advisories, if the E/WD engine vibration parameters are flashing. High VIB indications alone are insufficient reason to shut down an otherwise good engine.

While high N2 indications can occur without perceptible airframe vibrations, high N1 indications are generally accompanied by perceptible vibrations. High engine vibrations may be accompanied by smoke or a burning smell, due to blade tip contact with a breakable material. Vibrations may also be observed after a bird strike.

If in icing conditions an increase of engine vibration with ENG ANTI ICE ON or OFF may be due to fan and/or spinner icing.

If not in icing conditions, check/cross check engine parameters, especially EGT. Reduce thrust on affected engine to maintain vibration indications below advisory threshold.

If the VIB indications do not decrease with reduced thrust, this may indicate other problems. Continue to monitor all engine parameters.

If vibration remains unacceptable, descending to a lower altitude (terrain permitting) allows a lower airspeed and normally lower vibration levels.

Once airframe vibration has been reduced to acceptable levels, the crew must evaluate the situation and determine a new course of action based on weather, fuel remaining, and available airports.

Recommended Technique for an In-Flight Engine Shutdown

Any time an engine shutdown is needed in flight, good crew coordination is essential.

When the flight path is under complete control, the crew should proceed with a deliberate, systematic process that identifies the affected engine and ensures that the operating engine is not shut down. Do not rush through the shutdown checklist, even for a fire indication.

A319/320/321 Flight Crew Training Manual

Bird Strikes

Experience shows that bird strikes are common in aviation. Most bird strikes occur at very low altitudes, below 500 feet AGL. This section deals with bird strikes that affect the engines.

Recent studies of engine bird strikes reveal that approximately 50% of engine bird strikes damage the engine(s). The risk of engine damage increases proportionally with the size of the bird and with increased engine thrust settings. When an engine bird strike damages the engine, the most common indications are significant vibrations due to fan blade damage and an EGT increase.

Note: After any bird strike, the engines should be inspected by maintenance.

Preventative Strategies

Airports are responsible for bird control and should provide adequate wildlife control measures. If large birds or flocks of birds are reported or observed near the runway, the crew should consider:

- delaying the takeoff or landing when fuel permits. Advise the tower and wait for airport action before continuing.
- taking off or landing on another runway that is free of bird activity, if available.

To prevent or reduce the consequences of a bird strike, the crew should:

- Discuss bird strikes during takeoff and approach briefings when operating at airports with known or suspected bird activity.
- Be extremely vigilant if birds are reported on final approach.
- If birds are expected on final approach, plan additional landing distance to account for the possibility of no thrust reverser use if a bird strike occurs.

Note: The use of weather radar to scare the birds has not been proven effective.

Crew Actions for a Bird Strike During Takeoff

If a bird strike occurs during takeoff, the decision to continue or reject the takeoff is made using the criteria found in chapter 3, Rejected Takeoff Decision.

If a bird strike occurs above 80 knots and prior to V1, and there is no immediate evidence of engine failure (e.g. failure, fire, power loss, or surge/stall), the preferred option is to continue with the takeoff followed by an immediate return, if required.

Crew Actions for a Bird Strike During Approach or Landing

If the landing is assured, continuing the approach to landing is the preferred option. If more birds are encountered, fly through the bird flock and land. Maintain as low a thrust setting as possible.

If engine ingestion is suspected, limit reverse thrust on landing to the amount needed to stop on the runway. Reverse thrust may increase engine damage, especially when engine vibration or high EGT is indicated.

EGT OVERLIMIT (Exceedance) During Takeoff

The CFM engine is susceptible to high exhaust gas temperatures (EGTs) during takeoff and initial climb, especially when operating from high altitude airports during warm weather. FOQA has further identified first flights as having the highest rate of EGT over-temps. To reduce the likelihood of a high EGT, crews are reminded to observe first flight engine warm up requirements. This ensures that the engine is thermally stabilized prior to setting takeoff thrust.

Both pilots must maintain EGT awareness throughout the takeoff and initial climb and comply with the following guidance:

- The takeoff limit is 890°C (A321- 950°C) and a “latching” scheme keeps the EGT at this limit as long as possible. There is no pilot action required as long as the EGT stays at 890°C (A321- 950°C) or less.

If the EGT creeps into the 891°C to 935°C (A321- 950°C to 970°C) range, the EGT indication turns red but there is no ECAM warning. Pilot response:

- If below 80 knots, reject the takeoff.
- If above 80 knots, continue the takeoff leaving the thrust “as is.” After 400 feet and when safe to do so, retard the THR LEVERs to maintain the EGT below 890°C (A321 - 950°C). Contact Flight Control/MCC when time permits.

CAUTION: Any thrust reduction below the specified takeoff N1 prior to V1 invalidates takeoff performance.

- If an "ENG 1(2) EGT OVERLIMIT" ECAM message occurs, follow the ECAM and QRH procedure and contact Flight Control to discuss further action. Document any EGT exceedances in the aircraft logbook. Technique: Brief the possibility of high EGT as part of the WARTS briefing when departing from high altitude airports during warm/hot conditions. Some airports Special Pages include a caution regarding the possibility of high EGT on takeoff where FOQA indicates a trend (e.g. KABQ, KDEN, MMMX, etc).



Evacuation

If an evacuation is planned and time permits, a thorough briefing and preparation of the crew and passengers improves the chances of a successful evacuation. Flight deck preparations should include a review of pertinent checklists and any other actions to be accomplished. Appropriate use of autobrakes should be discussed. If evacuating due to fire in windy conditions, consider positioning the aircraft so the fire is on the downwind side.

Notify cabin crew of possible adverse conditions at the affected exits. The availability of various exits may differ for each situation. Crewmembers must make the decision as to which exits are usable for the circumstances.

For unplanned evacuations, the captain needs to analyze the situation carefully before initiating an evacuation order. Quick actions in a calm and methodical manner improve the chances of a successful evacuation.

Refer to the Flight Crew Duties Summary For Emergency Landing/Ditching Evacuation table, this chapter.

Method of Evacuation

When there is a need to evacuate passengers and crew, the captain has to choose between commanding an emergency evacuation using the emergency escape slides or less urgent means such as deplaning using stairs, jetways, or other means. All available sources of information should be used to determine the safest course of action including reports from the cabin crew, other aircraft, and air traffic control. The captain must then determine the best means of evacuation by carefully considering all factors. These include, but are not limited to:

- the urgency of the situation, including the possibility of significant injury or loss of life if a significant delay occurs
- the type of threat to the aircraft, including structural damage, fire, reported bomb on board, etc.
- the possibility of fire spreading rapidly from spilled fuel or other flammable materials
- the extent of damage to the aircraft
- the possibility of passenger injury during an emergency evacuation using the escape slides.

If in doubt, the crew should consider an emergency evacuation using the escape slides.

If there is a need to deplane passengers, but circumstances are not urgent and the captain determines that the Evacuation NNC is not needed, the normal shutdown procedure should be completed before deplaning the passengers.

Discharging Fire Bottles during an Evacuation

The evacuation NNC specifies discharge of the engine or APU fire bottles if an engine or APU fire warning light is illuminated. However, evacuation situations can present possibilities regarding the potential for fire that are beyond the scope of the NNC and may not activate an engine or APU fire warning. The crew should consider the following when deciding whether to discharge one or more fire bottles into the engines and/or APU:

- If an engine fire warning light is not illuminated, but a fire indication exists or a fire is reported in or near an engine, discharge both available fire bottles into the affected engine.
- If the APU fire warning light is not illuminated, but a fire indication exists or a fire is reported in or near the APU, discharge the APU bottle.
- The discharged halon agent is designed to extinguish a fire and has very little or no fire prevention capability in the engine nacelles. Halon dissipates quickly into the atmosphere.
- There is no reason to discharge the engine or APU fire bottles for evacuations not involving fire indications existing or reported in or near an engine or APU, e.g., cargo fire, security or bomb threat, etc.

Emergency Landing Preparation

Refer to the QRH, NNC, Emergency Landing Considerations.

Refer to the FOM, chapter 10.1, Emergency Landing Preparation.



Flight Crew Duties Summary For Emergency Landing/ Ditching Evacuation

The following flight crew duties summary is designed to assist the crew members in preparing the aircraft's occupants for emergency landing and evacuation. Time is essential in preparing passengers for the evacuation (especially non-ambulatory). Flight attendants should be advised of the problem(s) as soon as flight safety is in doubt. Specific flight attendant duties are outlined in the In-Flight Service On-Board Manual. Additionally, the flight attendants should be informed of any conditions such as high winds, irregular ground condition, sea state, structural damage, and/or fire that affect or alter status of the escape slides/raft deployment.

CAPTAIN	FIRST OFFICER
Call for and complete EVACUATION checklist If in water, don a life vest. Do not inflate it until you are outside the aircraft. Take a flashlight, proceed to the cabin and assess the conditions. Direct the evacuation as necessary. After ensuring that all passengers are off the aircraft or possible assistance has been given, exit from the rear of the aircraft, if able. Attempt to keep the passengers together and away from the aircraft. Try to account for all passengers and crew, and provide for their safety.	Notify tower, ground control or make necessary distress calls. Read the EVACUATION checklist. If in water, don a life vest. Do not inflate it until you are outside the aircraft. Take portable ELT (Ditching). Take a flashlight and proceed to the cabin. Leave the aircraft from the forward most usable exit. Use door 1R if it is a usable exit. Direct the evacuation of the aircraft from outside. Assign passengers to assist with escape slides. Direct passengers away from the aircraft. Assist in accounting for all passengers and crew, and provide for their safety.

AUGMENTED / EXTRA CREWMEMEBERS

Assist as necessary or directed in the evacuation.

Flight Controls**Leading Edge or Trailing Edge Device Malfunctions**

Flap and/or slat malfunctions have the following in common:

- The characteristic speeds that are displayed on the PFD speed tape are computed using the flap handle position, not the actual position of the flaps/slats. This may result in an unsafe speed if managed speed is used with jammed flaps or slats.
- The maximum speeds and the speed additives that are displayed on the ECAM non-normal and the STATUS page are correct since the FWCs are using the actual flap or slat position to determine these speeds.
- With the SLATS FAULT or FLAPS FAULT, the pilot is permitted to attempt to correct the problem by recycling the flap handle to the previous position and then back. This step is not required in the event the fault was received after departure with the slats indicating '0'. This allows the pilot to continue the flight normally before dealing with the slat abnormal on approach.
- The pilots may not pull any flap/slat control circuit breakers associated with the associated flap/slat system. Pulling these circuit breakers could have unintended consequences.
- CAT I Autolands, CAT II, and CAT III approaches are not authorized.
- The AP, F/D, and A/THR may or may not be available.

Procedures

After the crew realizes that there is a problem with the flaps or slats, it is important that they quickly determine the actual position of the flaps and slats. The characteristic speeds that are shown on the PFD speed tape may not be safe for the actual configuration of the aircraft. For example, if the flap handle is moved to FLAPS 1 but the slats do not move, the aircraft should not be slowed to “S” speed displayed on the airspeed tape. The safe speed is Green Dot since neither the flaps or slats are extended.

**A319/320/321 Flight Crew Training Manual**

All QRH procedures that deal with flap or slat non-normals direct the crew to land the aircraft with the flap handle in the FLAPS 3 position. It is best to fly an extended final approach (15 to 20 miles) and follow the step-by-step procedure that directs the configuration changes. The suggested technique is to have the PF request the flap changes and have the PM read each step in detail. The procedure will prevent flap overspeeds and at the same time provide adequate stall margins.

The fleet suggests that an emergency be declared with ATC any time the flap/slat configuration is other than normal. In addition, the flight attendants should be notified of a Yellow Emergency.

With the slats fully retracted (flaps only) approach, the pitch attitude will be much lower than normal. There will be a tendency to get high on approach and balloon during the landing. With a flaps retracted (slats only) approach, the pitch attitude is much higher than normal so there is a tendency to get low on final and a danger of a tail strike on landing. Do not attempt to hold the aircraft off the runway to make a smooth landing.

- No Slats - Approximately 0° of pitch during final.
- No Flaps - Approximately 8° of pitch on final.

Abnormally operating flaps or slats should be left extended after landing until maintenance has a chance to inspect the system.

Zero Flap / Zero Slat Landing

Placing the flap handle to the "1" position increases the engines to approach idle and makes the go-around mode available. Slat position triggers the center tank fuel pumps to stop during the approach so placing the CTR TK pumps to OFF will guard against center tank fuel from feeding both engines during the approach.

Extend the landing gear early to increase drag and plan on an extended final to give time to stabilize the airspeed. Speedbrakes are not useful since the aircraft's maneuvering speed is relatively close to VLS. The VLS will increase as the speedbrakes are extended.

When established on final approach, the pilot may receive an occasional stall warning.

The thrust should be slowly and smoothly brought to IDLE on a 1 nm final. In this configuration deceleration will be slow and acceleration rapid. Do not allow the aircraft to float just off the runway surface. Fly the aircraft onto the runway at the recommended touchdown point. Expeditiously select reverse thrust after touchdown. Use of autobrakes medium, if available, is recommended.



Jammed Stabilizer

In most cases, the ELACS will detect that the horizontal stabilizer is not moving as commanded which will generate the message, F/CTL STABILIZER JAM, on the ECAM. There is a possibility that the pilots may notice sustained elevator deflections (e.g., auto elevator trim inoperative) and there is no ECAM warning. Eventually as the airspeed changes significantly, the jammed stabilizer may be detected and the message displayed on the ECAM.

If the stabilizer jam is detected by the FWC, the flight controls revert to alternate law since automatic trimming is necessary for normal law. If the jam is not detected, the aircraft remains in normal law. In either case, manual trim may or may not be available. If manual trim is not available, the pilots will experience unusual and sustained sidestick force while hand flying the aircraft.

Note: It is important not to lower the landing gear until at VAPP flaps 3 speed. The elevators will perform trim functions until the gear is lowered. If the gear is lowered at higher speeds, the trimming function ceases and greater aft stick displacement will be required for flying the approach. Adequate back stick may not be available for flare or go-around. Raising the gear restores this elevator trimming function.



Flight Instruments, Displays

Airspeed Unreliable

Most failure modes of the airspeed/altitude system are detected by the ADIRS. These failure modes lead to the loss of corresponding cockpit indications and the triggering of associated ECAM messages.

However, there may be some cases where the airspeed or altitude output is erroneous without being recognized as such by the ADIRS. In these cases, the cockpit indications appear normal but are actually false and pilots must rely on their basic flying skills to identify the faulty source and take the required corrective actions. When only one source provides erroneous data, a straightforward crosscheck of the parameters provided by the three ADRs allows the faulty ADR to be identified. This identification becomes more difficult in the extreme situation when two, or even all of three, sources provide erroneous information.

The most probable reason for erroneous airspeed and altitude information is obstructed pitot tubes or static sources. Depending on the level of obstruction, the symptoms visible to the flight crew will be different. However, in all cases, the data provided by the obstructed probe will be false. Since it is highly unlikely that more than one aircraft probe will be obstructed at the same time, to the same degree, and in the same way, the first indication of erroneous airspeed/altitude data available to flight crews will most likely be a discrepancy between the various sources.

Radome damage can also cause erroneous airspeed indications because it can cause disruption in airflow to the pitot tubes.

Recovery

If it is obvious that one source is wrong, select the corresponding ADR OFF and reconfigure the instruments accordingly by applying the ECAM procedure. However, crews should be aware that in rare circumstances, two or even three ADRs may provide identical and erroneous data. Therefore, the suspected ADRS should only be switched OFF, if it is positively confirmed the other two ADRs are reliable.

If in doubt:

- Disconnect the autopilot, flight directors, and autothrust.
- Fly target pitch attitude and thrust setting.

If one IR remains operating, the flight path vector (the bird) is a useful tool to return the aircraft to a straight and level attitude. The IVSI data is also generated by the IR and can be considered reliable when experiencing pitot/static malfunctions.

Note: If altitude indications are not reliable, FPV and IVSI are affected and should not be used.

Once the aircraft is stabilized on the target pitch attitude and thrust settings, the procedure in the QRH, Unreliable Airspeed /ADR Check Procedure/Radome Damage should be followed to determine the precise pitch and power setting required. An additional table of pitch and power setting are located in the ODM, Abnormal section.

After completing the QRH procedure, and the aircraft is stable, the flight crew should try to identify the faulty ADR(s). When the faulty ADR(s) is (are) identified, it (they) should be selected OFF. This will trigger corresponding ECAM warnings which should be followed to address the consequences of other affected aircraft systems.

Depending on the cause of the failure, the altitude indications may also be unreliable. This may cause incorrect transponder altitude reporting and result in ATC confusion. Therefore, an emergency should be declared to advise ATC of the situation.

When flying the aircraft with unreliable speed and/or altitude indications, it is recommended to make small changes and to change only one parameter at a time. During the approach and landing, other data such as ground speed and radio altimeter height can be used to aid in flying the approach. A wide, long, and stabilized approach is recommended.



Fuel

Fuel Balance

The primary purpose of fuel balance limitations is for the structural life of the airframe and landing gear and not for controllability. A reduction in structural life of the airframe or landing gear can be caused by frequently operating with out-of-limit fuel balance conditions. Lateral control is not significantly affected when operating with fuel beyond normal balance limits.

The primary purpose for fuel balance alerts is to inform the crew that imbalances beyond the current state may result in increased trim drag and higher fuel consumption. The Fuel Leak NNC should be accomplished when the fuel balance alert is received.

There is a common misconception among flight crews that the fuel crossfeed valve should be opened immediately after an in-flight engine shutdown to prevent fuel imbalance. This practice is contrary to recommended procedures and could aggravate a fuel imbalance. This practice is especially significant if an engine failure occurs and a fuel leak is present. Arbitrarily opening the crossfeed valve and starting fuel balancing procedures, without following the checklist, can result in pumping usable fuel overboard.

The misconception may be further reinforced during simulator training. The fuel pumps in simulators are modeled with equal output pressure on all pumps so opening the crossfeed valve appears to maintain a fuel balance. However, the fuel pumps in the aircraft have allowable variations in output pressure. If there is a sufficient difference in pump output pressures and the crossfeed valve is opened, fuel feeds to the operating engine from the fuel tank with the highest pump output pressure. This may result in fuel unexpectedly coming from the tank with the lowest quantity.

Fuel Balancing Considerations

The crew should consider the following when performing fuel balancing procedures:

- Use of the Fuel Balancing Supplementary Procedure in conjunction with good crew coordination reduces the possibility of crew errors.
- Routine fuel balancing when not near the imbalance limit increases the possibility of crew errors and does not significantly improve fuel consumption.
- During critical phases of flight, fuel balancing should be delayed until workload permits. This reduces the possibility of crew errors and allows crew attention to be focused on flight path control.
- Fuel imbalances that occur during approach need not be addressed if the reason for the imbalance is obvious (e.g. engine failure or thrust asymmetry, etc.).

Fuel Leak

Any time an unexpected fuel quantity indication, FMS or ECAM fuel message, or imbalance condition is experienced, a fuel leak should be considered as a possible cause. Maintaining a fuel log and comparing actual fuel burn to the flight plan fuel burn can help the pilot recognize a fuel leak.

Significant fuel leaks, although fairly rare, are difficult to detect.

There is no specific fuel leak annunciation on the flight deck. A leak must be detected by discrepancies in the fuel log, by visual confirmation, fuel observed to be decreasing from one tank at an unusual rate (due to an engine leak or a hole in the tank), fuel tank imbalance observed on the FUEL systems page with relatively little difference in the engines' fuel used indications, a tank overflowing (due to a pipe rupture within a tank), or fuel fumes present in the aircraft. Any unexpected change in fuel quantity or fuel balance should alert the crew to the possibility of a leak. If a leak is suspected, it is imperative to follow the Fuel Leak NNC.

The NNC leads the crew through steps to determine if the fuel leak is from the strut or the engine area. If an engine fuel leak is confirmed, the NNC directs the crew to shut down the affected engine. There are two reasons for the shutdown. The first is to close the spar valve, which stops the leak. This prevents the loss of fuel which could result in a low fuel state. The second reason is that the fire potential is increased when fuel is leaking around the engine. The risk of fire increases further when the thrust reverser is used during landing. The thrust reverser significantly changes the flow of air around the engine which can disperse fuel over a wider area.

When a fuel leak is confirmed or suspected, the QRH Fuel Leak procedure should be applied while ignoring any fuel-related ECAM. Do not open the fuel crossfeed valve when a fuel leak is suspected even if called for by another ECAM message.

If a fuel leak is suspected, land as soon as possible and:

- The pilot should declare an emergency and request a clearance to the nearest suitable airport.
- Use the "Closest Airports" prompt on the DATA page to determine the nearest available airports.
- Flight attendants should be briefed for a Yellow Emergency unless the pilot suspects fuel exhaustion before landing at a suitable airport, in which case a Red Emergency should be briefed.

The Fuel Leak procedure can be used as the sole non-normal checklist even if an engine is shut down as a result of the procedure as the engine inoperative procedures are included in the Approach procedures.



Low Fuel

A low fuel condition exists when the aircraft will land with less than its minimum or emergency fuel, or when the ECAM displays FUEL L + R WING TK LO LVL.

Approach and Landing

In a low fuel condition, the clean configuration should be maintained as long as possible during the descent and approach to conserve fuel. However, initiate configuration changes early enough to provide a smooth, slow deceleration to final approach speed to prevent fuel from running forward in the tanks.

A normal landing configuration and airspeed appropriate for the wind conditions are recommended.

Runway conditions permitting, heavy braking and high levels of reverse thrust should be avoided to prevent uncovering all fuel pumps and possible engine flameout during landing roll.

Go-Around

If a go-around is necessary, apply thrust slowly and smoothly and maintain the minimum nose-up body attitude required for a safe climb gradient. Avoid rapid acceleration of the aircraft. If any wing tank fuel pump low pressure light illuminates, do not turn the fuel pump switches off.

Hydraulics

Proper planning of the approach is important. Consideration should be given to the effect the inoperative system(s) has on crosswind capabilities, autoflight, stabilizer trim, control response, control feel, reverse thrust, stopping distance, go-around configuration, and performance required to reach an alternate airfield.

Single Hydraulic System Failure

A loss of one hydraulic system generally does not necessitate a diversion unless MC desires a diversion due to operational needs.

With the loss of a single hydraulic system:

- Flight controls remain in normal law.
- All autoflight systems (FD, AP, and A/THR) remain fully operational.
- CAT III approaches are not authorized.
- The flaps and/or slats may operate slower than normal but all approaches are made with full flaps (landing distance multipliers apply).

Special consideration for the failure of individual hydraulic systems:

- With the loss of the blue electric pump, the RAT should not be extended unless there are extenuating circumstances.
- With the loss of the yellow system, if the parking brake accumulator is low or inoperative the parking brake should not be set. Do not shut down the engines until the aircraft chocks are in place.

A319/320

- The loss of the green system renders the gear retraction and nosewheel steering inoperative. The aircraft will need to be towed off the runway or the captain can use differential braking to exit the runway on a high speed taxiway.

A321

- The loss of the green system renders the gear retraction inoperative, however nosewheel steering remains operative allowing the aircraft to taxi normally.

Note: Gear pins do not need to be installed following a green hydraulic failure with normal gear down indications for all aircraft.

Dual Hydraulic System Failure

A dual hydraulic failure is a serious non-normal situation as indicated by the red LAND ASAP in the memo section of the ECAM. The loss of the third hydraulic system is guaranteed to be catastrophic. The crews must be expeditious in landing the aircraft but at the same time should judiciously complete the ECAM and QRH procedures.

**A319/320/321 Flight Crew Training Manual**

An emergency should be declared with ATC and the flight attendants should be briefed for a Yellow Emergency. If the captain suspects aircraft damage or personnel injury during landing, a Red Emergency should be briefed. The ECAM procedure should be completed to a “lights out” condition and then the PM should complete the QRH procedure.

Procedure

The crews should complete the preparation steps of the QRH procedure while maneuvering the aircraft to an extended final. The final part of the QRH checklist should be completed on final. These procedures are similar to the flap/slat non-normals that gives step-by-step procedures to direct the crew with flap/ slat configuration changes. The suggested technique is to have the PF request the flap changes and have the PM read each step of the checklist in detail. The procedure will prevent flap overspeeds and at the same time provide adequate stall margins. It is recommended to select FLAPS 3, capture the glide slope, and then slow to final approach speed before gravity extending the landing gear.

The PF should make small corrections and avoid the tendency to overcontrol the aircraft because of degraded flight controls. The approach and landing pitch attitude will be different when the flaps or slats are inoperative. Perform a basic flare maneuver and fly the aircraft on to the runway. A tail strike can occur if the pilot raises the nose too high in an attempt to obtain a smooth landing. Compared to the normal 3° nose-up pitch attitude on final approach, the abnormal hydraulics approach pitch attitude will be approximately:

- G+B SYS LO PR (no slats): 0°
- G+Y SYS LO PR (no flaps): 8°

Without Green system pressure, nosewheel steering will be inoperative. ATC should be advised that the aircraft will be disabled on the runway. Taxi with differential braking is not recommended with the G + Y dual hydraulic failure since the brakes are operating with only accumulator pressure.

Landing Gear

Braking with Antiskid Inoperative

If anti-skid braking is lost due to a non-normal, alternate braking is available when the A/SKID NW STRG switch is selected to OFF. The PF should apply the brakes in a smooth application, up to the maximum of 1,000 psi and the PM should monitor the brake pressure on the BRAKE pressure indicator and advise the PF of the current pressure being applied.

Brake Malfunctions

If the brakes appear to be grabbing excessively during taxi, it is likely that the brake pedals were depressed at the time of the last engine shutdown. If brakes grab excessively, see BSCU reset procedures, QRH NNOI.

If a loss of braking occurs during ground operations, apply the Loss of Braking memory procedure (Ref. QRH section 14).

The loss of braking on the ground has the following memory items.

1. Thrust LeversMaximum Reverse (as reqd)
2. Brake pedalsRelease
3. A/SKID & NWS switchOFF
4. Brake pedalsAPPLY (max 1000 psi)

If this fails, apply PARK BRK using short successive applications. Refer to the QRH, section 14, Loss of Braking.

Tire Failure during or after Takeoff

If the crew suspects a tire failure during takeoff, advise ATC of the potential for tire pieces remaining on the runway. The crew should consider continuing to the destination unless there is an indication that other damage has occurred (non-normal engine indications, engine vibrations, hydraulic system failures or leaks, etc.).

Continuing to the destination will allow the aircraft weight to be reduced normally, and provide the crew an opportunity to plan and coordinate their arrival and landing when the workload is low.

Considerations in selecting a landing airport include, but are not limited to:

- sufficient runway length and acceptable surface conditions to account for the possible loss of braking effectiveness
- sufficient runway width to account for possible directional control difficulties
- altitude and temperature conditions that could result in high ground speeds on touchdown and adverse taxi conditions



- runway selection options regarding “taxi-in” distance after landing
- availability of operator maintenance personnel to meet the aircraft after landing to inspect the wheels, tires, and brakes before continued taxi
- availability of support facilities should the aircraft need repair.

Landing on a Flat Tire

Aircraft are designed so that the landing gear and remaining tire(s) have adequate strength to accommodate a flat nose gear tire or main gear tire. When the pilot is aware of a flat tire prior to landing, use normal approach and flare techniques, avoid landing overweight, and use the center of the runway. Use differential braking as needed for directional control. With a single tire failure, towing is not necessary unless unusual vibration is noticed or other failures have occurred.

In the case of a flat nose wheel tire, slowly and gently lower the nose wheels to the runway while braking lightly. Runway length permitting, use idle reverse thrust. Autobrakes LO should be selected if performance permits. Once the nose gear is down, vibration levels may be affected by increasing or decreasing sidestick back pressure. Maintain nose gear contact with the runway.

Flat main gear tire(s) cause a general loss of braking effectiveness and a yawing moment toward the flat tire with light or no braking and a yawing moment away from the flat tire if the brakes are applied harder. Maximum use of reverse thrust and autobrakes LO are recommended.

If uncertain whether a nose tire or a main tire has failed, slowly and gently lower the nose wheels to the runway. Differential braking may be required to steer the aircraft. Use idle or higher reverse thrust as needed to stop the aircraft.

Note: Extended taxi distances or fast taxi speeds can cause significant increases in temperatures on the remaining tires.

Landing with Abnormal Landing Gear

Land on all available gear. The landing gear absorbs the initial shock and delays touchdown of aircraft body parts. Some landing gear non-normal procedures direct multiple recycle attempts. When working through this type of non-normal, crews should establish time parameters, or a minimum fuel level, for when to begin the approach. Fuel consumption may be considerably higher, possibly as much as doubled, with the landing gear extended. A gear up or partial gear landing is preferable to running out of fuel while attempting to solve a gear problem.

Note: A tower fly-by is not recommended.

Landing Runway

Consideration should be given to landing at the most suitable airport with adequate runway and fire fighting capability. Foaming the runway is not Delta Air Lines' policy.

Refer to the QRH, Landing with Abnormal Landing Gear NNC.



Overspeed

VMO/MMO is the aircraft maximum certified operating speed and should not be exceeded intentionally. However, crews can occasionally experience an inadvertent overspeed. Aircraft have been flight tested beyond VMO/MMO to ensure smooth pilot inputs will return the aircraft safely to the normal flight envelope.

During cruise at high altitude, wind speed or direction changes may lead to overspeed events. Although autothrust logic provides for more aggressive control of speed as the aircraft approaches VMO or MMO, there are some conditions that are beyond the capability of the autothrust system to prevent short term overspeeds.

During cruise, the typical causes of overspeed events are windshear encounters or high altitude wave activity.

When operating in normal law the aircraft has High Speed Protection. High speed protection activates slightly above VMO/MMO and prevents aircraft damage due to excessive speed. When high speed protection activates:

- The autopilot(s) disconnect.
- Nose down trim is inhibited.
- The flight control computers attempt to limit further acceleration by commanding a gentle pitch up. This protection limits maximum airspeed by automatically increasing the aircraft's pitch attitude even if the sidestick is held full forward.
- The bank angle limit is reduced from 67° to 45° (limit marks do not move).
- Positive spiral stability becomes active at all bank angles (instead of the usual 33° in normal law). Therefore, the sidestick must be held to maintain any bank angle. If the sidestick is released the aircraft returns to a bank angle of 0°.
- The CRC and MASTER WARN lights activate and an O/SPEED warning is displayed on the E/WD. The CRC can be silenced only by slowing down or pushing the EMER CANC pb.

In certain configurations of alternate law, high-speed stability is available as a replacement to high speed protection. High-speed stability provides the same function as high-speed protection, however, the nose up command is overridable.

When correcting an overspeed during cruise at high altitude, avoid reducing thrust to idle which results in slow engine acceleration back to cruise thrust and may result in over-controlling the airspeed or a loss of altitude. If autothrust corrections are not satisfactory, temporarily deploying partial speedbrakes can assist in reducing speed and avoiding the need for idle thrust.



During descents at or near VMO/MMO, most overspeeds are encountered after the autopilot initiates capture of the managed descent path from above or during a level-off when the speedbrakes were required to maintain the path. In these cases, if the speedbrakes are retracted during the level-off, the aircraft can momentarily overspeed. During descents using speedbrakes near VMO/MMO, delay retraction of the speedbrakes until after managed descent path or altitude capture is complete. Crews routinely climbing or descending in windshear conditions may wish to consider a 5 to 10 knot reduction in climb or descent speeds to reduce overspeed occurrences. This will have a minimal effect on fuel consumption and total trip time.

Encountering an inadvertent overspeed can be quite startling as the autopilot disconnects, the CRC sounds and the MASTER WARN lights flashes. The pilot should realize that pitch may increase, due to normal law, even if the sidestick is pushed forward. As soon as the speed decreases below the overspeed condition, the warnings ceases and aircraft pitch can be controlled normally.

Note: Any time VMO/MMO is exceeded, the maximum airspeed should be noted in the logbook.



Smoke/Fumes Principles

General

All smoke/fire/fumes events are different, and every contingency cannot be addressed in a single checklist. At the beginning of any smoke/fire/fumes event, crews should always consider the following:

- protecting themselves (e.g., oxygen masks)
- communicating (crew and ATC)
- diverting
- assessing the smoke/fire/fumes situation and available resources

If smoke/fire/fumes are associated with an annunciated checklist (e.g., SMOKE AFT CARGO SMOKE), accomplish that checklist prior to the "Removal of Smoke/Toxic Fumes" checklists.

Known Source

Many smoke/fire/fumes events involve aircraft equipment or materials readily accessible. Rapid, positive extinguishing of the source is the key to preventing escalation of the event. Confirmation that the situation has been resolved is critical. Do not consider flight continuation unless the source is positively identified, confirmed to be extinguished and smoke/fumes are decreasing.

Unknown Source

It may not always be possible to accurately identify the smoke/fire/fumes source due to ambiguous cues, such as multiple sources. It may not be possible to determine the difference between electrical smoke/fumes and air conditioning smoke/fumes by smell. The source identification and elimination steps in the "Cabin Smoke/Fire/Fumes" Checklist will systematically remove the most probable smoke/fire/fumes sources.

Inordinate de-powering of airplane systems is not likely to benefit an unknown smoke/fire/fumes situation. Such action significantly reduces airplane capabilities without commensurate likelihood of de-powering the unknown smoke/fire/fumes source.

Smoke/Fumes Priorities

General

All applicable non-normal checklists can be found in the QRH, Section 8 (Fire Protection).

Note: Pilots should remain at their stations to fly the aircraft, coordinate with ATC and accomplish the checklists. The incapacitation of a pilot fighting a fire would seriously complicate the situation.

Priorities

WARNING: Do not activate the emergency passenger oxygen system. It provides no smoke protection for passengers as it mixes oxygen with cabin air. It is also an extreme fire hazard.

Diversion

After making a preliminary assessment of the smoke/fire/fumes source, the flight crew is reminded that a diversion may be necessary. Landing at the nearest suitable airport is required if smoke or fire continues. For smoke that continues or a fire that cannot be positively confirmed to be completely extinguished, the earliest possible descent, landing and evacuation must be done.

Oxygen Masks (if required)

The flight crew should don the oxygen mask anytime smoke/fire/fumes are detected on the flight deck. If smoke/fire/fumes are detected in another part of the aircraft, flight crew judgment will determine if/when the Oxygen Masks are donned.

Crew and Cabin Communications

For a cabin smoke/fire/fumes situation, continuous communications between the flight crew and a designated flight attendant is essential. Flight attendants should be directed to inspect the entire cabin in an attempt to locate the smoke/fire/fumes source. Passengers should be moved away from the source.

Identification/Elimination

The flight crew should, without delay or analysis, perform the initial annunciated checklist steps that remove the most probable smoke/fire/fumes sources. The flight crew should attempt to identify and eliminate the source, and visually confirm it is extinguished and the smoke/fumes are decreasing.



Removal

The Removal of Smoke/Toxic Fumes checklist should be accomplished only when the smoke/fumes are the greatest threat, or when the source is confirmed to be extinguished. Smoke/fumes removal may change the airflow and make the situation worse by fanning or masking the ignition source.

Warning Systems

If an unexpected landing gear configuration or GPWS alert occurs, the flight crew must ensure the proper configuration for the phase of flight. Time may be required in order to assess the situation, take corrective action and resolve the discrepancy. Flight path control and monitoring of instruments must never be compromised.

Note: If the warning occurs during the approach phase, a go-around may be necessary, followed by holding or additional maneuvering.

Windows

Window Damage

Refer to the QRH, NNC, Cracked Flight Deck Window.

Flight with the Side Window(s) Open

The inadvertent opening of an unlatched flight deck window by air loads during the takeoff roll is not considered an event that warrants a high-speed RTO. Although the resulting noise levels may interfere with crew communications, it is safer to continue the takeoff and close the window after becoming airborne and the flight path is under control. The flight may be continued once the window is closed and locked and pressurization is normal. If the window is damaged and will not close, return to the departure airport.

If needed, the windows may be opened in flight after depressurizing the aircraft. It is recommended that the aircraft be slowed since the noise levels increase at higher airspeed. Maneuver speed for the current flap setting is a good target speed. Intentions should be briefed and ATC notified prior to opening the window as the noise level can be high and make communications difficult, even at slow speeds.

Note: Speed should be kept below 200 knots with a flight deck window open.

Situations Beyond the Scope of Non-Normal Checklists

It is rare to encounter in-flight events which are beyond the scope of the recommended NNCs. These events can arise as a result of unusual occurrences such as a midair collision, bomb explosion, or other major malfunction. In these situations the flight crew may be required to accomplish multiple NNCs, selected elements of several different NNCs applied as necessary to fit the situation, or be faced with little or no specific guidance except their own judgment and experience. Because these situations are rare, it is not practical or possible to create definitive flight crew NNCs to cover all events.

The following guidelines may aid the flight crew in determining the proper course of action should an in-flight event of this type be encountered. Although these guidelines represent what might be called “conventional wisdom”, circumstances determine the course of action which the crew perceives will conclude the flight in the safest manner.

Basic Aerodynamics and Systems Knowledge

Knowledge of basic aerodynamic principles and aircraft handling characteristics and a comprehensive understanding of aircraft systems can be key factors in situations of this type.

Basic aerodynamic principles are known and understood by all pilots. Although not a complete and comprehensive list, following is a brief review of some basic aerodynamic principles and aircraft systems information relevant to such situations:

- If aileron control is affected, rudder inputs can assist in countering unwanted roll tendencies. The reverse is also true if rudder control is affected.
- If both aileron and rudder control are affected, the use of asymmetrical engine thrust may aid roll and directional control.
- If elevator control is affected, stabilizer trim, bank angle and thrust can be used to control pitch attitude. To do this effectively, engine thrust and airspeed must be coordinated with stabilizer trim inputs. The aircraft continues to pitch up if thrust is increased and positive corrective action is not taken by re-trimming the stabilizer. Flight crews should be aware of the aircraft’s natural tendency to oscillate in the pitch axis if the stable pitch attitude is upset. These oscillations are normally self damping, but to ensure proper control, it may be desirable to use thrust and/or stabilizer trim to hasten damping and return to a stable condition. The aircraft exhibits a pitch up when thrust is increased and a pitch down when thrust is decreased. Use caution when attempting to dampen pitch oscillations by use of engine thrust so that applications of thrust are timed correctly, and diverging pitch oscillations do not develop.

**A319/320/321 Flight Crew Training Manual**

- Stall margin decreases with angle of bank and increasing load factors. Therefore, it is prudent to limit bank angle to 15° in the event maneuver capability is in question. Increasing the normal flap/speed maneuver schedule while staying within flap placard limits provides extra stall margin where greater bank angles are necessary.
- All Delta Air Lines' aircraft have the capability to land using any flap position, including flaps up. Use proper maneuver and final approach speeds and ensure adequate runway is available to stop the aircraft after landing.

Flight Path Control

When encountering an event of the type described above, the flight crew's first consideration should be to maintain or regain full control of the aircraft and establish an acceptable flight path. This may require use of unusual techniques such as the application of full aileron or rudder, or in an asymmetrical thrust situation, reduction of thrust on the operating engine(s) to regain lateral control. This may also require trading altitude for airspeed or vice versa. The objective is to take whatever action is necessary to control the aircraft and maintain a safe flight path. Even in a worst case condition where it is not possible to keep the aircraft flying and ground contact is imminent, a "controlled crash" is a far better alternative than uncontrolled flight into terrain.

If the operation of flaps is in doubt, leading and trailing edge flap position should not be changed unless it appears that aircraft performance immediately requires such action. Consideration should be given to the possible effects of an asymmetrical flap condition on aircraft control if flap position is changed. If no flap damage exists, wing flaps should be operated as directed in the associated NNC. Any time an increasing rolling moment is experienced during flap transition (indicating a failure to automatically shutdown an asymmetric flap situation), return the flap handle to the previous position.

Unusual events adversely affecting aircraft handling characteristics while airborne may continue to adversely affect aircraft handling characteristics during landing ground roll. Aggressive differential braking and/or use of asymmetrical reverse thrust, in addition to other control inputs, may be required to maintain directional control.

Checklists with Memory Steps

After flight path control has been established, do the memory steps of the appropriate NNC. The emphasis at this point should be on containment of the problem. Reference steps are initiated after the aircraft flight path and configuration are properly established.

Complete all applicable ECAM actions (if any), followed by the NNC (time permitting) prior to beginning final approach. Exercise common sense and caution when accomplishing multiple NNCs with conflicting directions. The intended course of action should be consistent with the damage assessment and handling evaluation.

Communications

Establish flight deck communications as soon as possible. This may require use of the flight deck interphone system or, in extreme cases of high noise levels, hand signals and gestures in order to communicate effectively.

Declare an emergency with Air Traffic Control (ATC) to ensure priority handling and emergency services upon landing. Formulate an initial plan of action and inform ATC. If possible, request a discrete radio frequency to minimize distractions and frequency changes. If unable to establish radio communication with ATC, squawk 7700 and proceed as circumstances dictate.

Communications with the cabin crew and with company ground stations are important, but should be accomplished as time permits. If an immediate landing is required, inform the cabin crew as soon as possible.

Damage Assessment and Aircraft Handling Evaluation

Unless circumstances such as imminent aircraft breakup or loss of control dictate otherwise, the crew should take time to assess the effects of the damage and/or conditions before attempting to land. Make configuration and airspeed changes slowly until a damage assessment and aircraft handling evaluation have been done and it is certain that lower airspeeds can be safely used. In addition, limit bank angle to 15° and avoid large or rapid changes in engine thrust and airspeed that might adversely affect controllability. If possible, conduct the damage assessment and handling evaluation at an altitude that provides a safe margin for recovery should flight path control be inadvertently compromised. It is necessary for the flight crew to use good judgment in consideration of the existing conditions and circumstances to determine an appropriate altitude for this evaluation.

The evaluation should start with an examination of flight deck indications to assess damage. Consideration should be given to the potential cumulative effect of the damage. A thorough understanding of aircraft systems operation can greatly facilitate this task.

**A319/320/321 Flight Crew Training Manual**

If structural damage is suspected, attempt to assess the magnitude of the damage by direct visual observation from the flight deck and/or passenger cabin. While only a small portion of the aircraft is visible to the flight crew from the flight deck, any visual observation data can be used to gain maximum knowledge of aircraft configuration and status and can be valuable in determining subsequent actions.

The flight crew should consider contacting the company to inform them of the situation and use them as a potential source of information. In addition to current and forecast weather, and airfield conditions, it may be possible to obtain technical information and recommendations from Delta Air Lines and the aircraft manufacturer.

If controllability is in question, consider performing a check of the aircraft handling characteristics. The purpose of this check is to determine minimum safe speeds and the appropriate configuration for landing. Limit bank to 15° and avoid rapid thrust and airspeed changes which might adversely affect controllability. If flap damage has occurred, prior to accomplishing this check, consider the possible effects on aircraft control should an asymmetrical condition occur if flap position is changed. Accomplish this check by slowly and methodically reducing speed and lowering the flaps. Lower the landing gear only if available thrust allows.

After the damage assessment and handling characteristics are evaluated, the crew should formulate a sequential plan for the completion of the flight.

If aircraft performance is a concern, use of the alternate gear extension system may dictate that the check of aircraft handling characteristics be done during the actual approach. Configuration changes made by the alternate system may not be reversible. The crew must exercise extreme caution on final approach with special emphasis on minimum safe speeds and proper aircraft configuration. If asymmetrical thrust is being used for roll control or pitch authority is limited, plan to leave thrust on until touchdown.

Landing Airport

The following items should be considered when selecting an airport for landing:

- weather conditions (VMC preferred),
- enroute time,
- length of runway available (longest possible runway preferred, wind permitting),
- emergency services available,
- flight crew familiarity, and
- other factors dictated by the specific situation.

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Human Factors

Table of Contents

Chapter 9

Section TOC

Overview	9.1
History of CRM and TEM	9.1
Introduction	9.1
CRM Skills	9.3
Communication	9.3
Situational Awareness	9.4
Planning	9.5
Decision Making	9.5
Workload Management	9.6
Professional Management	9.7
The Threat and Error Management (TEM)	9.9
Error	9.10
Error Types	9.10
Decision Errors	9.12
Skill-based Errors	9.12
Perceptual Errors	9.12
Error Management	9.13
Threat Management Tools	9.13
Expected Threat Management Tool	9.14
The Highest Threat	9.15
Unexpected Threat Management Tool	9.16



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Human Factors

Chapter 9

Overview

This chapter is designed to provide the crewmember with a practical guide on how to better incorporate CRM procedures and Threat Management behaviors on the flight deck to reduce operational errors.

History of CRM and TEM

In 1978, a United Airlines DC8 crew requested a delay before landing due to a gear malfunction. While troubleshooting the malfunction they failed to monitor their fuel which led to fuel starvation, and they crashed near Portland, OR. The roots of Human Factors, Crew Resource Management (CRM) and Threat and Error Management (TEM) can be traced to a 1979 NASA workshop formed to research the causes of air transport accidents such as this DC8. Research presented at this meeting identified the human error aspects (Human Factors) of the majority of air crashes as failures of interpersonal communications, decision making, and leadership. At this meeting the label Cockpit Resource Management, later changed to Crew Resource Management, was applied to the process of training crews to reduce pilot error by making better use of the human resources on the flight deck.

CRM training programs have evolved in the years since the NASA meeting. First generation courses were broad in nature, with a heavy focus on psychological testing and general concepts such as leadership. These courses advocated general strategies of interpersonal behavior without providing clear definitions of appropriate behavior in the cockpit. Games and exercises, unrelated to aviation, were employed to illustrate concepts.

Five generations of CRM training later, CRM interpersonal skills are clearly defined. Combined with Delta Safety Management System (SMS) data from FOQA and ASAP, CRM skills are being used to proactively mitigate threats and manage errors (TEM). Within Delta's SMS, Human Factors is the science that defines CRM skills through a process called TEM.

Introduction

CRM is a discipline within the larger field of Human Factors and can be defined as the effective use of all resources, including hardware, software, and people, to achieve the highest possible level of safety. The use of CRM enhances the safety and effectiveness of your crew (pilots and flight attendants) as well as the expanded team (Flight Control, Line Maintenance, Ramp Service, etc.).

- Crew = pilots and flight attendants.
- Resource = people, skills, equipment, and services.
- Management = directing, controlling, and coordinating.

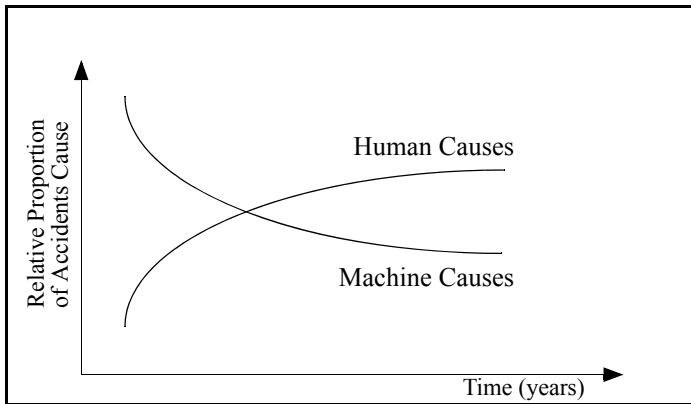
**A319/320/321 Flight Crew Training Manual**

Experience and research show that crews with effective CRM skills more ably mitigate threats and reduce the likelihood of making errors. Thus, the goal of Delta Flight Operations CRM and TEM programs is to build defenses that reduce the likelihood of error and when necessary mitigate or fix committed errors.

The following figure illustrates the causal factors in civil aviation accidents:

Changes in Accident Causal Factors Over Time

(ICAO, 1984)



CRM Skills

Delta Flight Operations defines a set of behaviors that affect the performance of pilots as crewmembers and more importantly of the crew as a whole. This set of behaviors are referred to as CRM skills. Each skill represents a desired behavior to be practiced during training and line operations. The CRM skills are divided into seven broad categories: Communication, Workload Management, Planning, Situational Awareness, Decision Making, Threat and Error Management, and Professional Management.

Communication

Effective CRM begins with effective communication. Communications are the verbal and nonverbal activities that represent the transfer of information to and from the flight crew.

- **Conduct thorough briefings.**
- Briefings should be given throughout the flight to address pertinent safety and operational issues, as necessary. They provide guidelines for crew actions, including operating procedures, distribution of crew workload, and any anticipated deviations.
- The captain sets the tone for the team during the flight attendant briefing by emphasizing the importance of interactive decision making and participation by the entire crew, thus encouraging crewmembers to voice any concerns they may have.
- **Clearly communicate operational decisions.**
- Crewmembers should clearly state operational decisions. The captain shares the parameters of operation with the entire crew throughout the flight and the crew contributes their perspectives. Minimum acceptable standards for safe operation (or “bottom lines”) are established and communicated. Likewise, the pilot flying (PF) ensures the pilot monitoring (PM) is kept apprised of current and intended flight actions.
- **Explicitly encourage participation**
- The captain encourages participation by the entire crew and emphasizes the importance of crew interaction in maintaining a safe operation. Crewmembers are encouraged to ask questions about crew actions and decisions.
- **Seek information and direction from others when necessary.**
- Crewmembers recognize personal limitations, such as limited experience in a particular seat or aircraft. When needed to solve operational issues or make decisions, these limitations are mitigated by actively seeking direction or advice from each other. Confusion on the flight deck is minimized by using sufficient inquiry to remain informed.



A319/320/321 Flight Crew Training Manual

- **Assert with appropriate level of persistence as required to maintain a safe operation.**
- Crewmembers state their ideas, opinions, and recommendations, asserting themselves and advocating their point of view as required to maintain safety of flight.
- At times personality differences affect crewmember interaction, especially when combined with a change in organizational culture. To deal with these, a five-step assertive statement process has proven effective.
 - Opening or attention getter - Address the individual. "Hey Chief," or "Captain Smith," or "Bob," or whatever name or title will get the person's attention.
 - State your concern - State what you see in a direct and unemotional manner. "We're low on fuel."
 - State the problem as you see it - "I don't think we have enough fuel to fly around this storm system."
 - State a solution - "Let's divert to another airport and refuel."
 - Obtain agreement (or buy-in) - "Does that sound good to you, Captain?"
- **Critique self and other crewmembers, when appropriate.**
- Continually assess performance to improve the operation on the flight deck. Feedback may be of a positive or negative nature. Feedback should be specific, based on observation, and provided for the purpose of maximizing crew effectiveness.

Situational Awareness

Situational Awareness is the pilot's ability to monitor or perceive elements in the environment, the comprehension of their meaning, and the projection of their status in the near future. This includes physical relationships (e.g. proximity to mountainous terrain), but it can also include other environmental circumstances.

- **Monitor, assess, and share all relevant operational factors to remain situationally aware.**
- Crewmembers monitor, assess, and share with other crewmembers climatic conditions, traffic, internal and external communications, aircraft instruments and performance, automated systems, and all other relevant operational factors to maintain situational awareness. Such information may be used to determine potential changes in operation.
- Complacency and fatigue undermine situational awareness. Combat these threats by diligently accomplishing repetitive/routine tasks and cooperatively monitoring other crewmembers' actions; challenge one another to ensure heightened awareness.

Planning

- **Anticipate and select a strategy.**
 - Planning is the anticipation and selection of actions and strategies to meet current and future operational requirements. Captains should focus the crew's attention on upcoming requirements/demands and divide planning tasks and responsibilities amongst crewmembers. Ask for clarification when plans are not clear.
 - As a guide:
 - remain ahead of the aircraft and situation;
 - adapt to changes and factors that affect the current or future flight status;
 - plan and prebrief crew tasks, the operational prioritization of upcoming tasks, and the levels, modes, and configurations of automation to be used; and
 - execute plans as briefed or communicate changes/deviations from the plan.
-

Decision Making

- **Determine the best course of action.**
- Decision making is the systematic approach to determine the best course of action in response to a given set of circumstances and involves the prioritized, appropriate use of resources both inside and outside the aircraft. Though captains are the final decision making authority, good decision making emphasizes the crew's involvement in the decision-making process. Decisions should be made in a timely and competent manner and conveyed to the entire crew.
- Effective, safety-minded decisions utilize explicit guidance and are not biased regarding competing goals. Poor decisions often result when the crew has time constraints, outside pressure (e.g. Flight Control, Maintenance, personal desires), or lack of experience.
- It is extremely important for crews to recognize when expanding the team is necessary in making the most informed decision. Examples of this are utilization of the Security Conflict Team during security incidents and Maintenance Control Center (MCC) for complex MELs or for multiple equipment failures while airborne.
- Captains are the final decision makers; take command, be decisive, and do not hesitate to make the difficult decisions to ensure the safety of your passengers and crew. If you involve the expanded team when necessary, make informed decisions, and use your best judgment - the Flight Operations management team will always support your decision.

Workload Management

- **Distribute tasks to maximize efficiency and effectiveness.**
- Workload management describes the distribution of workload so that everyone is utilized and no one is overtaxed. In addition, it facilitates teamwork in a coherent and unified manner. Recognize and report work overload in yourself and in others. Effective workload management results in a well coordinated crew.
- Use all available resources to accomplish required tasks in the most efficient and effective way. Resources may include flight crew, cabin crew, deadheading crewmembers, as well as external resources. Examples of external resources include Flight Control, ATC, and Maintenance. To decrease workload, use aircraft automation whenever appropriate.
- **Prioritize tasks for effective accomplishment.**
- The crew clearly prioritizes operational tasks. Primary tasks, such as continuing to fly the aircraft, are allocated sufficient resources before assessing secondary duties, such as external communications.
- Ensure that low priority or non-essential activities such as social interaction do not interfere with more important tasks.
- **Manage time for accomplishing tasks.**
- The crew allows sufficient time to accomplish flight duties. They recognize the need for and create additional time to complete tasks when operational considerations dictate. Crewmembers are not rushed in the discharge of their duties.

Professional Management

- **Professional Management** allows pilots to maximize individual and team performance to minimize risk.

Professional management skills focus on individual interactions in a team environment and help identify personality traits and cultural differences that affect individual and team performance. These cultural differences and personality traits can harbor threats that are latent and by their very nature difficult to predict, identify, and mitigate. Common latent threats to be aware of include: Power Distance, Individualism/Collectivism, Uncertainty Avoidance, Complacency, Fatigue, and Stress.

- **Power Distance** - Is defined as one's perception and response to hierarchy, seniority or rank. Power Distance is subdivided into High Power Distance and Low Power Distance. High Power Distance exists when first officers do not question a captain's decision or articulate disagreement. Low Power Distance exists when captains and first officers are considered nearly equal in their roles and responsibilities.
- **Individualism/Collectivism** - Refers to whether a person's goals are self-oriented (individualism) or team-oriented (collectivism). This orientation impacts a pilot's willingness to appropriately operate in a team environment.
- **Uncertainty Avoidance** - Is defined as the threat level perceived during high stress events. High Uncertainty Avoidance involves a preference for standard operating procedures and leaving as little as possible to chance. Low Uncertainty Avoidance involves acceptance of high stress and higher exposure to risk as part of the job, with more tolerance and flexibility.
- **Complacency** - Often referred to as 'the silent killer,' the pilot is unaware that complacency is occurring. There is a feeling of contentment or self-satisfaction that is especially problematic when coupled with an unawareness of actual danger, trouble, or deficiencies. Example: Routine takeoff on a familiar runway and at the hub airport. Remedy: Adopt a diligent and alert attitude towards accomplishing repetitive routine tasks and develop methods of challenging the awareness of other crewmembers.



A319/320/321 Flight Crew Training Manual

- **Fatigue** - Physiological studies and real-world experience both validate the negative effects on pilot performance of performing duties while fatigued. While scheduling and crew rest policies endeavor to mitigate the worst impacts of fatigue, responsibilities for personal habits and maintaining a disciplined approach to limiting the effects of fatigue also reside with the pilot. In addition, when fatigue is noted in one's self or another crewmember simply recognizing the situation and advising the other crewmember(s) can be an effective mitigation strategy. If fatigue is a certainty, and it cannot be effectively mitigated, and you believe that it would compromise the safety of flight, then the flight should not be attempted and Crew Scheduling and the chief pilot should be contacted. It is the pilot's responsibility to be properly rested, but it is also the pilot's responsibility to recognize the existence and impacts of fatigue and handle it appropriately.
- **Stress** - Closely related to and contributory to fatigue, stress stems from a range of sources including life events, physical conditions, time constraints, and a host of others. Like fatigue, it is essential for pilots to recognize when stress has the potential to negatively impact performance and to consider mitigation strategies to minimize its effects such as proactively monitoring one another for signs of distraction and communicating concerns clearly.

The Threat and Error Management (TEM)

- TEM is the effective management of Expected and Unexpected Threats using Delta's Threat and Error Management (TEM) process. TEM involves crewmembers proactively identifying threats and vigilantly identifying errors and managing those threats and errors before they impact the safety of flight.
- **Expected Threats** - Threats that are anticipated to effect operations are known as expected threats. Examples of expected operational threats are: adverse weather, MCOs, runway conditions, terrain, complex taxi instructions, a challenging SID or Special Pages. (Note: These types of threats are currently considered and briefed during the WARTS and NATS briefs). Examples of expected latent threats are: fatigue after a short layover, complacency on a routine takeoff or arrival a crewmember has accomplished hundreds of times. (Note: These types of threats are currently not considered as part of the WARTS and NATS briefs).
- **Unexpected Threats** - Threats that cannot be anticipated or planned for in advance are known as unexpected threats. Examples of unexpected operational threats are: abnormals, system malfunctions, passenger medical issues, and security threats. Examples of unexpected latent threats are fatigue during a long flight, similar sounding call signs, and complacency.

A319/320/321 Flight Crew Training Manual

Error

An error is an action or inaction by the flight crew that leads to deviations with undesired or unexpected consequences. Error management is the process of understanding that errors will occur during operations; emphasis is then placed on crewmember vigilance and effective monitoring/crosschecking so the error is identified or trapped in a timely manner and then mitigated. The importance of the role of the pilot monitoring (PM) in trapping errors is emphasized later in this section.

Errors are defined as flight crew actions or inactions that:

- lead to a deviation from crew or organizational intentions or expectations,
- reduce safety margins, and
- increase the probability of adverse operational events on the ground or during flight.

Error Types

Aircraft Handling Errors	Examples
Automation	Incorrect altitude, speed, heading, autothrottle settings, mode execution, or FMC entries
Flight Control	Incorrect flaps, speed brake, autobrake, thrust reverser, or power settings
Ground Navigation	Attempting to turn down wrong taxiway/runway; Missed taxiway/runway/gate
Manual Flying	Hand flying vertical, lateral, or speed deviations; Missed runway/taxiway failure to hold short, or taxi above speed limit
Systems/Radio/Instruments	Incorrect pack, altimeter, fuel switch, or radio frequency settings

A319/320/321 Flight Crew Training Manual

Procedural Errors	Examples
Briefings	Missed items in the brief, omitted departure, takeoff, approach, or crew change briefing
Callouts	Omitted takeoff, descent, or approach callouts
Checklist	Performed checklist from memory or omitted checklist; Missed items, wrong challenge and response, performed late or at wrong time
Documentation	Wrong weight and balance, fuel information, ATIS, or clearance recorded; Misinterpreted items on paperwork
Pilot Flying (PF)/ Pilot Monitoring (PM) Duty	PF makes own automation changes while hand flying, PM doing PF duties, PF doing PM duties
SOP Cross-verification	Intentional and unintentional failure to cross-verify automation inputs
Decision-Making Errors	Un-warranted high-speed aborts
Other Procedural	Other deviations from government regulations, flight manual requirements, or standard operating procedures

Communication Errors	Examples
Crew to External	Missed calls, misinterpretation of instructions, or incorrect read-backs to ATC. Wrong clearance, taxiway, gate, or runway communicated
Pilot to Pilot	Within-crew miscommunication or misinterpretation

Unmanaged or mismanaged errors can lead to an undesired aircraft state (e.g., off altitude, off airspeed, off course, or being in the wrong place at the wrong time).

In addition to the types of errors described above, errors can be classified into three categories, decision errors, skill-based errors, and perceptual errors.



Decision Errors

Decision errors are often procedural in nature. Aviation is very structured and has standard policies and procedures. In this type of error the crew either misapplied the procedure or used an inappropriate action that led to the error. Poor choice errors occur when the crew has time constraints, outside pressure, or lack of experience. These can also be thought of as knowledge-based errors as the crew finds themselves in a situation that they neither understand nor has ever faced before and the situation has exceeded their ability. In many cases the crew can slow the pace and use methodical reasoning to deal with the problem. In other cases decisions have to be made immediately, such as in the decision to abort or continue a takeoff.

Skill-based Errors

A skill-based error occurs when the crewmember knows the correct procedure, tries to perform it correctly, but makes a mistake. These types of errors are unintentional, and can be considered proficiency related. Examples of this kind of error are an omitted checklist item or an unstable approach resulting from deficiencies in technical proficiency.

Perceptual Errors

Perceptual errors are caused by visual illusions, spatial disorientation/vertigo or misjudged distance, altitude, airspeed, or clearance.

Error Management

Strict adherence to Delta's approved checklists, procedures, and policies is essential in mitigating operational errors. Additionally, the role of the Pilot Monitoring (PM) has evolved and is now paramount to further manage operational errors.

The original concept of the Pilot Not Flying (PNF) was a supporting crewmember to assist the Pilot Flying (PF). Research performed by NASA Ames Research Center indicated a change from the passive role of PNF to a more assertive role of Pilot Monitoring (PM).

This concept focuses on the second pilot as not only supporting the PF but, as a fully qualified pilot, mentally following the PF in a monitoring task. As a monitoring pilot, the PM would catch those errors the PF might inadvertently make due to any number of reasons. Recent incidents indicate a more assertive role is necessary for the PM. The NTSB found that many of these recent incidents were due to the failure of the Monitoring Pilot to actively monitor.

This suggests the notion that monitoring can be either passive or active. In these incidents the PM was passively monitoring or not monitoring at all during critical flight segments. The question is why? Research on flight crew error points towards two areas of error in highly skilled pilots; interruptions/distractions and active monitoring. Just as CRM has evolved to Threat & Error Management, Error Management is evolving to proactive strategies such as active monitoring by the PM.

Threat Management Tools

Delta's Threat Management Process is an ordering of CRM skills that help the crewmember proactively mitigate threats to safe operations. These tools are offered to crewmembers as a method of mitigating threats by planning in advance for those that are expected, and simplifying the process for handling those that are unexpected. Data indicates that crews who proactively deal with threats make fewer errors than crews who react to threats as they occur.

Currently, separate Threat Management tools exist for both expected and unexpected threats.



Expected Threat Management Tool

Studies have shown that the greatest concentration of threats exists between pushback thru top-of-climb, and then again from top-of-descent thru taxi to the gate. In addition to all the normal latent threats such as stress, complacency and personality conflicts, these flight segments contain operational threats such as airport irregularities, weather and complex departures/arrivals that require pilot attention. Crewmembers must identify expected (known) threats before each flight segment, plan for each threat, and communicate the plan to other crewmembers. The Threat Management tools for this purpose are the W-A-R-T-S and N-A-T-S briefings described in FOM Chapter 3.

When conducting these briefings, be sure to include the expected threats in each major category, and the plan to mitigate each threat. WARTS and NATS refer to operational threats but crews should also include latent threats (complacency, stress, fatigue) and plans to mitigate such threats in their Departure and Approach briefings as necessary.

Threat management tools, WARTS and NATS, incorporate all of Delta's seven CRM skills:

- Situational Awareness - Threats identified through proper situational awareness.
- Decision Making - Pilot flying decides which threats to brief and identifies highest threat for the flight segment.
- Planning - Plan is made to mitigate the threats.
- Communication - Plans are communicated to other crewmembers and expanded team members.
- Workload Management - Briefings are accomplished during periods of low workload (e.g. at the gate or before top of descent).
- Threat and Error Management - Is the effective management of expected and unexpected threats using Delta's Threat and Error Management (TEM) process.
- Professional Management - Allows pilots to maximize individual and team performance to minimize risk.

The Highest Threat

While it is a sound TEM practice to identify expected threats and communicate plans to mitigate those threats, pilots should verbalize the highest threat to each flight segment, as stated in FOM, Chapter 3. The purpose of identifying the highest threat from those threats already briefed is twofold. First, a critical element to TEM is the constant evaluation and prioritizing of threats by the crewmembers. While a crew may have briefed several threats during a WARTS Departure brief, there is value in mentally reviewing those threats and prioritizing which among them is most likely to negatively affect the flight. Verbalizing this threat at the end of the briefing separates it out from the others and emphasizes its importance.

Secondly, it is possible that the highest threat is a latent threat that was not included in WARTS or NATS. This is a likely scenario for many crews who have vast experience departing from or arriving to a particular airport or runway (e.g. T/O from KATL Rwy 08R). For example: “The highest threat for today is complacency and the plan to mitigate this threat is to simply recognize that we are susceptible and to realize that today might be the day that the departure does not go as planned.”

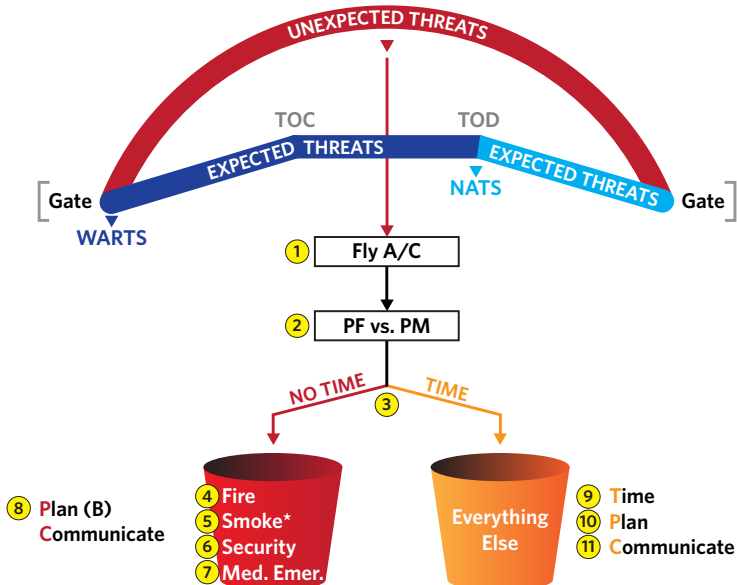
Note: It is not necessary to re-brief the plan to mitigate the highest threat if it was previously covered in WARTS or NATS.

It is critically important to remember to brief a mitigation plan for each threat, but it is especially important in regards to the highest threat. For example, when departing an airport with high terrain in the vicinity, it would be appropriate to brief: terrain location in relation to the planned departure route, the use of terrain mapping in an effective range, the MSA, grid MORA and the green pages for special engine out departure procedures. Additionally, a review of terrain avoidance procedures for GPWS alerts and warnings would be warranted.

Unexpected Threat Management Tool

Unlike expected threats that can be planned for in advance, unexpected threats can occur at any time from initial pushback from the gate to block-in at the destination. Generally, pilots react to these types of threats as they occur, using their CRM skills acquired from past experience or training. The goal of Delta TEM is to give pilots a CRM process to proactively handle these threats and manage resultant error. Properly utilized, this threat management process enables crews to know what to do to manage a threat before it occurs. The following TEM model orders crew CRM skills into a process that allows the crew to proactively manage both expected and unexpected threats.

Threat & Error Management Model



(1) Flying the aircraft is the top priority. After assuring aircraft control, stabilize the situation by accomplishing immediate action items (if applicable), offsetting from NAT tracks or WATRS routes (in case of engine failure), etc. Use of automation is highly encouraged.

(2) Decision Making, Workload Management - The captain should divide the flight deck and assign duties. Any one crewmember that attempts to fly the aircraft, respond to ATC and respond to a non-normal event (manage the threat) risks task saturation and creates the potential for error. Under normal circumstances, effective workload management might divide crewmember duties as follows:

- PF - Primary responsibilities are to fly the aircraft, listen, respond and adhere to ATC clearances. Maintain situational awareness through periodic communication with PM. Involve PM if any problems or difficulties are encountered.
- PM - Primary responsibilities are to maintain constant situational awareness, prioritize threats, manage the highest threat by building (expanding) a CRM team for input, create enough time to formulate a plan of action, communicate that plan as necessary and continue to actively monitor the PF as able.

The captain (as pilot in command) must make several decisions in the course of managing the threat (build the CRM team and solicit input, evaluate options, decide on where to land, etc.). This suggests that, under many circumstances, the captain should assume the PM role when faced with an unexpected threat. (Exceptions to this situation might include a low time first officer in mountainous terrain, an uncontrollable aircraft, etc.)

Additionally, extensive analysis in the simulator during LOEs confirms an increase in crew errors when the captain assumes the PF role and attempts to manage the threat while simultaneously controlling the aircraft. This is corroborated by an NTSB study from 1979-1994 which determined that in 81% of aircraft incidents during that time period the captain was the PF.

Note: Nothing expressed in the preceding paragraphs supersedes in any way the captain's emergency authority to take any and all action, including the assignment of PF/PM duties during non-normal situations, to provide for the safety of the passengers and crew. The captain should recognize, however, that attempting to manage a threat while controlling the aircraft increases the chance of error and he/she should consider further steps to mitigate these errors (e.g., creating more time to consider a plan of action, increased use of automation, remaining in protected airspace while dealing with the threat by entering holding, etc.)

**A319/320/321 Flight Crew Training Manual**

(3) Decision Making - After the captain assigns PF duties to the first officer, he or she must pause to determine the criticality of the highest threat before assigning a TIME or NO TIME designation. This may require expanding the team, such as contacting STAT-MD when evaluating the criticality of a medical event.

Note: ASAP data indicates captains may overlook this step, particularly in misdiagnosing a medical event as a medical emergency. Take the time to expand the team if necessary (i.e. contact STAT-MD for a medical event) before choosing a TIME or NO TIME threat management path.

NO TIME Threats - Include unexpected threats that are time critical in nature and usually require landing as soon as safely possible.

- NO TIME threats require that the captain have a plan of action in mind (Plan B) to enact as soon as the threat occurs.
- NO TIME threats may be aircraft specific. For example, a simple engine failure in a Cessna 150 would be considered a NO TIME threat where it is not in a B747. NO TIME threats listed here are common to all Delta aircraft. Individual fleets may consider additional NO TIME threats based on the needs of their particular type of aircraft.
- NO TIME threats may be flight segment specific and are not listed in the TEM model. Examples of these threats are engine failure on a WATRS route and rapid depressurization over critical terrain. Threats of this type and an intended plan of action (Plan B) must be pre-briefed by the crew prior to each applicable flight segment.
- Even during a NO TIME threat, TEM never has an aircraft land as soon as possible, but rather as soon as is safely possible.

(4) Fire - Fires of an unknown origin, intensity or disposition should always be considered a NO TIME Threat. Even fires that appear to be extinguished may have caused unknown damage to components and landing should not be delayed (exception, lavatory waste fire, etc.)

(5) Smoke - Delta policy allows for time to evaluate a smoke threat before determining the criticality of the threat. For example, the crew may elect to continue a flight if the smoke is from an extinguished lavatory trash bin fire. Refer to the QRH Checklist Instructions for Smoke/Fumes for further information.

(6) Security - Refer to the FOM 4.4, Sensitive Security Information, Common Strategy for further information.

(7) Medical Emergency - Delta policy is to contact STAT-MD to determine the criticality of a medical event. STAT-MD is to be considered primary guidance in the decision to upgrade a medical event to a medical emergency. An expedited landing or diversion to an alternate airport should not be commenced before contacting STAT-MD (unless contacting STAT-MD will delay landing at the destination airport). Refer to FOM 7.4 for further information.

(8) Plan (B) suggests that each captain have a plan of action in mind before an actual NO TIME event occurs. Captains should always have an emergency divert field in mind from takeoff through landing for each flight. Updates to this alternate destination should be made periodically throughout the flight as necessary due to location of the aircraft, suitability of the alternate airport (Refer to AM, Theaters & Airports) and weather.

Note: Although it is essential that captains always have a divert field in mind, the actual decision to divert and the most suitable alternate should be determined in conjunction with the dispatcher and STAT-MD (for a medical emergency).

Upon determining that an expedited landing must be made, the captain could use the following Plan (B):

“F/O you have the aircraft and the radios. Declare an emergency. Take the aircraft to (designated alternate airport), longest landing runway, 10NM final, 200kts. Go as fast as you are comfortable but no faster, and get my attention if you run into any problems or have any questions. Do you have any questions now?”

This plan exemplifies the CRM skills of workload management, decision making, planning and communication and allows the captain to focus on the threat at hand while maintaining critical Situational Awareness. Calmly communicated, this plan effectively manages the non-normal workload, ensures someone is flying the aircraft, is decisive, and sets the aircraft up for a stabilized approach. It is also a plan that can be proactively memorized by all captains.

Note: The preceding Plan (B) is used as an example only. It is only important that each captain have some plan of action in mind before encountering any NO TIME threats.

TIME Threats - Include any threat to safe operation of the flight that is not time critical in nature. Examples of these threats are medical events, most aircraft system malfunctions, deteriorating weather conditions, late runway changes, etc.

- TIME threats are not critical in nature and allow the crew time to fully evaluate a new plan of action.
- The vast majority of threats to crewmembers are TIME threats. Crews should recognize that very often they either have ample time or the ability to create additional time to effectively manage most threats to the operation.
- Misdiagnosing a TIME threat as a NO TIME threat (particularly upgrading a medical event to a NO TIME medical emergency without contacting STAT-MD) and rushing through a plan of action (i.e. non-normal checklists) are two of the most common errors crewmembers make.

**A319/320/321 Flight Crew Training Manual**

(9) Time - Create more time to consider a plan of action. Ways to create more time are often dictated by phase of flight and include:

- Slow down
- Request vectors
- Enter holding

Note: Crews must consider fuel load when creating time to make a plan.

(10) Plan - Expand your CRM team (other crewmembers, dispatch, STAT-MD, maintenance, deadhead crew, flight attendants, etc.) and use your onboard resources (QRH, Volume 1, ODM, etc.) to formulate a plan of action.

(11) Comm - Communicate the plan of action as necessary (2 in 2 out) meaning, communicate the plan to the flight attendants and passengers (2 in) and to ATC and the company (2 out).

Note: The captain must always maintain Situational Awareness, including during the implementation of the TPC model. Dynamic flight situations often present multiple threats which must be continuously considered and evaluated throughout the flight. It is possible that the TPC model will be interrupted and run again to address subsequent, more challenging threats.

Example: An engine fire (NO TIME) results in an expedited divert to a 10 mile final. The fire appears to be extinguished yet the crew finds itself unprepared to complete the approach (now the highest threat). The captain requests a 360-degree turn (TPC) to create time to prepare for the approach.

Selected References

Chapter 10

Table of Contents

Section TOC

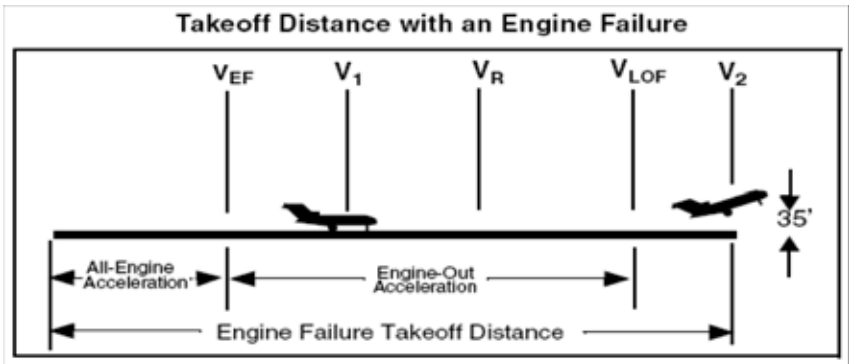
Engine Out.	10.1
Engine Failure Takeoff Performance	10.1
Takeoff Segments	10.2
Optimized V1	10.3
Improved Performance	10.4
Departure Procedures (DPs)	10.5
High Elevation Considerations	10.9
Aircraft Performance Characteristics	10.9
Stopping Dynamics	10.10
Performance Considerations	10.11
Factors Affecting Takeoff Performance	10.11
Factors Affecting Landing Performance	10.12
Climb Performance	10.13
Turning Performance	10.14
Weather Radar	10.16
Turbulence Avoidance	10.16
Windshear Avoidance	10.18
Hydroplaning	10.19
Dynamic Hydroplaning	10.19
Viscous Hydroplaning	10.21
Steam Hydroplaning (Reverted Rubber)	10.21
Controllable Physical Factors	10.22
Flight Deck Considerations and Techniques	10.23
Delta Maneuver Training	10.26
Aerodynamic Aspects of Maneuver	10.26
Flight Dynamics	10.27
Structural Aspects of Maneuver	10.35

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Engine Out

Engine Failure Takeoff Performance

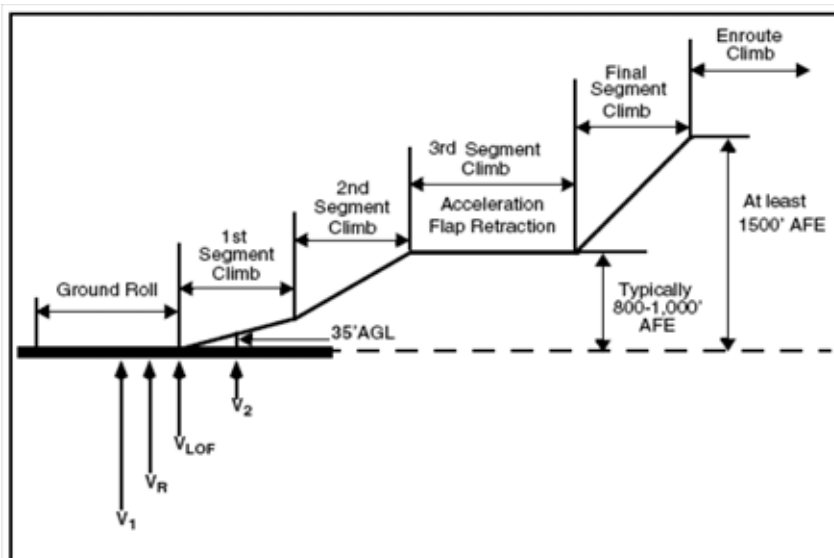
Engine failure takeoff distance is the distance from brake release to the point where the aircraft attains a height of 35 feet, assuming an engine fails at VEF. FAR 25 requires that the length of runway plus clearway be at least equal to the engine failure takeoff distance.



Takeoff Segments

FAR 25 specifies minimum climb gradients that must be achieved in the first, second, third and final segments.

- Delta schedules climb limit weight so that the aircraft can meet takeoff climb requirements in all climb segments. As such, climb limit weight is determined by aircraft performance and is not dependent on obstacles in the takeoff path.
- Delta schedules runway allowable weight to ensure that the net engine failure flight path will clear obstacles in the takeoff path. Regulations require that obstacles are cleared by 300 feet horizontally (200 feet within airport boundary) or by 35 feet vertically.



Basic Dispatch

Begins at liftoff (V_{LOF}) and ends when the landing gear is fully retracted.

Second Segment Climb

Begins when the landing gear is fully retracted and ends at the altitude chosen for the start of flap retraction. Delta calls this altitude “clean-up altitude.” The minimum speed to be used during the second segment is V_2 . For a two-engine aircraft, a 2.4 percent climb gradient is required.

Third Segment Climb

The aircraft is accelerating during flap retraction and should be in level flight. A minimum acceleration capability is imposed by FAR 25.

Final Segment Climb

From clean-up altitude to a minimum of 1500 feet AFE.



Optimized V1

What does Optimized V1 mean?

V1 has been adjusted either faster or slower in order to increase the RATOW. This performance is part of the FAA certified aircraft takeoff performance for all airplanes in Delta's fleet except for the MD-88/90.

How is it possible to adjust V1 and still comply with the engine inoperative accelerate-stop and accelerate-go requirement from V1?

Optimized V1 is only useful when the RATOW is limited by factors other than the pure runway length, slope, and wind. It is used when the RATOW is limited by either:

- Obstacle Clearance: the performance capability to clear obstacles in the takeoff flight path with one engine inoperative, or
- Brake Energy: the performance capability of the brakes to absorb all of the energy generated by an accelerate-stop without melting.

When the RATOW is limited by obstacle clearance or brake energy, excess usable runway exists, i.e., the weight and the corresponding runway required are less than the actual runway length for a pure balanced field length case. Because the runway length used is less, the V1 can be adjusted and still comply with the accelerate-stop and accelerate-go requirement. The adjusted V1 can result in using all of the available actual runway length. The V1s are customized to the specific runway. (V1s from the ODM and the FMS are not.)

Why use Optimized V1?

RATOW is increased on obstacle or brake energy limited runways. Approximately 60% to 70% of our runways are obstacle limited, not balanced field length limited. Because of that, there is a tremendous opportunity to increase RATOWs.

How can the pilot tell when the WDR is using Optimized V1?

The WDR does not have the capability to indicate when the RATOW and V1 are based on Optimized V1.



Shown below is an example using B767-400 pure performance (structural limits not withstanding) for ATL Runway 27R, which is obstacle limited.

OAT 65 deg F QNH 29.92 0 wind						
	Thrust/Flap	Climb Limit	RATOW	V1	VR	V2
Current Data:	PKOF TO/15	456168	444966	164	170	174
Optimized Vspeed Data:	PKOF TO/15	456168	450017	166	170	174
Balanced Field	PKOF TO/15	456168	456112	165	172	175
(no obstacles for comparison purposes)						

The relevant FAR takeoff performance runway distances for this comparison are:

	Runway Length	Accelerate- Go	Accelerate-Stop
Current Data:	11889	11349	11349
Optimized Vspeed Data:	11889	11153	11889
Balanced Field	118895	11889	11889
(no obstacles for comparison purposes)			

Improved Performance

This procedure is utilized at certain airports to optimize the takeoff V2 speed for improved takeoff weight capability. Standard takeoff speeds are set to provide good takeoff weight capability for a wide range of regular, non performance-critical airports. For some airports and runways, however, takeoff weight capability can be dramatically improved by selecting a different V2 speed that optimizes performance for the runway and elevation of interest. The technique of adjusting V2 up or down optimizes both runway and climb performance so that a maximum overall weight limit is obtained. V1 and Vr must also be modified to maintain consistent performance relationships.

The WDR will display “IMP” on the runway analysis line when Improved Performance is being utilized, refer to FOM chapter 5.6, Weight Data Record (WDR).

In general, Improved Performance can only be used when there is no standing water, ice, slush or snow on the runway. If Improved Performance is the only available performance for a particular runway due to departure procedure requirements, however, contaminated runway performance will be available.



Departure Procedures (DPs)

This section describes how engine-out climb performance affects DPs and Delta special procedures. DPs may be referred to as SIDs or IFR departures in some documents.

Profile Construction

There is no significant climb performance difference between an obstacle DP or a DP used for ATC purposes.

- A DP may be used to simplify ATC clearance delivery procedures. It may also be used to assist the pilot conducting IFR flight in avoiding obstacles during climbout to a MEA or it may be used for traffic separation.
- An obstacle DP is used primarily when an obstacle analysis reveals obstacles that penetrate the FAR required climb gradient on departure.
 - Obstacle clearance is based on the aircraft, crossing the end of the runway at least 35 feet AGL, climbing at least 200 feet per nautical mile, and climbing to 400 feet above airport elevation before turning, unless otherwise specified in the procedure.
 - A slope of 152 feet per nautical mile, starting no higher than 35 feet above departure end of the runway, is assessed for obstacles.
 - A minimum vertical obstacle clearance of 48 feet per nautical mile is assured provided the aircraft climbs at the minimum climb gradient. Unless published higher on the appropriate departure chart, the minimum climb gradient is 200 feet per nautical mile.

Note: This procedure can require a ceiling and visibility to allow the obstacles to be seen and avoided, a climb gradient greater than 200 feet per nautical mile, detailed flight maneuvers, or any combination of the above.

Performance Considerations

There are many differences between Terminal Instrument Procedures (TERPS) and engine-out criteria, including the lateral and vertical obstacle clearance requirements.

- Engine-out procedures do not need to meet TERPS requirements.
- TERPS climb gradient requirements do not necessarily ensure that engine-out obstacle clearance requirements are met.
- DPs allow relatively low minimums but may be predicated on climb gradients which may not be attainable after an engine failure.



Delta Special Departure Procedures

Delta is responsible for determining that all departures maintain the obstacle clearance required with an engine failure in accordance with FARs.

Maximizing Takeoff Weight

The most common procedure to maximize takeoff weight when significant obstacles are present along the normal departure route is to use a special departure routing in the event of an engine failure on takeoff.

- Obstacles along the engine failure departure routing are used to determine the maximum allowable takeoff weight for that runway.
- If possible, the engine-out departure routing is designed to coincide with the flight path for normal departures.

Determining Takeoff Weight

When determining the limiting takeoff weight, the obstacle analysis is carried out to the end of the takeoff segment. For the purpose of obstacle analysis, the end of the takeoff segment occurs when the aircraft is at:

- Minimum crossing altitude (MCA) at a fix, or
- Minimum enroute altitude (MEA) for a route to the intended destination, or
- Minimum vectoring altitude (MVA), or
- A fix and altitude from which an approach may be initiated to the departure airport or departure alternate.



A319/320/321 Flight Crew Training Manual

Airport Specific Departure Procedure

Delta provides special departure procedures for those stations which require additional guidance regarding the engine-out departure. The regulations require that the net takeoff flight path clears all obstacles by 35 feet vertically or 200 feet laterally inside the airport boundary or 300 feet laterally outside the airport boundary.

To ensure the required lateral clearance, Delta must account for factors that could cause a difference between the intended and actual flight paths and between their corresponding ground tracks.

For example, two considerations are the loss of climb capability during turns in holding patterns or other maneuvers which may be necessary to reach en route altitudes and aircraft speeds and their effect on turn radius during determination of flight paths.

- Engine-out bank angle must also be considered in procedure development. FAR 121.189 assumes an engine-out bank angle limited to 15 degrees at V₂ and the AFM generally provides a climb gradient decrement for a 15 degree bank. For angles less than 15 degrees, a proportionate amount of the 15 degree value may be applied, unless the manufacturer or AFM has provided other data.
- Obstacle clearance at certain airports can be enhanced by the use of bank angles greater than 15 degrees.
 - If bank angles of more than 15 degrees are used, V₂ speeds may have to be increased to provide an equivalent level of stall margin protection and adequate controllability (VMCA).
 - Bank angles up to 25 degrees engine-out are acceptable, provided that adequate controllability and equivalent stall margins are maintained and climb gradient decrements are applied.
 - Bank angles over 25 degrees may be appropriate in certain circumstances but require specific evaluation and FAA approval.
- FARs do not specifically require an obstacle clearance analysis for engine-out missed approaches or rejected landings since this would involve multiple failures. It is, however, appropriate to provide information to the flight crews on the safest way to perform such a maneuver should it be required. The operator may develop the methods and criteria for the analysis of engine-out missed approach procedures which best reflect that operator's operational procedures.
- Generally, published missed approach procedures provide adequate terrain clearance; however, further analysis may be required if:
 - Published missed approach has a climb gradient requirement, or
 - Departure procedure for the runway has a published minimum climb gradient, or
 - A special engine-out takeoff procedure is required. A distinction needs to be made between a missed approach and a rejected landing.



- An engine-out missed approach from the minimum descent altitude (MDA), decision height (DH), or above, can frequently be flown following the published missed approach procedure.
- When rejecting a landing past the published missed approach point pilots must be aware of any published special departure procedure for terrain clearance. Consult the applicable 10-7 Delta Special Pages for the runway in use.

Go-around, missed approach, and rejected landing have been mistakenly interchanged. A brief definition of each follows:

- **Go-around** is a generic term used to describe pilot actions and configuration/power changes applied when an approach is discontinued. For a visual approach or VFR, unless otherwise directed, over-fly the runway, climb to pattern altitude, and enter crosswind leg.
- **Missed approach** is a published procedure beginning at the missed approach point (MAP).
- **Rejected landing** is a go-around initiated past a published missed approach point.

WARNING: Terrain clearance is guaranteed only when executing a published missed approach procedure at the missed approach point. A rejected landing past the missed approach point may require some other choice, such as a departure procedure.



High Elevation Considerations

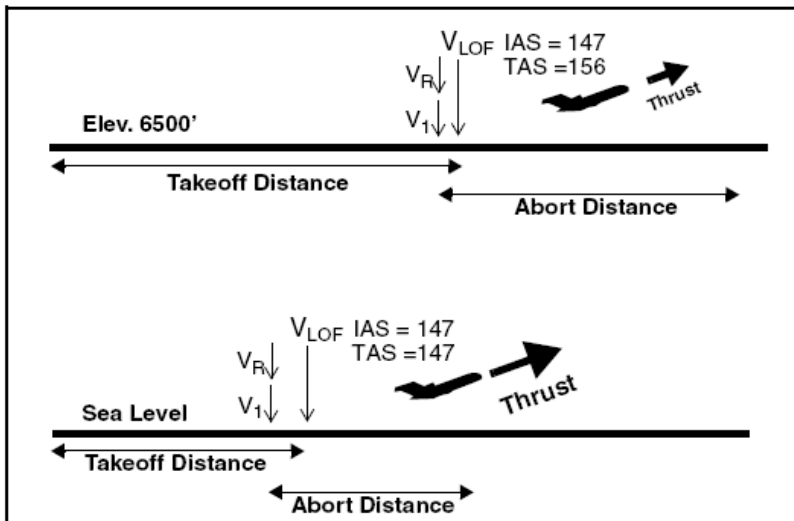
Aircraft Performance Characteristics

Two principles combine to degrade jet aircraft performance at high elevation.

- Available thrust is reduced.
- True air speed (TAS) is higher for a given indicated air speed (IAS).

Overall performance degradation is obvious for runways of identical length and ambient conditions except for a significant pressure altitude difference.

Performance Comparison



Significant effects are summarized as follows:

- Takeoff distance required is increased. Although IAS remains unchanged for the same gross weight and drag, ground speed is higher.
- Stopping distance required is increased. Landing distance increases approximately 3.5 percent for every 1000 feet of elevation above sea level.
- Distance required to reject takeoff is increased.
- Turning radius is increased.
- Higher N1 setting is required to maintain same thrust.
 - Higher N1 required on final approach for same descent rate.
 - Go-around capability (or excess thrust) is reduced.

Stopping Dynamics

The critical physical dynamics of high elevation stopping are considered within takeoff and landing limitations. The greater the pressure altitude (or greater the true airspeed for an IAS), the greater the stopping distance required. This reduces takeoff and landing performance limit weights at high elevation airports.

- High elevation takeoffs are usually limited by the climb limit weight. Whenever the runway allowable takeoff weight (RATOW) is larger than the climb limit weight, an excess of runway for a rejected takeoff is available, but no extra comfort level should be assumed.
- Landing climb performance limitations at high elevation airports, as elsewhere, are dependent upon the ability of an aircraft to meet engine-out rejected landing parameters. It is possible to dispatch an aircraft to a high elevation station contingent upon a reduced flap landing. The “performance cushion” is generally small and correct landing speed, touchdown point and braking are necessary to ensure a safe landing.
- Higher landing TAS is fully appreciated by crews experienced with high elevation flying. Kinetic energy can be appreciated by understanding the formula: $KE = 1/2 MV^2$ where M represents mass (or weight) and V represents velocity or ground speed. A change in the speed has a greater impact on kinetic energy than a proportional change in weight.

Note: At an elevation of 5000 feet, kinetic energy is approximately 16 percent greater for the same landing speed range compared to an aircraft of the same weight at sea level.

- A decision for a high speed rejected takeoff maneuver is protected to V1, so long as the anomaly is indeed loss of an engine, it is recognized prior to V1 and MAX braking is applied by V1. Crews tempted to reject a takeoff for non-airworthy faults should be conscious of the relatively greater kinetic energy to be arrested when operating at higher elevations. Likewise, crews should have confidence in the safeguards provided within the limitations and configurations used to maximize payloads to and from high elevation stations.



Performance Considerations

Note: All numerical comparisons are for example only and do not replace the actual values found in the aircraft manuals.

Factors Affecting Takeoff Performance

Dynamic pressure is measured in the flight deck by KIAS. An airplane in a set configuration requires a certain dynamic pressure for takeoff which provides lift equal to weight, referred to as takeoff speed. It is invariant with altitude, temperature, wind, etc. It does vary directly with gross weight.

Altitude

Aircraft operated from increased altitudes require increased takeoff distances. The same dynamic pressure, therefore the same KIAS, is required as at sea level. But due to reduced air density, a greater actual velocity (true airspeed) is necessary to provide that pressure. At 6500 feet MSL a typical takeoff true airspeed is increased about 10 knots over that at sea level. Depending on the specific engines, less thrust may be available at higher elevations for acceleration.

Slope

The effect of runway slope is due to the component of weight along the inclined path. It's effect is usually minor. A one percent slope may cause a two to four percent change in takeoff distance. Aircraft with high thrust-to-weight ratios are least affected.

Weight

Aircraft acceleration also varies directly with gross weight. A heavy aircraft accelerates slower and must be accelerated to a higher velocity for takeoff, lengthening the takeoff roll. A 10 percent increase in gross weight typically increases takeoff distance by 20 percent.

Wind

Wind influences takeoff distance by affecting the ground velocity required for takeoff. A wind parallel to the runway which is 10 percent of the takeoff speed will affect takeoff distance by about 20 percent.

Factors Affecting Landing Performance

Any factor that alters landing velocity or deceleration will affect landing distance. An increase in gross weight requires a greater speed to support the airplane at the landing angle of attack.

- A 20 percent increase in weight will require about a 10 percent increase in landing KIAS to support the greater weight, producing an approximate 20 percent increase in landing distance.
- Increased gross weight causes like increases in the sum of drag plus braking friction, so deceleration is essentially unaffected.

A reduction in density will increase the landing velocity at a constant KIAS, but does not alter the retarding force. The airplane lands at altitude with the same weight and dynamic pressure as at sea level; therefore, drag and braking frictions have the same values. As long as the condition is within the capability of the brakes, net retarding force is unchanged and deceleration is the same as sea level. The increase in landing distance with altitude is approximately 3.5 percent for each 1000 feet of change.

All aircraft land at a particular airspeed independent of wind. Wind changes the ground velocity at which the airplane touches down. As previously discussed, a 10 percent change in the ground velocity will produce about a 20 percent change in distance required.

While corrections are made for the effect of runway slope on landing distance they are typically small. Runway selection is usually based on wind.

Velocity on the ground determines landing roll if braking is constant. Pilot technique can impact the velocity. Pilots also control braking (to the limits of the aircraft) and touchdown point. Fast or long touchdowns or improper braking technique may add up to a landing roll greater than the distance available, even if all the book numbers add up.



Climb Performance

Best Angle of Climb Speed

The best angle of climb occurs at a particular KIAS where thrust required for flight is at a minimum. The maximum steady state climb angle can be attained at this speed, with the angle increasing directly with the amount of thrust available over that required. Any factor that increases thrust required, such as banking the aircraft, or that reduces the thrust available, such as an increase in altitude, will reduce the angle. Of course, the actual angle in relation to the earth varies with winds. Best angle of climb speeds are lower than those for best rate of climb or computed enroute climb speeds based on costs. Best angle of climb speeds are useful when obstacles exist in the departure path and/or where a large radius of turn could pose problems. In that environment, pilots should consider use of best angle of climb speed to the appropriate minimum altitude (MEA, MVA, MSA, etc.).

Note: For the A320 family, Green Dot approximates best angle of climb speed.

Best Rate of Climb Speed

The rate of climb (vertical velocity) depends on the flight speed and the inclination of the flight path. The rate of climb is the vertical component of the flight path velocity. The maximum rate of climb occurs where there exists the greatest difference between power available and power required. Jet aircraft have a linear variation of power available with speed, so the speed for maximum rate of climb is usually well above that for best angle. An increase in weight will reduce the maximum rate of climb, but the airplane must be operated at a higher speed to achieve the smaller peak climb rate. An increase in altitude will at the same point start to lower the power available for the climb; therefore, a deterioration of climb performance at higher altitudes should be expected. Steady state wind has no effect on rate of climb, although wind shears can dramatically alter climb rates.

Note: For the A320 family, ECON climb speed approximates best rate of climb.

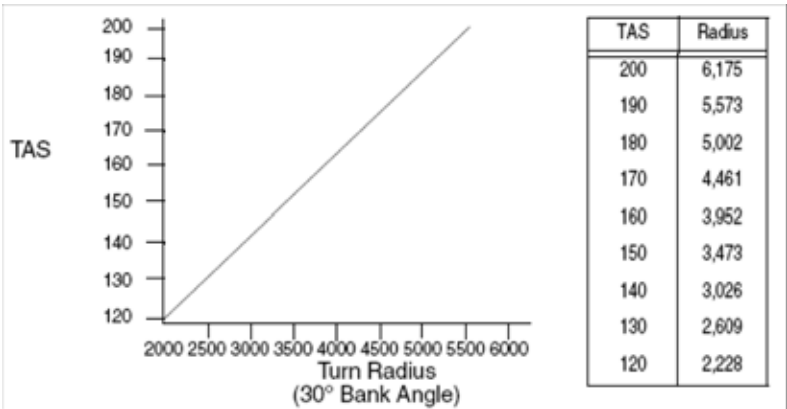
Turning Performance

A level flight coordinated turn is one in which the vertical component of lift is equal to the weight of the aircraft; no vertical acceleration takes place. As bank angle is increased, the load factor required to maintain level flight is increased from 1.0 G at 0 degrees, to 1.036 G at 15 degrees, 1.154 G at 30 degrees, and 1.414 G at 45 degrees. Induced drag also increases with bank angle, increasing the thrust or power required to maintain altitude and increasing stall speed. In a sense, aircraft performance in a turn is affected in much the same manner as an increase in gross weight. At 45 degrees, bank induced drag is increased by 100 percent.

Within the airplane’s structural limitations, turning performance is determined by bank angle and velocity (true airspeed). When flown in a steady, coordinated turn at a specific bank angle and velocity, turn rate and radius are fixed and independent of aircraft.

Turns at 160 KTAS		
Bank	Radius	Diameter (NM)
30	3,952	1.3
25	4,853	1.6
20	6,269	2.1
15	8,516	2.8
10	12,941	4.3

Turn radius varies with velocity at constant angles of bank. Use the following chart to determine turn radius with 30 degree bank angles.





A319/320/321 Flight Crew Training Manual

Estimating Turn Radius

Mile Per Minute

A good estimate of turn radius at 30 degrees bank is velocity measured in miles per minute (mpm) - 2.

radius (nm) = mpm - 2

Use each unit of 60 knots TAS as 1 mpm, $TAS/60 = \text{mpm}$. At 180 knots TAS, aircraft velocity is approximately 3 mpm so turn radius at a constant 30 degrees bank is about 1 nm.

Mach Number

Mach number may also be employed. Use each 0.1 unit of Mach to represent 1 mpm, $\text{Mach} \times 10 = \text{mpm}$, so at .8 Mach velocity is about 8 mpm and turn radius is approximately 6 nm.

Rate of Turn

An alternate and very useful method of estimating an aircraft's radius of turn is to consider turning performance at a constant rate of turn of 1.5 degrees per second. Use 10 percent of velocity (TAS) to figure turn radius in nm, 1.5 degrees rate of turn radius (nm) = $TAS/10$. A 1.5 degree per second turn at 200 TAS requires about 17 degrees of bank, at 150 TAS around 13 degrees.

Determining Lead Point

It is relatively simple to apply turn radius information when tracking toward a facility with DME, just remember to consider start range when required. It is a little more involved when flying across radials, such as during an arcing procedure. It is necessary to use the relationship that the width of a degree varies directly with distance from its origin.

- At 60 miles from the origin each degree is 1 mile wide; at 30 miles each is .5 mile; at 15 miles each is .25 mile, etc. The phrase "10 at 6, 6 at 10" is useful. At 10 miles there is 6 degrees per mile and at 6 miles there is 10 degrees per mile.
- For example, if an aircraft velocity is 210 knots TAS, using the formula $TAS/60 = \text{mpm}$ it is traveling at 3.5 mpm, radius (nm) = $\text{mpm} - 2$ (30 degrees bank) so the turn radius is about 1.5 nm. If arcing at 10 miles, a turn to a radial would require about 9 degrees of lead for the example above.

Minimum Turn Radius

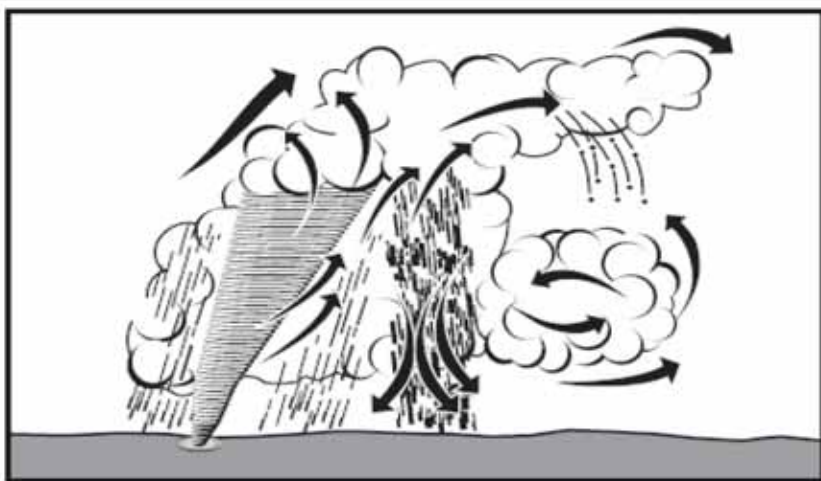
When a minimum radius turn is required or anticipated it is important to slow the aircraft. When the turn is initiated, use the maximum bank angle available. Winds cannot be ignored. Turns into the wind reduce turn radius in relation to terrain.

Weather Radar

Turbulence Avoidance

Research has shown that when any part of a storm reaches Level 3 strength, moderate to severe turbulence occurs with equal probability throughout all areas of the storm, including the Level 1 and 2 areas. For turbulence avoidance, all areas of a storm should be avoided when any part reaches Level 3.

The color green is often associated with safe to go or normal operation. Green does not imply go or safe in conjunction with weather radar or turbulence avoidance. In weather depiction, green simply denotes the area of Level 1 precipitation. When associated with convective weather, green areas of rain may contain violent vertical activity. The graphic below illustrates how tornadoes are most often located at the outer edge of thunderstorms in the Level 1 areas of precipitation.





A319/320/321 Flight Crew Training Manual

Turbulent Activity

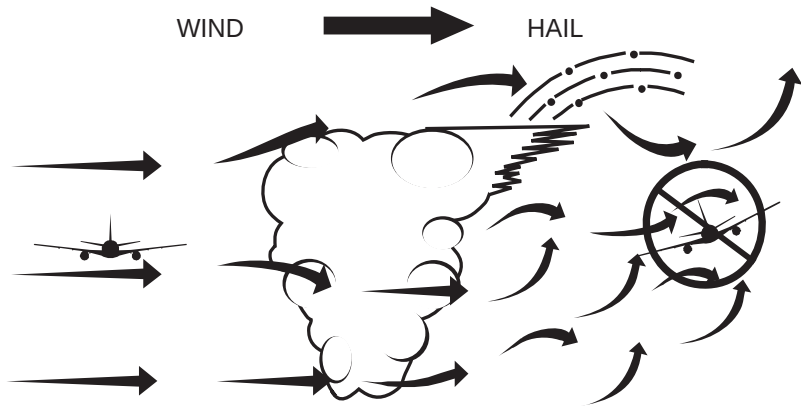
Turbulent activity occurs away from the heavy rain core. Enroute deviations should be made upwind of the storm whenever possible, especially if winds aloft are strong. Deviating downwind greatly increases the chance of encountering hail and turbulence. Turbulence can be expected to exist downwind of the storm 1nm for every knot of windspeed at flight altitude. The storm acts as an obstruction to the wind, creating turbulent eddies downwind of the storm.

To detect turbulence select the TURB mode to identify areas of horizontal movement of precipitation, which can be a good indication of turbulence.

- Turbulence will be displayed in magenta, overlaying the weather display.
- TURB mode will not detect clear air turbulence.
- Turbulence detection is limited to 40 nm.

Turbulence detection can be useful in identifying areas of turbulence, particularly in light rain areas. Some storm targets may display little or no turbulence, but that does not mean it is safe to penetrate. An absence of indicated turbulence does not justify penetrating a weather area that by other indications is hazardous.

The graphic below illustrates how enroute deviations should be made upwind of the storm and the turbulence that can be encountered downwind of the storm.



Windshear Avoidance

Airborne radar cannot detect microbursts. However, microbursts are a product of convective cells, so airborne radar should be one of several factors considered.

Wet Microburst Environment

Wet microbursts are associated with extremely high rain rates.

- Be alert for signs of attenuation, such as crescent shaped returns or radar shadows.
- Strong returns at mid to upper levels of weather are signs of hazardous convective activity.
- Microburst producing storm cells can be small in diameter, so use short ranges when evaluating nearby cells.

Dry Microburst Environment

Dry microbursts can be produced by very light rain cells.

- Level 1 returns can produce severe microbursts.
- Dry microbursts are produced by high based virga activity.
 - Use UP TILT (A319/320) to direct the beam well above the flight path. For A321, it is recommended to operate the MULTISCAN radar in AUTO.
 - When evaluating the departure path before takeoff, full UP TILT may be inadequate to detect high based showers within 10 nm.
- TURB mode may be useful. Turbulence indicated in light returns is evidence of strong activity.
- Cells may be small. Use short ranges when evaluating nearby targets.

Radar has inherent limitations when evaluating nearby and or intense weather areas. Consider all factors, including visual cues, in making windshear avoidance decisions.

Predictive Windshear Alerts (A321 Only)

The weather radar uses radar imaging to detect disturbed air prior to entering a windshear. Weather radar:

- Provides windshear alerts for windshear events containing some level of moisture or particulate matter.
- Detects microbursts and other windshear with similar characteristics.
- Does not provide alerting for all types of windshear.



Hydroplaning

Scientific reports on hydroplaning cite water depth, speed, tire tread depth, runway surface texture, tire inflation pressure, effective weight, and landing gear arrangement as contributing factors.

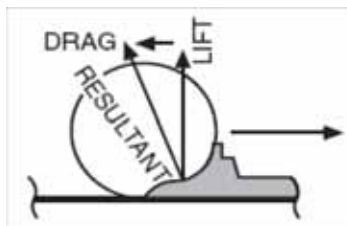
Experts generally agree that there are three types of hydroplaning: dynamic (or hydrodynamic), viscous, and steam (or reverted rubber). It is to be noted that these may be indistinguishable from the flight deck. All three types can seriously degrade the braking effectiveness and directional capability of the aircraft tires.

Dynamic Hydroplaning

This type of hydroplaning is a function of high speeds and can occur only when the runway surface is critically flooded. The critical depth of water (or slush) can vary from 0.1 to 0.4 inches, depending on tire and surface condition.

In the case where an aircraft is accelerating on a water-covered runway, partial hydroplaning begins as the moving tires contact and displace the stationary water. The resulting change in momentum of the water creates hydrodynamic pressures that react on the runway and tire surfaces.

The resultant force forms a fluid “wedge” which, to some degree, separates the tire from the runway and decreases the footprint area available for braking action. At some higher speed the hydrodynamic lift developed under the tire equals that part of the aircraft weight being supported by the tire, so that the tire is lifted completely off the runway surface.



The critical ground speed at which the latter occurs is termed the “tire hydroplaning speed” (VP). Partial hydroplaning is occurring at speeds below VP, total hydroplaning at speeds at or above VP.

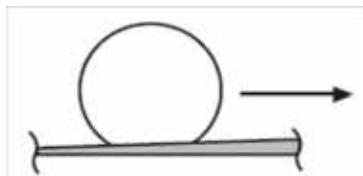
Additionally, as the tire accelerates, the center of hydrodynamic pressure shifts increasingly forward of the axle center line, creating a wheel spindown moment.

At the same time, the friction-induced spin-up moment is decreasing with decreased footprint area until, at some vehicle speed, the wheel will begin to slow down and stop. This can occur before hydroplaning commences and at this point the effectiveness of wheel braking is lost. The small residual footprint disappears at VP along with all tire-to-surface friction and cornering effects.

Of additional concern in the takeoff regime is the effect of fluid displacement drag. Where a runway is heavily flooded with water or slush, this drag factor increases with speed, peaking near VP. This can result in greatly increased takeoff distances, and is the main reason for the “1/2 inch rule.”

Some discussion is in order on the subject of total hydroplaning speed (VP), which is defined as the speed at which the tire is lifted completely off the surface. The most preponderant opinion is that this speed in knots may be approximately by the formula $VP = 9\sqrt{p}$, Where p is the tire inflation pressure. If this thesis is accepted as true, then most aircraft will find themselves in a total hydroplaning condition at the high-speed end of the takeoff and landing operations (if fluid is above the critical depth). Other respected opinion holds that this formula is oversimplified and that the total hydroplaning condition is never reached within the normal groundspeed envelope. The argument is academic, however, since effective footprint area will be minimal at speeds approaching Vp on flooded runways.

For the decelerating or landing condition where hydroplaning occurs, the effects will be the same as in acceleration, but in inverse order. Experiments have shown that, in deceleration from a hydroplaning condition, a tire will spin up at a slower ground speed than that required for spin-down in an accelerating condition. This suggests that dynamic hydroplaning may be more serious for landings and aborted takeoffs than for takeoffs because of the greater speed range of potential exposure.



The question may arise whether fluid displacement drag may help in slowing an aircraft in hydroplaning conditions. This parameter will be helpful at speeds close to VP, but the effect drops sharply at higher or lower speeds.

It should be noted that, while hydroplaning is the most serious condition, some degradation in braking and cornering effectiveness begins with partial hydroplaning at speeds well below VP. From this point, adverse effects increase as a function of the square of the ground speed.



Viscous Hydroplaning

Even slight amounts of precipitation, such as heavy dew, can result in this type of hydroplaning. Loss of traction can occur at relatively low speeds because of the inability of the tires to penetrate a very thin but tenacious fluid film on a smooth pavement surface. The requirements for viscous hydroplaning are:

- A very smooth or smooth-acting runway surface.
- A thin film of water or other contaminant; film thickness required is estimated to be less than 0.01 inches.

Exposure to viscous hydroplaning is thus greatest on an abnormally smooth runway, or one that has become heavily coated with rubber from landings and wheel spin-up. Complete separation of tire and surface can occur at groundspeeds at least 35 percent less than the speeds required for total dynamic hydroplaning. The effects, however, can be equally hazardous.

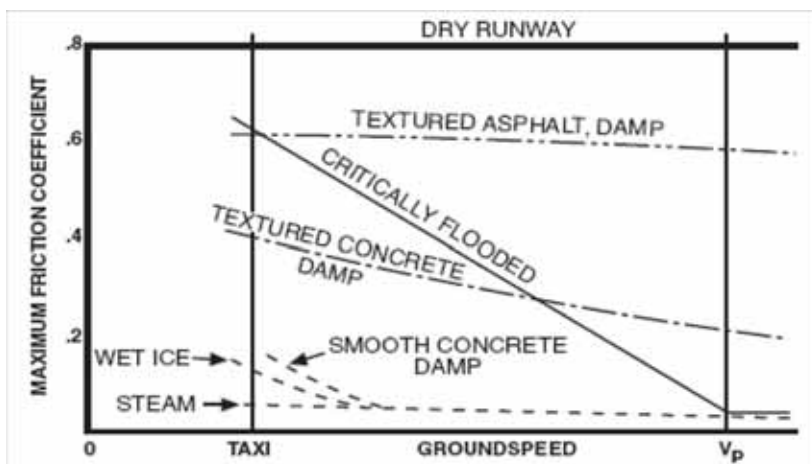
Steam Hydroplaning (Reverted Rubber)

This type of hydroplaning is associated with wet runway conditions where the tire is allowed to remain locked up for a period of time. The longer the tire remains stationary, the more total heat is dissipated in the footprint area, converting the water to superheated steam. Steam pressures then lift the tire from the runway surface.

Temperatures up to 500°F can be generated in this process, which tends to explain the observed damage to tire structure. The tire shows a patch of rubber that looks like it has been heated to the melting point and then reverted to the uncured state: hence the term “reverted rubber.” It has been suggested that this melted rubber may form a seal, trapping the steam in the footprint area, while some sources maintain that steam can be generated, without a seal, at a rate sufficient to sustain hydroplaning. The high-pressure steam also tends to explain the white (steam-cleaned) marks on the pavement, characteristic of steam hydroplaning.

Since one of the requirements of steam hydroplaning is a high temperature in the footprint, this is more likely to occur on damp to moderately wet pavement rather than in heavy water where a lower tire friction is experienced. In this process, friction coefficients are similar to total hydroplaning conditions. Most important is the fact that steam effect can persist to extremely low groundspeeds, measured in some cases to be below 20 knots.

The key to preventive measures in this case is the avoidance of wheel lockup and the resulting skid. It follows, therefore, that steam hydroplaning cannot occur if antiskid devices are operating properly and there is no residual drag in wheel bearings or brakes.



Controllable Physical Factors

Having discussed the conditions which cause hydroplaning, we may now describe measures to control the conditions.

Tires

Inflation Pressure

Considering the formula for total dynamic hydroplaning $VP = 9$, it would appear that an infinitely high inflation pressure could remove the threat of hydroplaning in the normal speed envelope. There is, though, only a small practical range of inflation pressures available.

Tread Design

Adequate tread designs tend to increase the groundspeed required for hydroplaning, while also increasing the minimum fluid depth required. Radically grooved tires tend to improve substantially the traction on a critically flooded surface, even when the fluid depth is greater than the tire tread depth. This design provides a low-pressure escape route for water and steam. Slippery runway performance is a prime consideration in Delta's selection of tread design.



A319/320/321 Flight Crew Training Manual

Runways

Pavement Crown

A good crown can inhibit hydroplaning conditions by draining water off rapidly. Slush conditions are not as readily drained.

Surface Texture

A rough or open textured surface can inhibit viscous hydroplaning by puncturing the thin fluid film with sharp asperities. It may also increase the minimum fluid depth for dynamic hydroplaning.

Pavement Grooves

Lateral grooving of runways is believed to be the most effective physical means of avoiding hydroplaning conditions. The pumping action of tires and grooves removes fluid rapidly from the footprint area. The grooves may also suppress formation of a viscous film, and the sharp edges may skim off melted rubber.

Flight Deck Considerations and Techniques

A pilot's best weapons against the problem of slippery runways are the knowledge of weather, runway conditions and the capability of planning ahead.

Weather

Snow, slush, or ice will create hazards. Heavy rain showers or continuous rain should raise the question of critically flooded runways. A heavy dew or drizzle on a smooth runway creates ideal conditions for viscous hydroplaning.

Runway Conditions

Smooth runways, or runways with heavy rubber deposits should be treated as very slippery under any moisture conditions. Care should be exercised when turning or taxiing on areas of rubber deposits, as near the ends of a runway. A runway with heavy puddling at the rollout end will not be as hazardous as one with standing water on the approach end.

Technique

If serious slippery runway conditions are known to exist, holding to allow water drainoff or diversion to an acceptable alternate should be considered. If a landing must be made on a very wet or slippery runway, appropriate operational techniques should be employed.

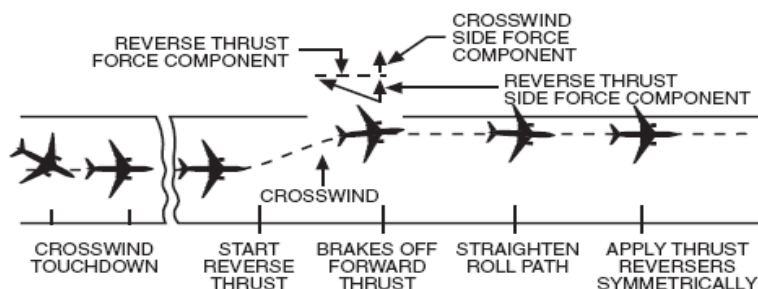
- Use minimum safe touchdown speed.
- Make early runway contact and early nosewheel contact to get maximum directional capability. A firm landing is better than a "grease job," which may induce hydroplaning in marginal conditions.

- Ensure spoilers are deployed following touchdown.
- Make early use of maximum allowable reverse thrust, which is most effective at the higher speeds.
- Allow autobrakes to decelerate the aircraft, unless additional braking force is required.
- Land on centerline and track straight down the runway.

Caution should be used to avoid asymmetric application of reverse thrust or brakes with the obvious directional hazards.

Since VP is a function of groundspeed, a landing directly into the wind will decrease the exposure to hydroplaning. The worst landing condition is one where slippery runway conditions prevail with a crosswind. Besides the hazard of the crosswind side force component, there is the side force component of reverse thrust, which will compound the wind drift if the airplane is allowed to weathercock. The addition of these two forces may cause an aircraft to drift off the side of the runway under low friction conditions. Preventive measures can lengthen landing distance by causing less than optimum handling of reverse thrust. Also, a crosswind blowing up the transverse slope of a runway could create a lateral difference in water depth, possibly resulting in hydroplaning on one side and, thus, asymmetric directional control.

The airplane centerline should be aligned with the runway at touchdown and initial directional control maintained aerodynamically. If the airplane weathercocks and drifts sideways during reversing, return engines to IDLE reverse, straighten aircraft path, then increase reverse thrust if desired.



It has been shown that any runway other than a dry runway can cause loss of traction through a wide range of speeds. General considerations and techniques have been reviewed, with emphasis on the anticipation of conditions and planning the proper action.

For maximum recommended crosswind components on a contaminated runway, refer to Vol. 1, SP.16, Adverse Weather.



Delta Maneuver Training

This information is provided so pilots may better understand the key aerodynamic and structural issues concerning maneuver of transport category aircraft in general and is not specific to any particular aircraft type.

Maneuver training is integrated throughout initial qualification (IQ) training on all fleets at Delta. Specific elements include stall, CFIT, windshear and upset recovery training. Each element likewise supports core objectives, which are:

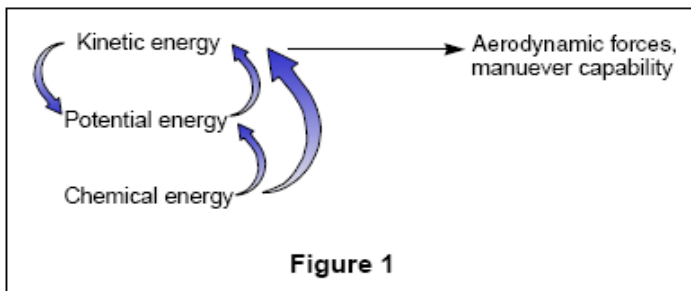
- Recognition to avoid or recognition to recover
- Protect from a stall
- Orient the lift vector
- Stabilize post recovery

Aerodynamic Aspects of Maneuver

There are three sources of energy available to the pilot:

- Kinetic energy (speed)
- Potential energy (altitude)
- Chemical energy (fuel)

The sum of all energy sources is defined as the “energy state” of the aircraft. It is important to note that only kinetic energy can be used to generate aerodynamic forces to maneuver the aircraft.



Understanding these energy relationships is fundamental to “energy situational awareness.” Ultimately, your objective is to manage energy in a way so that:

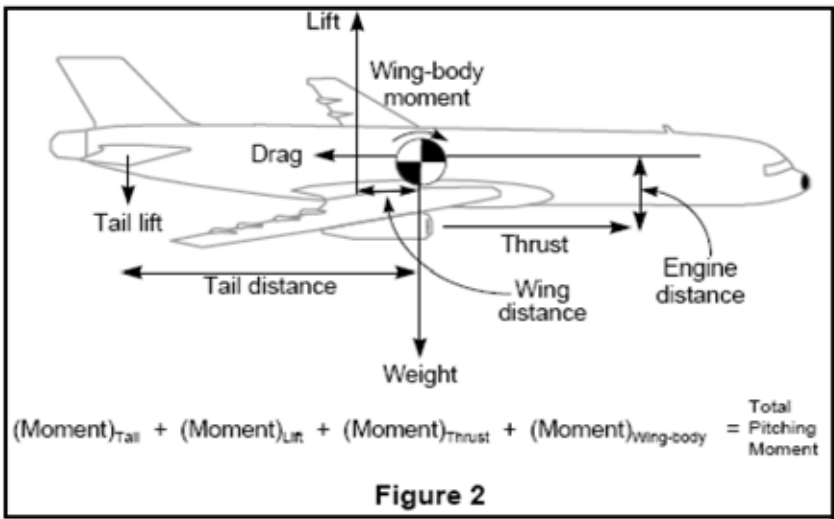
- Kinetic energy stays between the limits (stall and placards),
- Potential energy remains within limits (terrain to buffet altitude), and
- Chemical energy remains present (above fuel exhaustion).

Only within these parameters will you be able to generate the aerodynamic forces necessary to maneuver an aircraft to return it to normal flight.

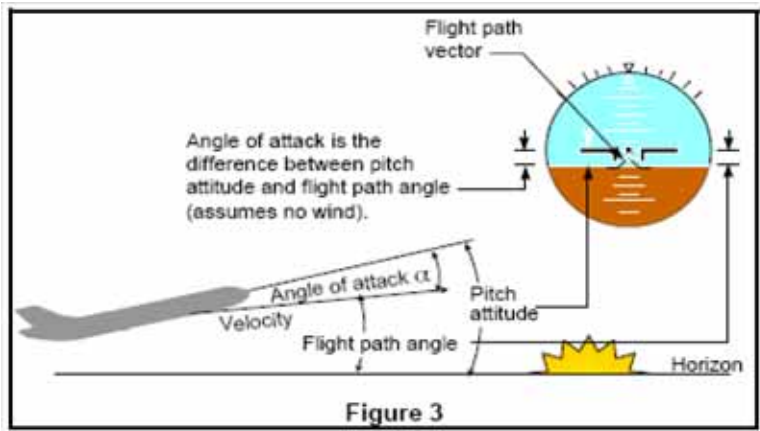
Flight Dynamics

Flight Path Control

In the simplest sense, the pilot only controls the orientation and magnitude of the forces acting on the aircraft, which in turn define the flight path angle of the aircraft.



It is control of the flight path angle (or vector) that is critical to an aircraft during dynamic maneuver.





A319/320/321 Flight Crew Training Manual

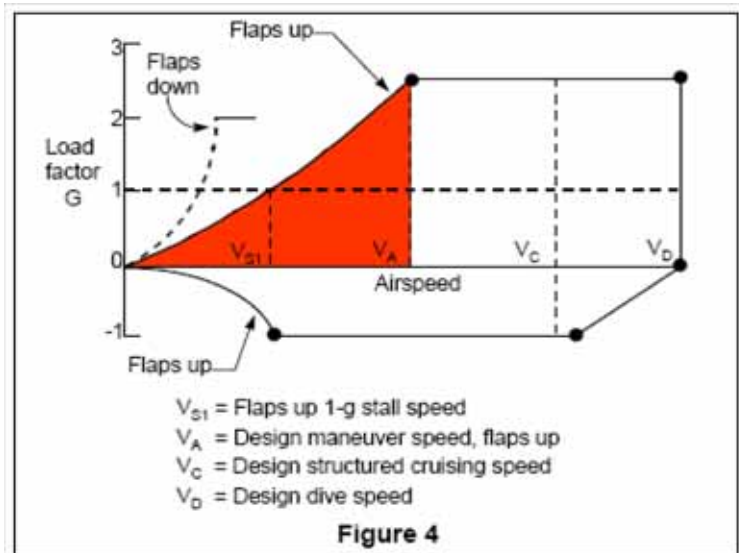
Load Factor

Load factor describes the accelerations being experienced by the aircraft. Load factors apply to any of the three axis of the aircraft; however, we are mainly interested in load factors (or G loading) along the vertical axis. It is along this axis that the lift on the wing is oriented and by which we control the flight path angle of the aircraft. Remember, the aircraft is acceleration limited. Transport category aircraft are limited to 2.5 Gs in a clean configuration and 2.0 Gs with any high lift devices extended.

The issue is two-fold:

- Keep the lift vector on the aircraft pointed up, and
- Manage the energy state in a way that generates adequate force to produce the full G capability for the aircraft configuration.

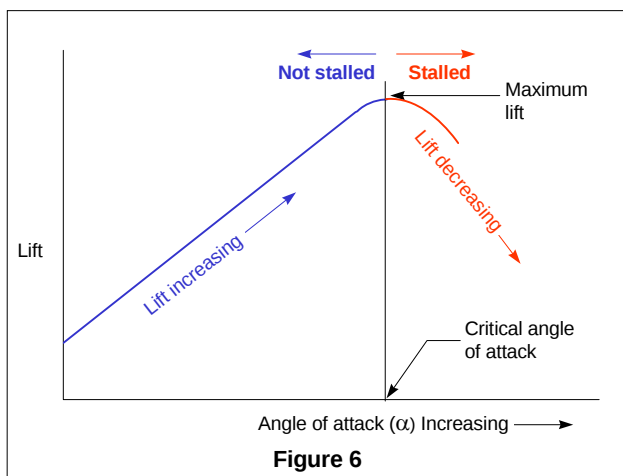
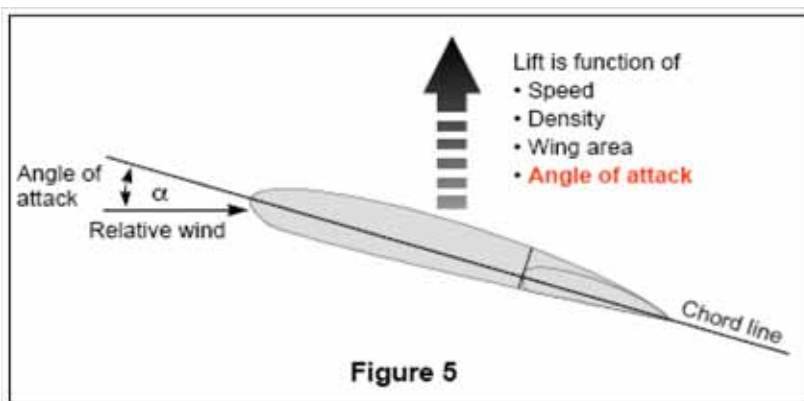
This idea is best captured in a classic speed vs. load factor diagram for a typical swept wing aircraft.



It is precisely in the shaded area along the 1G line that energy situational awareness must be most focused. Within this area of the flight envelope your recognition and response to an upset must be both timely and correct.

ALPHA Factor

The wings of modern transport aircraft are designed to produce lift efficiently. The lift force, in pounds, generated by the wing is a direct function of angle of attack (AOA), or Alpha. While the pilot does have limited control of airspeed in a decreasing energy state situation, lift is primarily controlled by AOA.



As indicated in the figure above, there is a linear increase in lift with increasing AOA up to the point of maximum lift. Beyond the critical AOA, lift decreases as the flow over the wing breaks down and the surface becomes stalled. It is the stalled condition which you must learn to recognize and recover from.



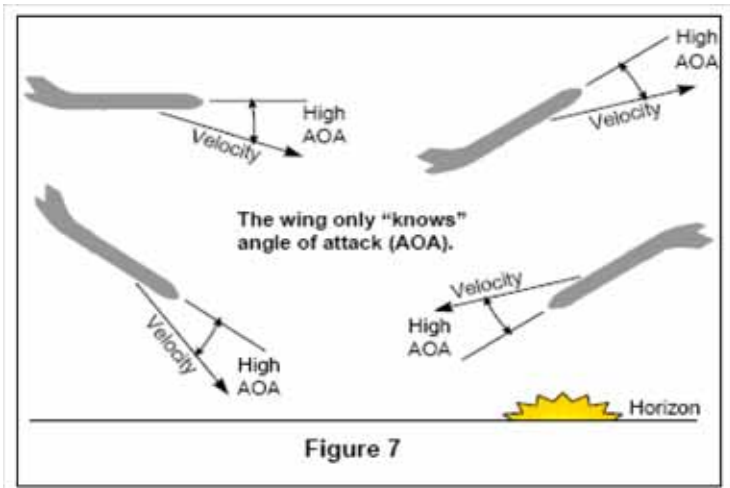
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Stalled Condition

A stall is characterized by one of, or a combination of, the following:

- Buffeting, which could be heavy,
- Lack of pitch authority,
- Lack of roll control, and/or
- Inability to arrest decent rate.

If the critical angle of attack is exceeded, the wing surface will stall and lift will decrease instead of increasing. This is true regardless of aircraft speed or attitude.



Note: You cannot recover an aircraft while it is stalled; you must first break the stall.

The stall speed for any aircraft is defined by the following conditions:

- Trim at 1.3 VS
- Forward CG
- Low altitude
- Deceleration rate of 1 knot/second
- Wings level
- Approximately 1G flight

In conditions other than these, the “speed at stall” is not the same as the “stall speed.” Aerodynamic stall depends only on AOA and has a specific relationship to the “stall speed” only under the conditions listed above.

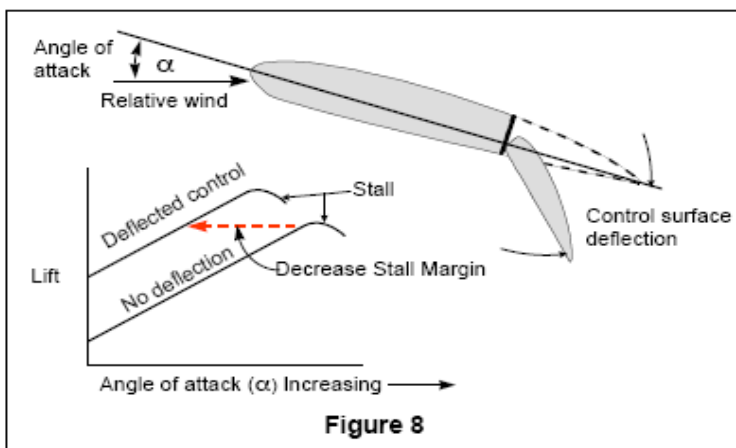
Note: Most upsets are quite dynamic in nature and involve elevated load factors and large speed rate changes.

Pilots should not expect the aircraft to remain unstalled just because the indicated airspeed is higher than AFM chart speeds because the conditions may be very different. In all cases, respect the stick shaker by unloading the aircraft (reduce AOA) if a stall is encountered.

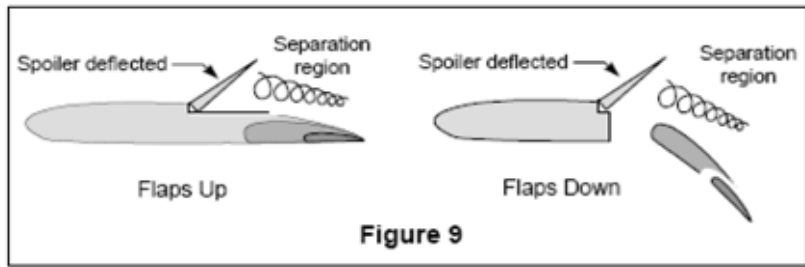
It is possible for an aircraft to be flown below the defined “stall speed.” In this low energy environment the trajectory will be largely ballistic and altitude will and must be traded to generate airspeed to produce sufficient lift for 1G flight. For this reason, at low airspeed it is important to reduce the AOA, and to use all aerodynamic controls available to orient the lift so a full recovery can be made when sufficient airspeed exists.

Lateral Control

From a flight dynamic point of view, the best use of lateral control in maneuvering the aircraft is using available energy to orient the lift vector to oppose gravity. Ailerons and spoilers normally generate sufficient force for lateral maneuver. As the energy state of the aircraft decreases and AOA increases, these devices can and will lose their effectiveness. Because of this decrease in effectiveness, full lateral control inputs, ailerons and spoilers, may be necessary to maintain or regain wings level attitude after an upset.



Note how the deflected aileron actually decreases the stall margin at high AOA in the figure above. Likewise, spoilers, which derive lateral control by “spoiling” lift locally on a wing, are very ineffective on a stalled wing (the flow is already separated) or on a wing producing very little lift (an unloaded wing). Thus, the need for large control inputs.



The rudder may also be used for lateral control, especially at higher AOAs, but must be used with caution.

CAUTION: Rudder is never the preferred initial response to induce a roll in a transport category aircraft.

Only under an extreme condition such as loss of a flap, midair collision, or when an aircraft has pitched to a very high pitch attitude and a pushover or thrust change has already been unsuccessful should careful rudder input be considered. Rudder input should be used in the direction of the desired roll to induce a rolling maneuver to start the nose down or to provide the desired bank angle. A rudder is never the preferred initial response for events such as a wake vortex encounter, windshear encounter or to reduce bank angle preceding an imminent stall recovery.

Rudder is a powerful aerodynamic tool capable of producing both yawing and rolling moments. The rudder is sized to control yawing moments for crosswind takeoffs and landings as well as adverse yaw generated by loss of engine thrust down to very low speeds. If, however, large rudder inputs are used in a symmetrical condition (i.e., no engine failure or crosswind) the rudder can produce large yawing moments resulting in very large sideslip angles and large structural loads.

Aircraft have demonstrated entry and recovery from full stalls without the need for rudder. In fact, the use of rudder beyond its intended use during engine out situations or in a crosswind takeoff/landing is almost never indicated.

Wing Dihedral and Sideslip

Dihedral refers to the positive angle between the center of the wing and the lateral axis of the aircraft.

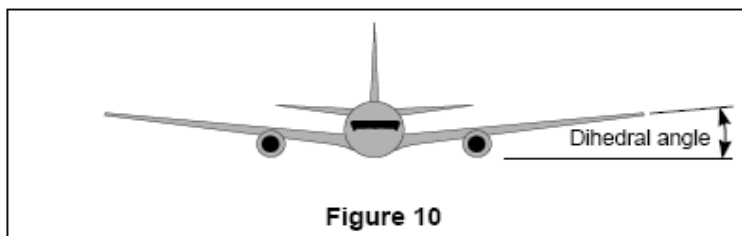


Figure 10

Wing dihedral contributes to lateral stability. Because dihedral has such a profound impact on aircraft stability, it is often used as a common term to describe other aircraft components or geometries that have a similar effect. Wing sweep is a common geometric characteristic of jet aircraft that contributes to dihedral effect. The rudder also contributes powerfully to lateral stability and control, but its use also introduces sideslip, which in turn will induce a rolling moment on the aircraft. By definition, sideslip is the angle between the longitudinal axis and the relative wind.

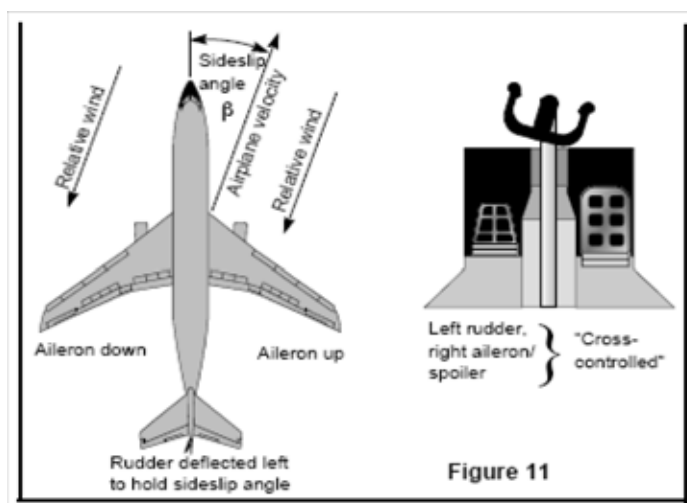


Figure 11

Sideslip can affect motion in all three axes, generating rolling as well as yawing motion. Roll coupling due to rudder induced sideslip is a common characteristic of swept wing aircraft with dihedral, especially at high AOAs and low energy states. Because of this, the rudder must be used with caution.

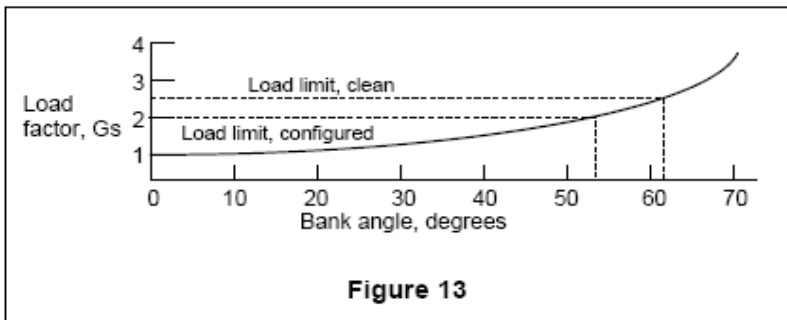
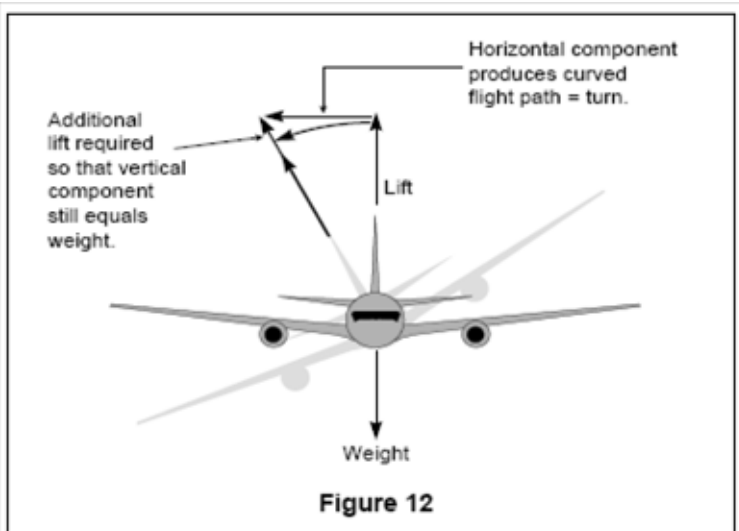


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CAUTION: Too much rudder applied too quickly or held too long may result in loss of lateral and directional control. Cyclic rudder pedal inputs can result in very large amplitude sideslip oscillations as well as very large, possibly excessive airframe structural loads.

Bank Angle

The horizontal component of lift will allow the aircraft to maneuver but will also require an increase in AOA (more back pressure = more load factor) to generate the additional lift necessary to maintain level flight.



Upon reaching a bank angle of 66 degrees, the load factor for sustained level flight exceeds the structural load limit for which transport category aircraft are certified. This relationship of more bank, more up elevator required, and more load factor, is very important to the mechanics of upset recovery. Since the objective is to arrest or minimize descent, an increase in pitch (back pressure), if the wings are not level, will only cause a tighter turn and, depending on the bank angle, may not help the recovery.

Note: In the context of extreme aircraft upsets, it is imperative to get the wings level before beginning any aggressive pitch maneuver.

Structural Aspects of Maneuver

Structurally, rudder should be used to induce a roll only if application of full lateral control (ailerons and spoilers) is incapable of stopping a roll rate or decreasing a bank angle.

There are several implications to the issue of full use and application of flight controls to accomplish a maneuver. Airbus fly-by-wire aircraft, when operating in Normal Law, have limitations active that prohibit reaching structural aircraft limits. The following discussion excerpted from another aircraft manufacturers technical bulletin details issues that would be of concern if Normal Law was not active.

Transport Category aircraft are:

- capable of sustaining a single input to any set of control surfaces (elevators, ailerons, rudder(s)) to their maximum available authority (as limited by control surface limiters, blowdown, or control stops). These control surface inputs are to be in one axis (not in combination) and do not include control input reversal or oscillatory inputs.
- designed for full rudder input out to the maximum operating airspeed VMO/MMO and for some models to the design dive speed VD/MD.
- designed to withstand a rapid rudder input to full rudder deflection starting from a zero sideslip condition. A Safety Factor of 1.5 is then applied. This means the structure must have at least a 50% safety margin over the maximum load generated by this maneuver.
- designed to withstand, starting from a zero sideslip condition, a rapid rudder input to full deflection until the maximum sideslip angle (over yaw) is achieved. The aircraft will exceed the maximum steady state sideslip due to the dynamic response characteristics of the aircraft. A Safety Factor of 1.5 is then applied.
- designed to withstand, starting from a maximum steady heading sideslip condition, a rapid rudder return to neutral while maintaining the initial sideslip angle. A Safety Factor of 1.5 is then applied.
- equipped with vertical fins that can sustain loads if the rudder is rapidly returned to neutral from a dynamic overyaw sideslip.

**A319/320/321 Flight Crew Training Manual**

Considered from either an aerodynamic or structural point of view, best use of the rudder would be in a manner to avoid unintended sideslip angles and the resulting (and possibly excessive) roll rates. Remember, the roll rate generated by using the rudder is proportional to the amount of sideslip, not the amount of rudder input.

Large amplitude rudder inputs can lead to abrupt roll onset and resulting large amplitude roll oscillations. The amplitude of these types of oscillations can generate loads that exceed the limit loads and possibly the ultimate loads to which the aircraft was designed. The very real possibility of significant structural damage should be obvious.

Lastly, it is important to remember that the rapid cycling of primary flight controls (also referred to as flight control reversals) from a deflection in one direction, through the neutral position, to a deflection in the opposite direction must be avoided. It is the cycling of the rudder, or any other primary flight control, that can rapidly lead to excessive structural load buildup on the associated flight surface or other areas of the aircraft such as the engine struts. In particular, sequential full or nearly full authority rudder reversals may not be within the structural design limits of the airplane, even if the airspeed is below the design maneuver speed. There are no procedures that would require this type of rudder input.

The recovery environment must take into consideration the possibility of larger than normal pitch and roll rates introduced by the amplitude of necessary aerodynamic control inputs.

- Achieving lateral directional stability, post recovery, becomes the primary focus.
- Careful judicious use of rudder must be the norm.
- Coordinated flight control inputs and coordinated flight dynamics to the maximum extent possible must be the target.
- Allowing the natural pitch and roll damping to affect recovery oscillations will prevent unnecessary or excessive cycling of primary flight controls.

Understanding dynamic maneuver of transport category aircraft is an integrated whole involving aerodynamic capabilities as well as structural limitations of the airframe. Both are important, and Delta's training will continue to emphasize the necessary skills development to counter the threats inherent to daily operations.



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Index

Chapter Index

Adverse Runway Conditions - Takeoff	3.12
Aerodynamic Aspects of Maneuver.	10.25
Air Crew Human Factors.	9.1
Aircraft Performance Characteristics.	10.9
Airspeed Unreliable.	8.19
Alert Height - AH	5.11
Alpha Floor Recovery	7.17
Antiskid Inoperative - Landing.	8.26
Antiskid Inoperative - Taxi.	2.11
Approach and Landing with Electrical Emergency Configuration	8.7
Approach Category	5.1
Approach Clearance	5.2
Approach NAV - Use Of	5.27
Approach to Stall Recovery.	7.13
Approach.	1.20
Assumed Temperature Method.	3.10
Autoflight Guidelines	1.30
Autoland Capabilities.	5.12
Automatic Flight.	1.30
Autopilot Engagement - After Takeoff	3.22
Autothrottle Use.	1.33
Bird Strikes	8.11
Bounced Landing Recovery	6.17
Brake Malfunctions	8.26
Center-Of-Gravity Effects on Takeoff	3.7
Circling Approach - One Engine Inoperative.	5.58
Circling Approach	5.37
Climb Constraints	4.2
Climb	
Flow Pattern Diagram	1.10
Climb Modes	4.1
Climb Performance	10.13



A319/320/321 Flight Crew Training Manual

Climb, Cruise and Descent Speeds	1.20
Controllable Physical Factors	10.22
Crew Resource Management	1.1
Crew Specific Behaviors	9.13
CRM Skills	9.3
Crosswind Guidelines - Takeoff	3.8
Crosswind Landings	6.28
Crosswind Takeoff	3.8
Cruise Performance Economy	4.14
Damage Assessment and Aircraft Handling Evaluation	8.36
Decision Altitude or Height - DA(H)	5.10
Delta Maneuver Training	10.25
Departure Procedures (DPs)	10.5
Derated Takeoff Thrust (Fixed Derate)	3.10
Descent Below Decision Altitude or Height	5.11
Descent Constraints	4.20
Descent Path	4.19
Descent Planning	4.17
Descent Rates	4.27
Descent Speed Determination	4.19
Ditching	8.5
Dual Engine Failure	8.9
Dual Hydraulic Failure	8.24
Dynamic Hydroplaning	10.19
Early Descent from Cruise	4.26
Economy Climb Schedule - FMS Data Unavailable	4.4
Economy Climb	4.4
EGT Exceedance During Takeoff	8.12
Emergency Descent	7.6
Engine Failure During a Combined ATM and Fixed Derate	3.37
Engine Failure During a Derated Takeoff Thrust (Fixed Derate)	3.37
Engine Failure During a Reduced Thrust (ATM) Takeoff	3.37
Engine Failure Recognition - Takeoff	3.30
Engine Failure Takeoff Performance	10.1



A319/320/321 Flight Crew Training Manual

Engine Failure versus Engine Fire After Takeoff.	8.8
Engine Icing During Climb.	4.4
Engine Icing During Descent.	4.29
Engine Inoperative Approach Operations	5.48
Engine Inoperative Climb	4.5
Engine Inoperative Cruise/Driftdown.	4.15
Engine Out Familiarization	7.4
Engine Out Taxi.	2.9
Engine Out	10.1
Engine Start.	2.4
Engine Tailpipe Fire	8.8
Engine Vibration	8.10
ETOPS	4.16
Evacuation.	8.13
Factors Affecting Landing Performance	10.12
Factors Affecting Takeoff Performance.	10.11
Fail Operational.	5.12
Fail Passive.	5.12
Fatigue	9.10
FCU Guidelines.	1.33
Flap Configurations for Approach and Landing.	5.5
Flap Maneuver Speeds.	1.18
Flap Retraction - One Engine Inoperative.	3.33
Flap Retraction Schedule	3.22
Flaps and Landing Gear	4.29
Flaps and Slats Up Landing	8.17
Flare and Touchdown	6.12
Flight Deck Considerations and Techniques.	10.23
Flight Dynamics.	10.26
Flight in Moderate to Heavy Rain, Hail, or Sleet	1.33
Flow Pattern Diagrams	1.1
Fly-By-Wire Flight Controls	1.37
FMS Preflight.	2.1
Fuel Balance	8.21



A319/320/321 Flight Crew Training Manual

Fuel for Enroute Climb	4.10
Fuel Leak	8.22
Fuel Temperature - Low	4.12
Go-Around after Touchdown	5.67
Go-Around and Missed Approach - All Engines Operating	5.64
Go-Around and Missed Approach - All Instrument Approaches	5.62
Go-Around and Missed Approach - Engine Failure During	5.61
Go-Around and Missed Approach - One Engine Inoperative	5.61
Go/Stop Decision Near V1	3.18
Ground De/Anti-Icing	2.25
High Altitude High Speed Flight	4.16
High Altitude Maneuvering, "G" Buffet	7.5
High Elevation Considerations	10.9
High Energy Approach	5.46
Holding Pattern Exit	4.31
Holding	4.30
Hydroplaning	10.19
Hydroplaning, Flight Deck Considerations and Techniques	10.23
Ice Crystal Icing	1.35
ILS Approach - One Engine Inoperative	5.50
ILS Approach - Landing Geometry	5.18
ILS Approach Profile	5.6
ILS Approach	5.8
ILS Performance	5.12
ILS PRM Approach	5.16
Immediate Turn after Takeoff - All Engines	3.21
Immediate Turn after Takeoff - One Engine Inoperative	3.33
Improved Performance	10.4
Initial Climb - All Engines	3.21
Initial Climb - One Engine Inoperative	3.32
Instrument Approach Using APP NAV	5.28
Instrument Approaches	5.1
Jammed Stabilizer	8.18
Landing at the Nearest Suitable Airport	8.3



A319/320/321 Flight Crew Training Manual

Landing Distance (Factors Affecting)	6.19
Landing Distance (Non-Normal)	6.20
Landing Flare Profile	6.13
Landing on a Flat Tire	8.27
Landing Performance Data	5.3
Landing Roll	6.18
Landing	1.21
Liftoff - Effect of Rotation Speed and Pitch Rate	3.6
Loss of Engine Thrust Control	8.9
Loss of Thrust on Both Engines	8.9
Low Altitude Level Off	4.2
Low Fuel Operations In-flight	8.23
Low Fuel Temperature	4.12
Low Visibility Takeoff	3.11
Managed Target Speeds	1.20
Maneuver Margin - Landing and Go-Around	5.3
Maneuver Margins	1.19
Maneuver Speeds and Margins	1.18
Manual Flight	1.33
Maximum Altitude - Cruise	4.7
Maximum Angle Climb	4.5
Maximum Rate Climb	4.4
Minimum Maneuver Speed	1.19
Noise Abatement Takeoff	3.29
Noise Abatement Takeoff	3.29
Non - ILS Instrument Approaches	5.19
Non-Normal Conditions	1.21
Non-Normal Situation Guidelines	8.1
Optimized V1	10.3
Optimum Altitude - Cruise	4.8
Overspeed Protection	7.3
Overspeed	8.29
Overweight Landing	6.29
Partial or Gear Up Landing	8.28



A319/320/321 Flight Crew Training Manual

Performance Considerations	10.11
Pitch and Roll Limit Conditions	6.14
Pitch Control	1.37
Pitch Modes - Takeoff	3.22
Post De/Anti-Icing Takeoff	3.11
Precision Approach Path Indicator (PAPI).	6.6
Preflight	2.1
Procedure Holding	4.31
Procedure Turn	5.2
Pushback and Towing	2.3
Quick Reference Landing Length	5.4
Radio Altimeter	5.3
Raw Data - (No Flight Director) - ILS.	5.14
Raw Data Monitoring Requirements - Non-ILS	5.25
Recommended Technique for an In-Flight Engine Shutdown	8.10
Reduced Thrust Takeoff	3.10
Reference Speeds	1.22
Rejected Landing	6.17
Rejected Takeoff Decision	3.14
Rejected Takeoff Maneuver	3.16
Resolution Advisory	7.25
Reverse Thrust Operation - Landing Roll	6.25
RNAV Operations	1.25
RNP and EPE Definitions	1.25
Roll Control	1.37
Roll Modes - Takeoff	3.22
Rotation and Liftoff - All Engines	3.4
Rotation and Liftoff - One Engine Inoperative	3.31
RTO Execution Operational Margins	3.19
Runway Markings (Typical)	6.7
Single Engine Taxi	2.9
Situations Beyond the Scope of Non-Normal Checklists	8.34
Smoke/Fumes Principles	8.31
Smoke/Fumes Priorities	8.32



A319/320/321 Flight Crew Training Manual

Speedbrakes	4.28
Stall Recovery	7.13
Steam Hydroplaning (Reverted Rubber)	10.21
Steep Turns	7.19
Stopping Dynamics	10.10
Structural Aspects of Maneuver	10.34
Tail Strike	3.20
Takeoff - Adverse Runway Conditions	3.12
Takeoff - Crosswind	3.8
Takeoff - Engine Failure	3.30
Takeoff - Reduced Thrust	3.10
Takeoff Crosswind Guidelines	3.8
Takeoff Profile - Normal	3.24
Takeoff Profile - Special	3.27
Takeoff Segments	10.2
Takeoff Speed	1.20
Takeoff	3.1
Taxi - Adverse Weather	2.24
Taxi - Engine Out	2.9
Taxi - Minimum Radius	2.18
Taxi - Single Engine	2.9
Taxi Speed and Braking	2.9
Taxi	2.5
TEM - Error Management	9.13
TEM - Error	9.10
Terrain Avoidance	7.21
Threshold Height	6.9
Thrust Management	1.23
Thrust Use - Taxi	2.7
Tiller/Rudder Pedal Steering	2.11
Tire Failure during or after Takeoff	8.26
Track - Flight Path Angle Mode	1.24
Traffic Advisory	7.25
Traffic Alert and Collision Avoidance System	7.23

**A319/320/321 Flight Crew Training Manual**

Transition to Climb	4.3
Troubleshooting	8.1
Turbulence Avoidance	10.16
Turbulent Air Penetration	1.34
Turning Performance	10.14
Turning Radius Diagrams	2.13
Upset Recovery	7.27
Viscous Hydroplaning	10.21
Visual Aim Point	6.7
Visual Approach Profile	5.43
Visual Approach Slope Indicator (VASI/T - VASI)	6.1
Warning Systems	8.33
Weather Radar	10.16
Window Damage	8.33
Window(s) Open	8.33
Windshear Avoidance	10.18
Windshear	7.32
Wing Anti-Ice Operation - In Flight	1.36
Zero Flap / Zero Slat Landing	8.17