

Preface

Table of Contents

Chapter PT

Section TOC

FCTM

Title Page	0
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
Index	Index

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717

Flight Crew Training Manual

Delta Air Lines, Inc.

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Preface

Model Identification

Chapter PT

Section 1

General

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

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

Aircraft number is supplied by the operator. Registry number is supplied by the national regulatory agency. Serial and tabulation numbers are supplied by Boeing.

The procedures and information contained in this manual also apply to aircraft acquired by Delta Air Lines subsequent to the current revision; however, this document may not address all pertinent information for these aircraft. In such instances, specific operating procedures and systems information can be found in appropriate Differences Chapter(s) and/or Fleet Bulletin(s) prior to their incorporation in the next scheduled revision.

Ship Number	Airplane Number	Registry Number	Serial Number
9500	95A001	N949AT	55003
9501	95A002	N940AT	55004
9502	95A003	N942AT	55005
9503	95A004	N943AT	55006
9504	95A005	N944AT	55007
9505	95A006	N945AT	55008
9506	95A007	N946AT	55009
9507	95A008	N947AT	55010
9508	95A009	N948AT	55011
9509	95A010	N950AT	55012
9510	95A011	N951AT	55013
9511	95A012	N952AT	55014

 DELTA
717 Flight Crew Training Manual

Ship Number	Airplane Number	Registry Number	Serial Number
9512	95A013	N953AT	55015
9513	95A014	N954AT	55016
9514	95A015	N955AT	55017
9515	95A016	N956AT	55018
9516	95A017	N957AT	55019
9517	95A018	N958AT	55020
9518	95A019	N959AT	55021
9519	95A020	N960AT	55022
9520	95A021	N961AT	55023
9521	95A310	N988AT	55068
9522	95A022	N963AT	55024
9523	95A023	N964AT	55025
9524	95A024	N965AT	55026
9525	95A025	N966AT	55027
9526	95A026	N967AT	55028
9527	95A311	N989AT	55152
9528	95A312	N990AT	55134
9529	95A313	N991AT	55135
9530	95A027	N968AT	55029
9531	95A028	N969AT	55030
9532	95A029	N970AT	55031
9533	95A030	N971AT	55032
9534	95A031	N972AT	55033
9535	95A314	N992AT	55136
9536	95A032	N974AT	55034
9537	95A033	N975AT	55035
9538	95A315	N993AT	55137

DELTA
717 Flight Crew Training Manual

Preface -
Model Identification

Ship Number	Airplane Number	Registry Number	Serial Number
9539	95A316	N994AT	55138
9540	95A317	N995AT	55139
9541	95A034	N977AT	55036
9542	95A318	N996AT	55140
9543	95A035	N978AT	55037
9544	95A036	N979AT	55038
9545	95A319	N997AT	55141
9546	95A037	N980AT	55039
9547	95A320	N998AT	55142
9548	95A038	N981AT	55040
9549	95A039	N982AT	55041
9550	95A040	N717JL	55042
9551	95A050	N891AT	55043
9552	95A051	N892AT	55044
9553	95A052	N893AT	55045
9554	95A053	N894AT	55046
9555	95A054	N895AT	55047
9556	95A055	N896AT	55048
9557	95A056	N899AT	55049
9558	95A057	N922AT	55050
9559	95A058	N923AT	55051
9560	95A059	N983AT	55052
9561	95A060	N938AT	55098
9562	95A061	N939AT	55099
9563	95A401	N936AT	55058
9564	95A402	N935AT	55069
9565	95A403	N934AT	55070

 DELTA
717 Flight Crew Training Manual

Ship Number	Airplane Number	Registry Number	Serial Number
9566	95A404	N933AT	55071
9567	95A405	N930AT	55072
9568	95A406	N932AT	55073
9569	95A407	N607AT	55074
9570	95A408	N929AT	55075
9571	95A409	N928AT	55076
9572	95A410	N927AT	55077
9573	95A411	N926AT	55078
9574	95A412	N925AT	55079
9575	95A413	N924AT	55080
9576	95A414	N608AT	55081
9577	95A415	N921AT	55082
9578	95A416	N920AT	55083
9579	95A417	N919AT	55084
9580	95A418	N915AT	55085
9581	95A419	N910AT	55086
9582	95A420	N906AT	55087
9583	95A421	N987AT	55088
9584	95A422	N986AT	55089
9585	95A423	N985AT	55090
9586	95A424	N937AT	55091
9587	95A306	N987DN	55064
9588	95A307	N988DN	55065
9589	95A309	N989DN	55067
9594	95A508	N603AT	55127

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, e.g., stall recovery and emergency descent. The Non-Normal Operations 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 perform 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 Panel (FCP) 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.

Airplane Configuration

The Flight Crew Training Manual (FCTM) is intended to provide information in support of procedures listed in the Operations Manual and techniques to help the pilot accomplish these procedures safely and efficiently. The FCTM is written in a format that is more general than the Operations Manual. It does not account for airplane 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 maneuvering 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 applicable Operations Manual is required for information on how to set climb thrust.

In cases where a procedure or technique is applicable only to an airplane with a specific configuration, the annotation "as installed" is used. Airplane configuration differences are found in the Operations Manual. In the event of a conflict, the procedures published in the Operations Manual take precedence over information presented in the Flight Crew Training Manual.

Manual Rights

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Corrections to the Manual

Log on to the Delta Flight Operations Portal, <https://deltanet.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 is a link to the PCR form at Deltanet > Our Company > Flight Operations > Pilot Support > Forms and Reports. 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, and
 - 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 and 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.

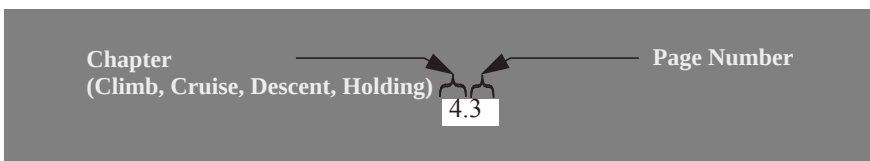
FCTM

- 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 EICAS 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.

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.

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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 this specific fleet.

A	
ABS	Auto Brake System
ABV	Above
AC	Alternating Current or Aircraft
ACARS	Aircraft Communications Addressing and Reporting System
ACE	Actuator Control Electronics
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
ADL	Airborne Data Loader
ADM	Air Data Module

ADS	Automatic Dependent Surveillance
AED	Automated External Defibrillator
AFB	Alternate Fuel Burn
AFDC	Autopilot Flight Director Computer
AFDS	Autopilot Flight Director System
AFE	Above Field Elevation
AFM	Airplane Flight Manual (FAA approved)
AFM - DPI	Airplane Flight Manual - Digital Performance Information
AFS	Automatic Flight System (Autopilot or Autothrottle)
A/G	Air/Ground
AGL	Above Ground Level
AH	Alert Height

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717 Flight Crew Training Manual

AHRS	Attitude Heading Reference System
AI A-ICE	Anti-Ice
AIL	Aileron
AIMS	Airplane Information Management System
ALFA	Safe Stall Margin Speed
ALN	Align
ALT	Altitude
ALT ACQ	Altitude Acquire
ALT HOLD	Altitude Hold
ALTN	Alternate
AM	Amplitude Modulation
AMI	Airline Modifiable Information
AMM	Aircraft Maintenance Manual
AND	Aircraft Nose Down
ANP	Actual Navigational Performance
ANT	Antenna
ANNUN	Annunciator
ANU	Aircraft Nose Up
AOA	Angle of Attack
AOC	Airline Operational Communication Data Link

A/P	Autopilot
APCDU	APU Power Conversion and Distribution Units
APL	Airplane
APP	Approach
APU	Auxiliary Power Unit
AR	Authorization Required
AREU	Audio Remote Electronics Unit
ARINC	Aeronautical Radio, Incorporated
ARPT	Airport
ARR	Arrival
ART	Automatic Reserve Thrust
A/S	Airspeed
ASA	Autoland Status Annunciator
ASAP	Aviation Safety Action Program
ASI	Airspeed Indicator
ASR	Airport Surveillance Radar
ASYM	Asymmetry
A/T	Autothrottle
ATA	Actual Time of Arrival
ATC	Air Traffic Control

DELTA
717 Flight Crew Training Manual

ATIS	Automated Terminal Information Service	BRG	Bearing
ATM	Assumed Temperature Method	BRT	Bright
ATR	Automatic Thrust Restoration	BTL	Bottle
ATT	Attitude	BTL DISCH	Bottle Discharge (fire extinguisher)
ATTND	Attendant	BTMS	Brake Temperature Monitoring System
AUTO	Automatic	C	
AUTO-THROT	Autothrottle	C	Captain or Celsius or Center or Cool
AUX	Auxiliary	CAA	Civil Aviation Authority
AVAIL	Available	CADC	Central Air Data Computer
AWABS	Automated Weight and Balance System	CALSEL	Call Select
B		CANC/RCL	Cancel/Recall
BARO	Barometric	CANPA	Constant Angle Non-Precision Approach
BAT or BATT	Battery	CAP	Capture
B/C or B/CRS or BAC or BCS	Back Course	CAPT	Captain
BFO	Beat Frequency Oscillator	CAWS	Central Aural Warning System
BITE	Built-In Test Equipment	CB	Circuit Breaker
BKR	Breaker	CCD	Cursor Control Device
BLD	Bleed	CDS	Common Display System
BLS	Bezel Light Sensor	CDU	Control Display Unit
BLW	Below		

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717 Flight Crew Training Manual

CFIT	Controlled Flight Into Terrain
CG	Center of Gravity
CH or CHAN	Channel
CHKL	Checklist
CHR	Chronograph
CKD	Checked
CKPT	Cockpit
CKT	Circuit
CL	Close
CLB	Climb
CLMP	Computer Lockout Manual Power
CLR	Clear
CMD	Command
CMP or CMPTR	Computer
CO	Company
COMM	Communication
COMP	Comparator
COMPT	Compartment
CON	Continuous
CONFIG	Configuration
CONSEQ	Consequence
CONT	Control
COOL	Cooling
CPA	Closest Point of Approach

CPC	Cabin Pressure Controller
C/PDLC	Controller/Pilot Datalink Communications
CRM	Crew Resource Management
CRS	Course
CRT	Cathode Ray Tube
CRZ	Cruise
CTL	Control
CTR	Center or Crosstie Relay
CVR	Cockpit Voice Recorder
CWS	Control Wheel Steering
D	
DA	Decision Altitude
DA(H)	Decision Altitude (Height)
DC	Direct Current
DCU	Display/Data Concentrator Unit
D/D	Direct Descent or Driftdown
DDA	Derived Decision Altitude (MDA +50 feet)
DDG	Dispatch Deviations Guide
DECR	Decrease
DEG	Degree

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717 Flight Crew Training Manual

DEL	Delete
DEP	Departure
DEP ARR	Departure Arrival
DEPR	Depressurize
DES or DESC	Descent
DEST	Destination
DET	Detector or Detection or Detect
DEU	Display Electronic Unit
DFCS	Digital Flight Control System
DFDAU	Digital Flight Data Acquisition Unit
DFDR	Digital Flight Data Recorder
DFGC	Digital Flight Guidance Computer
DFGS	Digital Flight Guidance System
DH	Decision Height
DIFF	Differential
DIR	Direct
DIR INTC	Direct Intercept
DISAG	Disagree
DISC	Disconnect
DISCH	Discharge
DK	Deck
DME	Distance Measuring Equipment

DN	Down
DP	Departure Procedures
DPC	Display Processing Computer
DSP	Display Select Panel
DSPL	Display
DTG	Distance to Go
DTW	Distance to Waypoint
DU	Display Unit
E	
EAD	Engine and Alert Display
EADI	Electronic Attitude Director Indicator
ECON	Economy
ECP	Electronic Control Panel
E/D	End of Descent
E/E	Electrical/ Electronic
EEC	Electronic Engine Control
EFI	Electronic Flight Instruments
EFIS	Electronic Flight Instrument System
EGPWS	Enhanced Ground Proximity Warning System
EGT	Exhaust Gas Temperature

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EHSI	Electronic Horizontal Situation Indicator
EICAS	Engine Indication and Crew Alerting System
EIS	Electronic Instrument System
ELEC	Electrical
ELEV	Elevator
EMER	Emergency
ENG	Engine
ENG OUT	Engine Out
ENG OUT D/D	Engine Out Driftdown
ENT	Entry
EO or E/O	Engine Out
EOAP	Electronic Overhead Annunciation Panel
EPC	Electrical Power Center
EPCU	Electrical Power Control Unit
EPR	Engine Pressure Ratio
EQPT or EQUIP	Equipment
ET	Elapsed Time
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure

ETE	Estimated Time En Route
ETOPS	Extended Range Operation with Twin Engine Airplanes
ETP	Equal Time Point
EVAC	Evacuation
EXEC	Execute
EXT	Extend or External
F	
F	Fahrenheit
FAA	Federal Aviation Administration
FAC	Final Approach Course
FADEC	Full Authority Digital Engine Control
FAF	Final Approach Fix
FANS	Future Air Navigation System
FAR	Federal Aviation Regulation
FB	Fleet Bulletin
FCC	Flight Control Computer
FCOM	Flight Crew Operations Manual
FCP	Flight Control Panel
FCTL	Flight Control
FCTM	Flight Crew Training Manual

DELTA
717 Flight Crew Training Manual

FCU	Flush Control Unit
FD, F/D or FLT DIR	Flight Director
FF	Fuel Flow
FFM	Force Fight Monitor
FGCP	Flight Guidance Control Panel
FGS	Flight Guidance System
FILT	Filter
FIR	Flight Information Region
FL	Flight Level
FLAR or FLR	Flare
FL CH or FLCH	Flight Level Change
FLEX TO	Flex Takeoff
FLO	Flow
FLT	Flight
FLT CTRL	Flight Control
FLT RCDR	Flight Recorder
FLPRN	Flapron
FMA	Flight Mode Annunciator
FMC	Flight Management Computer
FMS	Flight Management System
F/O, FO, F	First Officer
FOM	Flight Operations Manual

FOQA	Flight Operations Quality Assurance
FPA	Flight Path Angle
FPM	Feet Per Minute
FPV	Flight Path Vector
FQS	Fuel Quantity System
FREQ	Frequency
F/S	Fast/Slow
FT	Feet
FWD	Forward
FWSOV	Fire Wall Shut Off Valve
FX	Fix
G	
G	Acceleration of Gravity or Generator
GA	Go-Around
GEN	Generator
GLS	GNSS Landing System
GMT	Greenwich Mean Time
GND	Ground
GNSS	Global Navigation Satellite System
GNSSU	Global Navigation System Sensor Units
GP or G/P	Glide Path

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GPS	Global Positioning System
GPWS	Ground Proximity Warning System
GS	Ground Speed or Ground Service
G/S	Glide Slope
GW	Gross Weight
H	
HAA	Height Above Airport
HAT	Height Above Touchdown
HDG	Heading or Hydraulic Driven Generator
HDG REF	Heading Reference
HDG SEL	Heading Select
HF	High Frequency
HGS	Head-Up Guidance System (HGS® is a registered trademark of Flight Dynamics)
HI	High
HLD	Hold
HP	High Pressure
HPA	Hectopascals
HPSOV	High Pressure Shut Off Valve
HSI	Horizontal Situation Indicator
HUD	Head-Up Display

HYD	Hydraulic
I	
I/O	Input/Output
IAF	Initial Approach Fix
IAN	Integrated Approach Navigation
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
IGS	Instrument Guidance System
ILS	Instrument Landing System
IM	Inner Marker
IMC	Instrument Meteorological Conditions
IMPF	Improved Performance
IN	Inches
INBD	Inboard
INCR	Increase

DELTA
717 Flight Crew Training Manual

IND	Indicator
IND LTS	Indicator Lights
IN HG	Inches of Mercury
INOP	Inoperative
INIT	Initialization
INSTR	Instrument
INT or INTPH	Interphone
INTC	Intercept
INTC CRS	Intercept Course
IP	Instructor Pilot
IQ	Initial Qualification
IRS	Inertial Reference System
IRU	Inertial Reference Unit
ISA	International Standard Atmosphere
ISDU	Inertial System Display Unit
ISFD	Intergrated Standby Flight Display
ISIS	Integrated Standby Instrument System
ISOL	Isolation
ISLN	Isolation
J	
JAA	Joint Aviation Authority

K	
K or KTS	Knots
KCAS	Knots Calibrated Airspeed
KGS	Kilograms
KIAS	Knots Indicated Airspeed
L	
L	Left
LAT	Latitude or Lateral
LBS	Pounds
LCDU	Liquid-Crystal Display Units
LCM	Logic Control Module
LD	Load
LDA	Localizer-type Directional Aid
LDG	Landing
LDG ALT	Landing Altitude
LE	Leading Edge
LED	Light Emitting Diode
LIM	Limit
LIM SPD	Limit Speed
LKD	Locked
L NAV or LNAV	Lateral Navigation
LND	Land
LO	Low

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717 Flight Crew Training Manual

LOC	Localizer
LOC-BC	Localizer Back Course
LOE	Line Oriented Evaluation
LOM	Locator Outer Marker
LON or LONG	Longitude
LP	Low Pressure
LPR	Landing Performance Request
LRC	Long Range Cruise
LRU	Line Replaceable Unit
LSK	Line Select Key
LT	Light
LWD	Left Wing Down
LWR CTR	Lower Center
LWR DSPLY or LWR DSPL	Lower Display
M	
M	Mach
MAG	Magnetic
MAHP	Missed Approach Holding Point
MAINT	Maintenance
MAN	Manual or Maneuvering

MAP	Missed Approach Point
MASI	Mach/Airspeed Indicator
MAX	Maximum
MAX ALT	Maximum Engine Out Altitude
MAX CLB	Maximum Climb
MAX DES	Maximum Descent
MAX END	Maximum Endurance
MB	Millibars
MCA	Minimum Crossing Altitude
MCC	Maintenance Control Center
MCDU	Multi-function Control and Display Unit
MCL	Maximum Climb (Engine Rating)
MCO	Maintenance Carry Over
MCP	Mode Control Panel
MCT	Maximum Continuous Thrust
MDA	Minimum Descent Altitude
MDA(H)	Minimum Descent Altitude (Height)
MDM	Mechanical Dispatch Manual

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717 Flight Crew Training Manual

MEA	Minimum Enroute Altitude
MECH	Mechanic
MED	Medium
MEL	Minimum Equipment List
MFD	Multifunction Display
MHZ	Megahertz
MIC	Microphone
MIN	Minimum
MISC	Miscellaneous
MKR	Marker
MLG	Main Landing Gear
MLS	Microwave Landing System
MLW	Maximum Landing Weight
MM	Middle Marker
MMEL	Master Minimum Equipment List
MMO	Maximum Mach Operating Speed
MNPS	Minimum Navigation Performance Specification
MOCA	Minimum Obstruction Clearance Altitude
MOD	Modify
MOM	Momentary

MORA	Minimum OffRoute Altitude
MSA	Minimum Safe Altitude
MSG	Message
MSGs RCVD	Messages Received
MSL	Mean Sea Level
MSP	Mode Select Panel
MTES	Maintenance Test Enable Switch
MTOGW	Maximum Takeoff Gross Weight
MTRS	Meters
MU	Management Unit
MUH	Minimum Use Height
MVA	Minimum Vectoring Altitude
N	
N	Normal
N/A	Not Available
NACL	Nacelle
NADP	Noise Abatement Departure Procedures
NAR	North American Route
NASA	National Aeronautics and Space Administration

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717 Flight Crew Training Manual

NATS	North Atlantic Track System
NAV	Navigation
NAV RAD	Navigation Radio
ND	Navigation Display
NDB	Non-Directional Beacon
NL	Nose Left
NLG	Nose Landing Gear
NLT	No Later Than
NM	Nautical Mile(s)
NNC	Non-Normal Checklists
NNM	Non-Normal Maneuvers
NPS	Navigation Performance Scales
NORM	Normal
NR	Nose Right
NTSB	National Transportation Safety Board
N1	Low Pressure Rotor Speed
N2	High Pressure Rotor Speed (Pratt & Whitney and GE engines) or Intermediate Pressure Rotor Speed (Rolls Royce Engines)

N3	High Pressure Rotor Speed (Rolls Royce Engines)
O	
OAP	Overhead Annunciator Panel (a.k.a. EOAP)
OAT	Outside Air Temperature
OCC	Operations Control Center
ODM	Operational Data Manual
OFST	Offset
OHU	Overhead Unit
OM	Outer Marker
OP	Open
OUTBD DSPL	Outboard Display
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
PASS	Passenger

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PBD	Place/Bearing/ Distance	PLAN	Plan Mode
PBE	Protective Breathing Equipment	PLI	Pitch Limit Indicator
PCDU	Power Conversion and Distribution Units	PM	Pilot Monitoring
PCP	Pilot Call Panel	PMC	Power Management Control
PDC	Pitch Data Computer or Performance Data Computer or Pre-Departure Clearance	PMP	Pump
PED	Pedestal	PNEU	Pneumatic
PERF	Performance	PNF	Pilot Not Flying
PERF INIT	Performance Initialization	PNL	Panel
PERF PEN	Performance Penalty	PODS	Pneumatic Overheat Detection System
PES	Pitch Enhancement System	POS	Position
PF	Pilot Flying	POS INIT	Position Initialization
PFC	Primary Flight Computer	POS REF	Position Reference
PFD	Primary Flight Display	PPH	Pounds Per Hour
PI	Performance Inflight	PPI	Planned Position Indicator
PIP	Product Improvement Package	PPOS	Present Position
		PRAM	Prerecorded Announcement Machine
		PRES or PRESS	Pressure
		PREV	Previous
		PRI	Primary
		PRAIM	Predictive Receiver Autonomous Integrity Monitoring
		PROF	Profile

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PROG	Progress
PROX	Proximity
P/RST	Push To Reset
PRV	Pressure Regulating Valve
PSEU	Proximity Switch Electronics Unit
PSI	Pounds Per Square Inch
PSU	Passenger Service Utilities
PTH	Path
PTT	Push To Talk
PTU	Power Transfer Unit
PWR	Power
PWS	Predictive Windshear System
Q	
Q	Quantity
QFE	Local Station Pressure
QNH	Altimeter Setting
QRH	Quick Reference Handbook
QTY	Quantity
R	
R	Right
RA	Radio Altitude or Resolution Advisory
RAD	Radio

RAS	Remote Access System
RAT	Ram Air Temperature or Ram Air Turbine
RATOW	Runway Allowable Takeoff Weight
RCL	Request for Clearance
RDMI	Radio Distance Magnetic Indicator
RDR	Rudder
REC	Recorder
RECIR or RECIRC	Recirculation
REF	Reference
RET	Retract
RETD	Retard
REV	Reverse
RF	Radius-to-Fix (RF) Legs or Refill
RHM	Rudder Hook Monitor
RLS	Remote Light Sensor
RMI	Radio Magnetic Indicator
RON	Remain Overnight
RNAV or RNV	Area Navigation

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RNP	Required Navigational Performance	SAARU	Secondary Attitude Air Data Reference Unit
RPL	Rudder Pressure Limiter	SAT	Static Air Temperature or Satellite
RPM	Revolutions Per Minute	SATCOM	Satellite Communication System
RPR	Rudder Pressure Reducer	SB	Service Bulletin
RSEP	Rudder System Enhancement Program	S/B	Speedbrake
RSL	Rudder Stop Limiter	S/C	Step Climb
RST	Reset	SCP	System Control Panel
RSVR	Reservoir	S/D	Step Descent
R/T	Radio Transmit	SD	System Display
RTE	Route	SDCP	System Display Control Panel
RTO	Rejected Takeoff	SDF	Simplified Directional Facility
RTP	Radio Tuning Panel	SDP	System Display Panel
RUD	Rudder	SEI	Standby Engine Indicator
RVR	Runway Visual Range	SEL	Select
RVSM	Reduced Vertical Separation Minimum	SELCAL	Selective Calling
RWD	Right Wing Down	SENS	Sensitivity
RWY	Runway	SERV	Service
S		SG	Symbol Generator
SAAAR	Special Aircraft and Aircrew Authorization Required	SID	Standard Instrument Departure

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SISP	Source Input Select Panel
SMGCS	Surface Movement and Guidance Control System
SMOK	Smoking
SMS	Safety Management System
SPD	Speed
SPDBRK	Speedbrake
STA	Station
STAB	Stabilizer
STAR	Standard Terminal Arrival Route
STAT	Status
STBY	Standby
STD	Standard
SW	Switch
SYNC	Synchronizer
SYS	System
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
TAC	Thrust Asymmetry Compensation

TAI	Thermal Anti-Ice
TAS	True Airspeed
TAT	Total Air Temperature
TBD	To Be Determined
T/C	Top of Climb
TCA	Terminal Control Area
TCAS	Traffic Alert and Collision Avoidance System
T/D	Top of Descent
TD	Traffic Display
TDZ	Touch Down Zone
TDZE	Touch Down Zone Elevation
TE	Trailing Edge
TEM	Threat Error Management
TEMP	Temperature
TERP	Terminal Instrument Procedures
TERR	Terrain
TFC	Traffic
TFR	Transfer
TGT	Turbine Gas Temperature
THNDSTRM	Thunderstorm
THR	Throttle or Thrust
THR HOLD	Throttle Hold

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THROT	Throttle
TMC	Thrust Management Computer
TMI	Track Message Identifier
TMSP	Thrust Mode Select Panel
TO or T/O	Takeoff
TOC	Top of Climb
TOD	Top of Descent
TO FLEX	Takeoff Flexible Derate
TO/GA	Takeoff/Go-Around
TOGW	Takeoff Gross Weight
TOPR	Takeoff Performance Request
TPC	Tactical Pilotage Charts
TRK	Track
TRP	Thrust Rating Panel
TRU	Transformer Rectifier Unit
TURB	Turbine or Turbulence
U	
UNBAL	Unbalanced
UNLKD or U/L	Unlocked
UNSCHD or UNSCHED	Unscheduled

UPR DSPL	Upper Display
U.S.	United States
USB	Upper Side Band
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
VDC	Volts Direct Current
VDP	Visual Descent Point
VEF	Speed at Engine Failure
VERT	Vertical
VFE	Flap Extend Speed
VFR	Flap Retract Speed
VFR	Visual Flight Rules
VG	Vertical Gyro
VGE	Gear Extend Speed
VGR	Gear Retract Speed
VHF	Very High Frequency

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VIA	Versatile Integrated Avionics
VIB	Vibration
VLOF	Lift Off Speed
VLV	Valve
VMAX	FMC Calculated Max Operating Speed
VMIN	FMC Calculated Min Operating Speed
VMC	Visual Meteorological Conditions
VMCA	Minimum Control Airspeed or Single Engine Minimum Control Airspeed
VMCG	Minimum Control Speed Ground
VMO	Maximum Operating Speed
V NAV or VNAV	Vertical Navigation
VOL	Volume
VOR	VHF Omnidirectional Range
VP	Tire Hydroplaning Speed
VR	Rotation Speed
VREF	Reference Speed

VRNP	Vertical Required Navigation Performance
V/S	Vertical Speed
VS	Stall Speed
VSCF	Variable Speed Constant Frequency
VSD	Vertical Situation Display
VSE	Slat Extend Speed
VSI	Vertical Speed Indicator
VSO	Stall Speed in landing configuration
VSR	Slat Retract Speed
VSS	Stick-shaker Speed
VTK	Vertical Track
V1	Takeoff Decision Speed
V1 (MCG)	Minimum V1 for Control on the Ground
V2	Scheduled Takeoff Target Speed
V3	Final Segment Climb Speed
W	
W	Warm
WAGS	Windshear Alert Guidance System
WARN	Warning

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WATRS	Western Atlantic Route System
WDR	Weight Data Record
WGS-84	World Geodetic System of 1984
WHL	Wheel
WINDSHR or WNDSHR	Windshear
WOW	Weight On Wheel
WPT	Waypoint
W/S	Windshear
WSC	Windshear Computer
WT	Weight
WX or WXR	Weather Radar
WXBRT	Weather Radar Brightness
WX+T	Weather and Turbulence
X	
X-FEED	Crossfeed
XFER or XFR	Transfer
XPDR or XPNDR	Transponder
XTK	Cross Track
Z	
ZFW	Zero Fuel Weight
ZFWCG	Zero Fuel Weight Center of Gravity

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Revision Notification Transmittal Letter

To: All holders of Delta Air Lines, Inc. Operations Manuals.

Subject: Flight Crew Training Manual Revision.

This revision reflects the most current information available to Delta Air Lines, Inc. through the subject 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	July 14, 2015		1	September 16, 2016	

General

Delta Air Lines, Inc. 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 as soon as it is received, 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 record above should be completed by the person incorporating the revision into the manual.

Revision Highlights

All references to the Airway Manual (AM) have been updated to reflect the new organization of the Airway Manual. These changes will not be indicated with individual highlights.

All references to the “Delta Special Page(s)” and “Green Page(s)” have been removed and are now called “Company page(s).”

Added triggers to all flows (except Preflight) to match Volume 1 amplified procedures.

Chapter PT - Preface

Section 1 - Model Identification

PT.1.1 - Revised Flight Crew Bulletins to Fleet Bulletins.

PT.1.1 - Updated all ship numbers to match Volume 1.

PT.1.4 - Added new ship to Model Id's.

Section 2 - Introduction

General

PT.2.1 - Updated Introduction for fleet standardization.

Regulatory Agencies

PT.2.2 - Updated Introduction for fleet standardization.

Airplane Configuration

PT.2.2 - Updated Introduction for fleet standardization.

Corrections to the Manual

PT.2.3 - Updated reference to the new Deltanet website,
<https://deltanet.delta.com>.

PT.2.3 - Revised location where to submit PCR's within the new Deltanet website.

Organization

PT.2.5 - Added "human factors" to the list of information items contained the FCTM.

Section 3 - Abbreviations

PT.3.1 - Revised AED to "Automated External Defibrillator."

PT.3.5 - Added DP - Departure Procedures.

PT.3.7 - Added F - First Officer.

PT.3.7 - Added FOQA - Flight Operations Quality Assurance.

PT.3.8 - Added IMPF - Improved Performance.
PT.3.10 - Added LOE - Line Oriented Evaluation.
PT.3.10 - Added LPR - Landing Performance Request.
PT.3.10 - Added MCA - Minimum Crossing Altitude.
PT.3.11 - Added MVA - Minimum Vectoring Altitude.
PT.3.11 - Added NASA - National Aeronautics and Space Administration.
PT.3.12 - Added NATS - North Atlantic Track System.
PT.3.12 - Added NTSB - National Transportation Safety Board.
PT.3.13 - Added PNF - Pilot Not Flying.
PT.3.14 - Added RAS - Remote Access System.
PT.3.16 - Added SMS - Safety Management System.
PT.3.16 - Added TEM - Threat Error Management.
PT.3.16 - Added TERP - Terminal Instrument Procedures.
PT.3.17 - Added TOPR - Takeoff Performance Request.
PT.3.17 - Added TPC - Tactical Pilotage Charts.
PT.3.18 - Added VLOF - Lift Off Speed.
PT.3.18 - Added VP - Tire Hydroplaning Speed.
PT.3.18 - Revised Vso to "Stall Speed in landing configuration."

Chapter 1 - General Information

Crew Resource Management

1.1 - Updated references to Human Factors in chapter 9.

Before Takeoff

1.7 - Added "AUTOPILOT REL" step to the Before Takeoff flow.

Descent

1.9 - Added "Windshield anti-fog switch" to the Decent flow.

Climb, Cruise and Descent

1.20 - Added statement "To prevent overspeeds, crews may need to adjust the IAS/MACH or Cost Index to maintain an appropriate buffer from VMO/MMO and flap placard speeds."

Wing Anti-Ice Operation - In Flight

1.42 - Added "Wing Anti-Ice Operation - In Flight" section.

Chapter 2 - Ground Operations

Anomalies

- 2.5 - Revised tailwind component to 30 knots to match Vol. 1.

Taxi General

- 2.6 - Revised statement, "Complex taxi clearances should be written down or entered into the MDCU scratchpad."
- 2.6-7 - Revised language for cross-fleet standardization.
- 2.7 - Revised language in fourth bullet.
- 2.7 - Added TOPR to last bullet under Prior to Takeoff.
- 2.8 - Added third bullet for cross-fleet standardization.

Using Runways as Taxiways

- 2.9 - Added new section.

Turning Radius and Gear Tracking

- 2.16 - Revised statement "The pilot seat position is slightly aft of the nose wheel....."

Definitions and Concepts

- 2.24, 27- Revised reference to Airway Manual (AM) for Ground De/Anti-Icing.

Chapter 3 - Takeoff and Initial Climb

Takeoff Crosswind Guidelines

- 3.7 - Modified reference for contaminated runways.

Gusty Wind and Strong Crosswind Conditions

- 3.8 - Revised statement "For takeoff in gusty or strong crosswind, consider the use of a higher thrust setting than the minimum required."
- 3.8 - Deleted "Avoid rotation during a gust."

Adverse Runway Conditions

- 3.12 - Modified language for cross-fleet standardization.

Takeoff Performance Limit Weights

- 3.13 - Modified language for cross-fleet standardization.

Rejected Takeoff Decision

- 3.14 - Removed bullets regarding windshear and added windshear reference.

Immediate Turn after Takeoff - All Engines

3.19 - Relocated caution to "Immediate Turn after Takeoff - All Engines" section.

3.19 - Changed "AFE" to "AGL."

Autopilot Engagement

3.22 - Added AGL to statement.

Flap Retraction Schedule

3.22 - Added AFE to statement.

Chapter 4 - Climb, Cruise, Descent and Holding

Reduced Thrust Climb

4.1 - Deleted statement "CLB1 is normally selected on the THRUST LIMITS....."

Climb Speed Determination

4.6 - Changed "you" to "the flight", for clarity.

Cruise Speed Determination

4.12 - Modified Mach and True Airspeed for Cost Index modification changes.

Descent Path

4.32 - Changed "you have" to "the flight has", for clarity.

Chapter 5 - Approach and Missed Approach

Approach

5.20 - Changed visibility criteria to match the Airway Manual.

5.21 - Revised reference to Vol. 1.

ILS PRM Approach

5.26 - Added "Phraseology" to ILS PRM Approach.

5.27 - Revised title to "PRM Breakout Maneuver."

Non-ILS Approach Profile Using PROF

5.30 - Removed "rounded up to the nearest 100" as we no longer need to "round up" in the FCP. Revised "GS" to "Descent Angle" to match Jeppesen charts.

RNAV (GPS or GNSS), GPS, LOC, LDA (without GS), VOR, or NDB Expanded Approach Guide NAV or LOC ONLY & PROF Modes

5.32 - Revised statement "No waypoints may be added or deleted in the Flight Plan between the FAF and the MAP."

5.35 - Revised "GS" to "Descent Angle" to match Jeppesen charts.

5.35 - Revised to "No later than 50 feet below MDA or 100 feet below DDA."

Non-ILS Approach Profile Using FPA or V/S

5.36 - Removed "rounded up to the nearest 100" as we no longer need to "round up" in the FCP. Revised "GS" to "Descent Angle" to match Jeppesen charts.

RNAV (GPS or GNSS), GPS, ILS (G/S Out), LOC, LDA (without GS), VOR, or NDB Expanded Approach Guide NAV, LOC ONLY, or VOR ARM & FPA or V/S Modes

5.38 - Revised statement "No waypoints may be added or deleted in the Flight Plan between the FAF and the MAP."

5.41 - Removed "rounded up to the nearest 100" as we no longer need to "round up" in the FCP.

5.41 - Revised "GS" to "Descent Angle" to match Jeppesen charts.

5.41 - Revised to "No later than 100 feet below DDA."

Non - ILS Instrument Approaches - General

5.45 - Moved "Database Selection" section to better flow for Non-ILS approaches.

Non-ILS Instrument Approach Using NAV

5.47 - Revised from "to include" to "including" for clarity.

Non-ILS Instrument Approach Using PROF

5.49 - Removed statement "rounded up to the nearest 100 feet,"

5.49 - GS" to "Descent Angle" to match Jeppesen charts.

Non-ILS Instrument Approach Using FPA or V/S

5.50 - Removed statement "rounded up to the next highest 100 feet."

Circling Maneuver - General

5.54 - Revised statement concerning "Cross-cockpit" flying.

Obstruction Clearance

5.56 - Added "Expanded Circling Area Radius (r) from Threshold" column to FAA table.

5.56 - Added "(Cat C)" to associate the Max IAS with appropriate category.

5.56 - Added "(Cat D)" to associate the Max IAS with appropriate category.

5.57 - Added Noted for expanded circling radius.

Visual Approach - General

5.61 - Added new section "Vertical Guidance On a Visual Approach."

High Energy Approach

5.62 - Revised "1,000 feet HAT" to "1,500 feet HAT."

Non-ILS Instrument Approach Profile Using PROF - One Engine Inoperative

5.67 - Removed "rounded up to the nearest 100" as we no longer need to "round up" in the FCP.

Non-ILS Instrument Approach Profile Using FPA or V/S - One Engine Inoperative

5.69 - Removed "rounded up to the nearest 100" as we no longer need to "round up" in the FCP. Revised "GS" to "Descent Angle" to match Jeppesen charts.

Chapter 6 - Landing

Visual Approach Slope Indicator (VASI / T-VASI)

6.1 - Revised title for VASI.

Three Bar VASI / T-VASI

6.2 - Revised title to "VASI and T-VASI."

Landing Risk Factors

6.6 - Removed last sentence "In this case, the momentary addition of thrust may aid in preventing the tail strike, however can result in landing long or a runway over run."

Reverse Thrust Operation

6.18 - Revised "KIAS" to "Knots" for consistency.

Crosswind Landings

6.21 - Revised reference to Volume 1, "Guidelines for Takeoff on Contaminated Runways or Landing with Braking Action Less than good."

Chapter 7 - Maneuvers

Terrain Avoidance Maneuver

7.19 - Revised instruction to "Immediately adjust the flight path or initiate a go-around."

7.19-20 - Deleted note.

Traffic Alert and Collision Avoidance System

7.21 - TCAS information replaced, partial incorporation of FB 16-03: TCAS Resolution Advisory (RA) Policy Update.

Windshear During Takeoff Roll

7.36 - Changed "PWS" to "Predictive windshear" for clarity.

Windshear In Flight

7.36 - Added note about reactive and predictive windshear.

Chapter 8 - Non-Normal Operations

Non-Normal Situation Guidelines

8.1 - Changed reference from the FOM to chapter 9, Human Factors.

Leading Edge or Trailing Edge Device Malfunctions

8.16 - Revised statement "Speedbrakes are not recommended for airspeed reduction at radio altitude less than 1,000 feet."

Chapter 9 - Human Factors

9.1 - Added chapter 9 Human Factors from the FOM.

Chapter 10 - Selected References

10.1 - Added chapter 10 Selected References from the FOM.

Preface

Chapter PT

List of Effective Pages - FAA Approved

Section 5

Page	Date
FCTM	
* Title Page	September 16, 2016
* Blank	September 16, 2016
Preface (tab)	
* PT.TOC.1-2	September 16, 2016
* PT.1.1-4	September 16, 2016
* PT.2.1-6	September 16, 2016
* PT.3.1-20	September 16, 2016
* PT.4.1-8	September 16, 2016
* PT.5.1-2	September 16, 2016
General Information (tab)	
* 1.TOC.1-2	September 16, 2016
* 1.1-42	September 16, 2016
Ground Operations (tab)	
* 2.TOC.1-2	September 16, 2016
* 2.1-44	September 16, 2016
Takeoff, Initial Climb (tab)	
* 3.TOC.1-2	September 16, 2016
* 3.1-38	September 16, 2016
Climb, Cruise, Descent, Holding (tab)	
* 4.TOC.1-2	September 16, 2016
* 4.1-48	September 16, 2016
Approach, Missed Approach (tab)	
* 5.TOC.1-4	September 16, 2016
* 5.1-86	September 16, 2016

Page	Date
Landing (tab)	
* 6.TOC.1-2	September 16, 2016
* 6.1-24	September 16, 2016
Maneuvers (tab)	
* 7.TOC.1-4	September 16, 2016
* 7.1-38	September 16, 2016
Non-Normal Operations (tab)	
* 8.TOC.1-4	September 16, 2016
* 8.1-38	September 16, 2016
Human Factors (tab)	
* 9.TOC.1-2	September 16, 2016
* 9.1-18	September 16, 2016
Selected References (tab)	
* 10.TOC.1-2	September 16, 2016
* 10.1-36	September 16, 2016
Index (tab)	
* Index.1-8	September 16, 2016

* = Revised, Added, or Deleted

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General Information

Table of Contents

Chapter 1

Section TOC

Crew Resource Management	1.1
Flow Pattern Diagrams	1.1
Preflight	1.2
Pushback	1.3
Engine Start	1.4
After Start/Delayed After Start	1.5
Taxi	1.6
Before Takeoff	1.7
After Takeoff	1.8
Descent	1.9
Landing	1.10
After Landing	1.11
Shutdown	1.12
System Display	1.13
Flight Mode Annunciator	1.14
Maneuver Speeds and Margins	1.16
Minimum Flap/Slat Retraction Speeds	1.16
Maximum Flap/Slat Extension Speeds	1.16
Minimum Operating Speed (VMIN)	1.18
Maximum Operating Speed (VMAX)	1.19
Automatic Bank Angle Limits	1.19
Command Speed	1.20
Takeoff	1.20
Climb, Cruise and Descent	1.20
Approach	1.21
Landing	1.22
Non-Normal Conditions	1.23

Reference Speeds.....	1.24
Takeoff.....	1.24
Approach and Landing.....	1.24
FMS Inoperative Reference Speeds.....	1.25
Thrust Management.....	1.25
Setting Thrust.....	1.25
Maximum Thrust.....	1.25
Autothrottle Speed Protection.....	1.26
Flight Path Vector.....	1.27
Recommended Rudder Trim Technique.....	1.29
Drag Factors Due to Trim Technique.....	1.29
Primary Rudder Trim Technique.....	1.29
Alternate Rudder Trim Technique.....	1.30
RNAV Operations.....	1.30
RNP and ANP Definitions.....	1.32
Basic RNP Concept.....	1.33
Autoflight Guidelines.....	1.36
Automatic Flight.....	1.36
FCP Guidelines.....	1.37
FCP Altitude Setting Techniques Using PROF.....	1.38
Flight in Moderate to Heavy Rain, Hail, or Sleet.....	1.38
Turbulent Air Penetration.....	1.39
Ice Crystal Icing.....	1.40
Recognizing Ice Crystal Icing Weather.....	1.41
Avoiding Ice Crystal Icing Weather.....	1.42
Suspected Ice Crystal Icing.....	1.42
Wing Anti-Ice Operation - In Flight.....	1.42

Crew Resource Management

The nature of training requires that pilots have a clear understanding of human factors in chapter 9 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
- Mitigate the consequences of an error after detection.

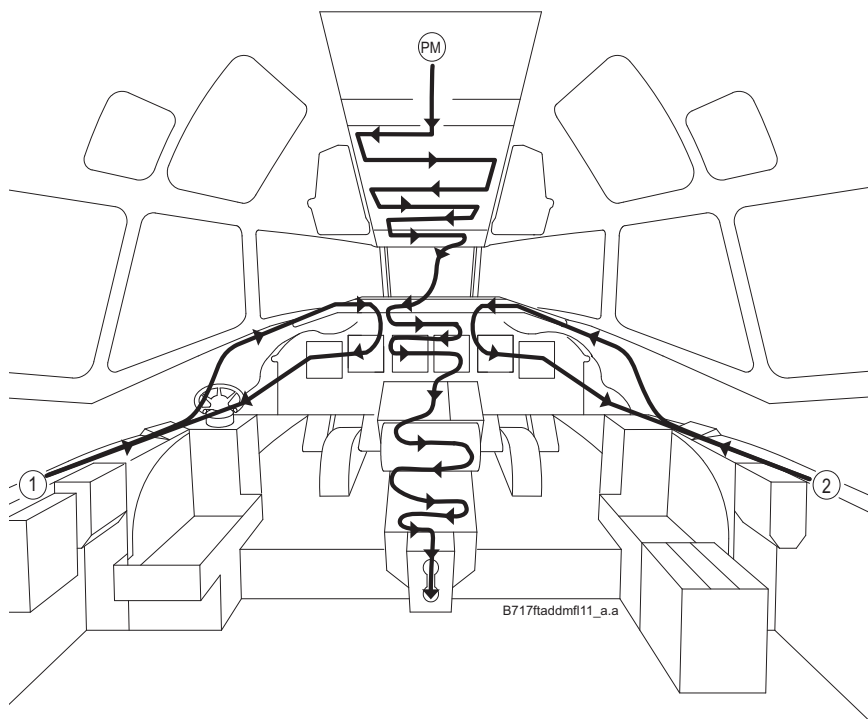
In addition to TEM strategies, pilots will use the following CRM tools during training:

- Situational awareness
- Decision making
- Planning
- Communication
- Workload management
- Professional management.

Flow Pattern Diagrams

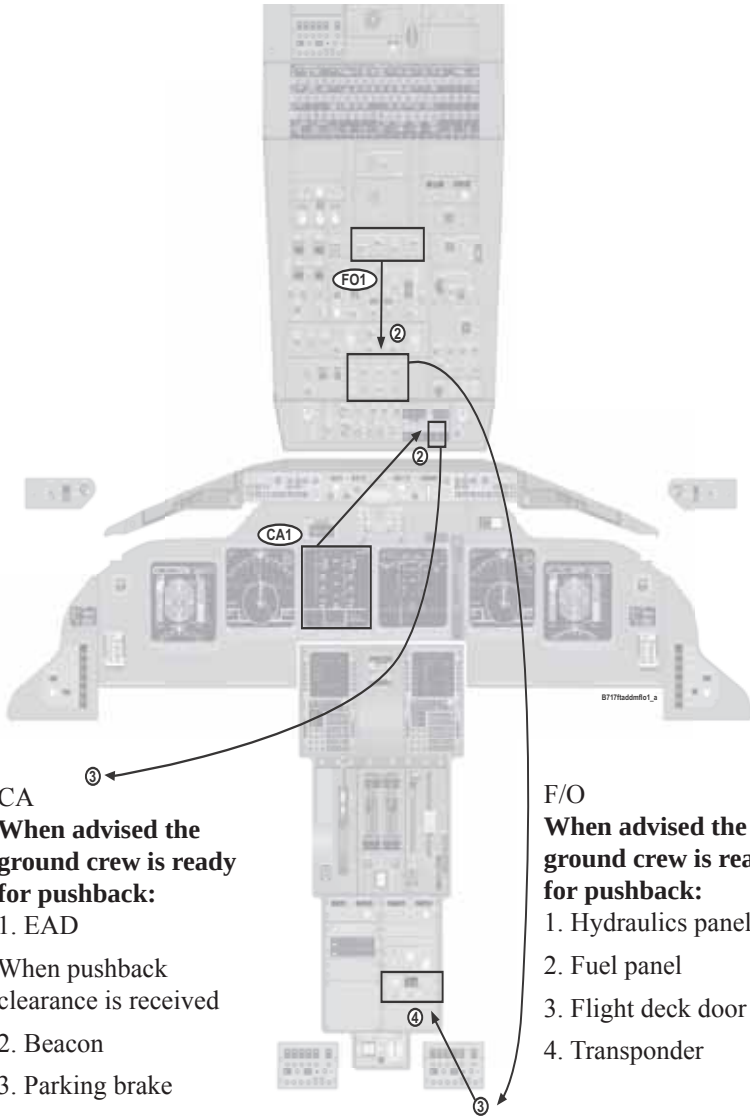
Flow patterns are based on their respective procedure and follow the order of the aircraft-specific tasks listed in the procedure. Flow pattern diagrams are a visual training aid used to facilitate accomplishing the steps listed in the respective procedure.

Preflight



1. Captain's Preflight Scan
 2. First officer's Preflight Scan
- PM: Pilot Monitoring Preflight Scan

Pushback



CA
When advised the ground crew is ready for pushback:

1. EAD

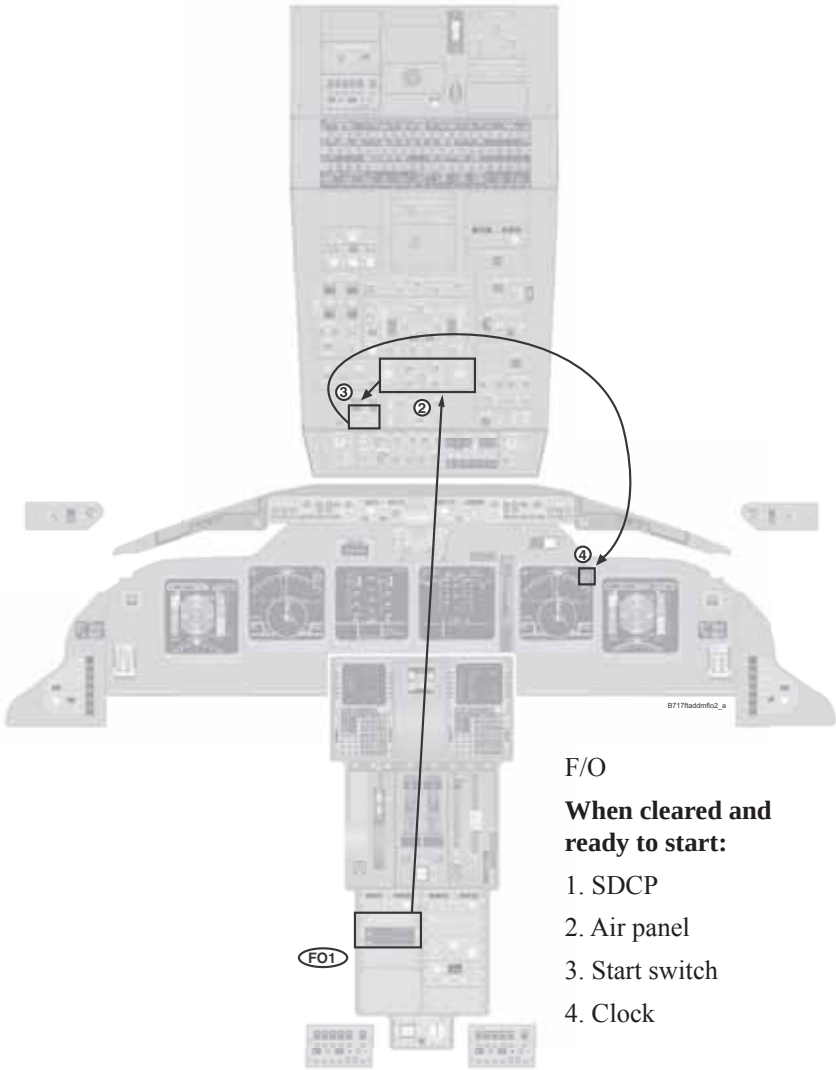
When pushback clearance is received

2. Beacon
3. Parking brake

F/O
When advised the ground crew is ready for pushback:

1. Hydraulics panel
2. Fuel panel
3. Flight deck door
4. Transponder

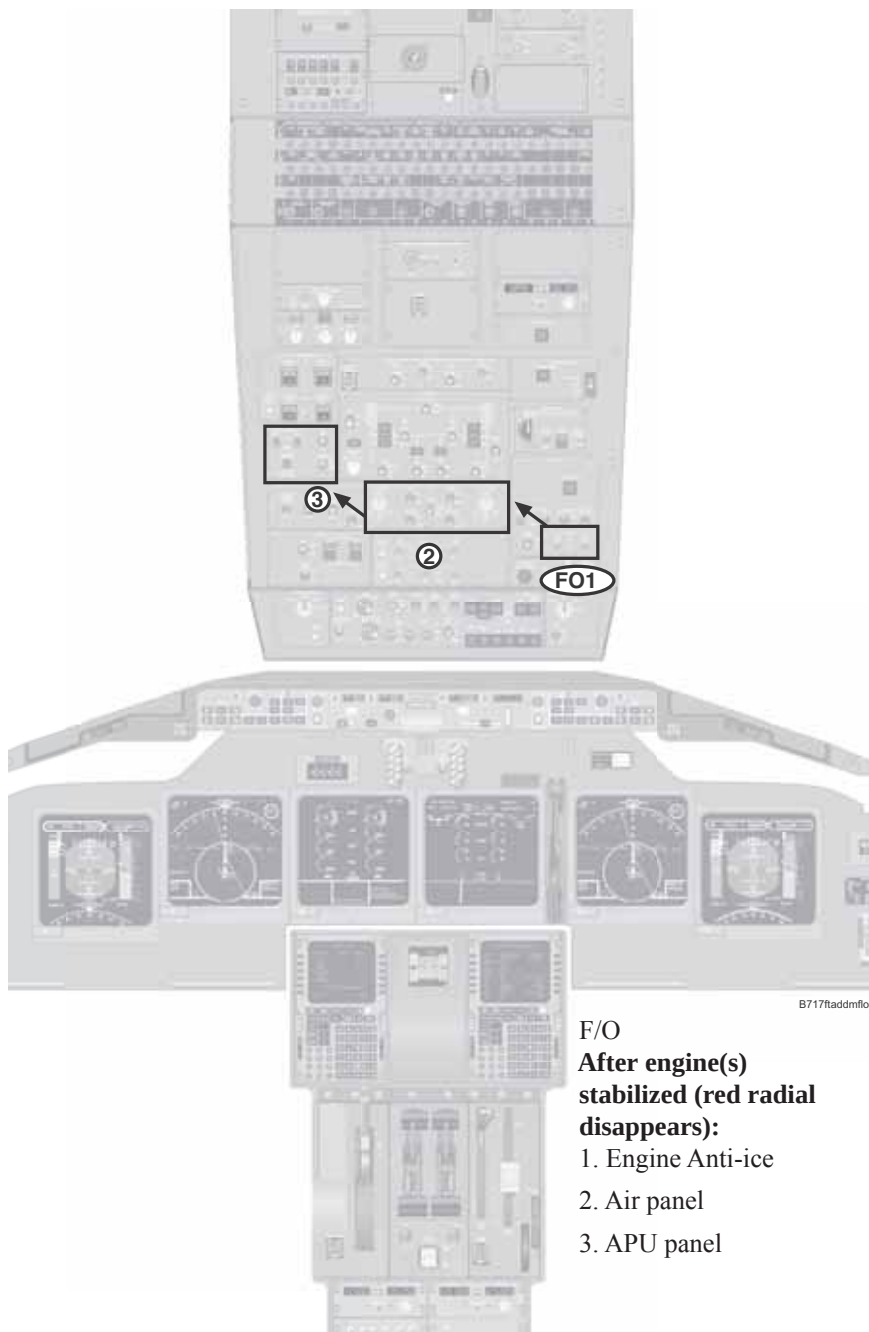
Engine Start



- F/O
- When cleared and ready to start:**
- 1. SDCP
 - 2. Air panel
 - 3. Start switch
 - 4. Clock

717 Flight Crew Training Manual

After Start/Delayed After Start



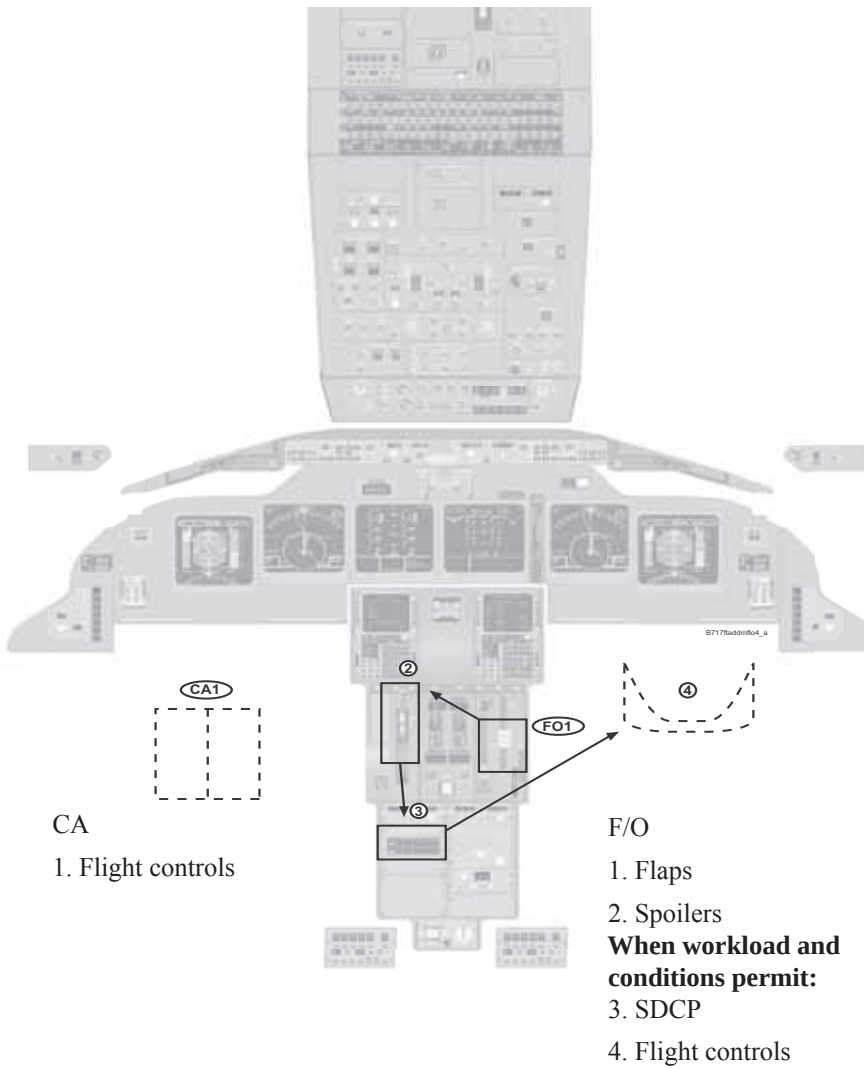
B717faddmflo:

F/O

**After engine(s)
stabilized (red radial
disappears):**

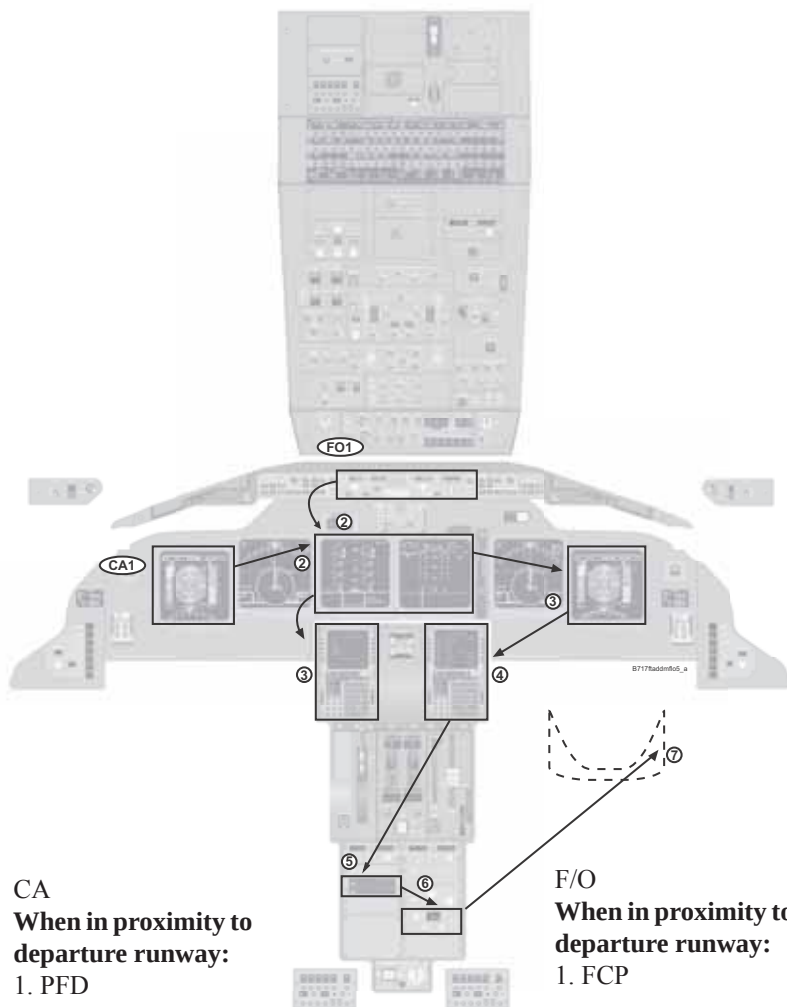
1. Engine Anti-ice
2. Air panel
3. APU panel

Taxi



717 Flight Crew Training Manual

Before Takeoff



CA

When in proximity to departure runway:

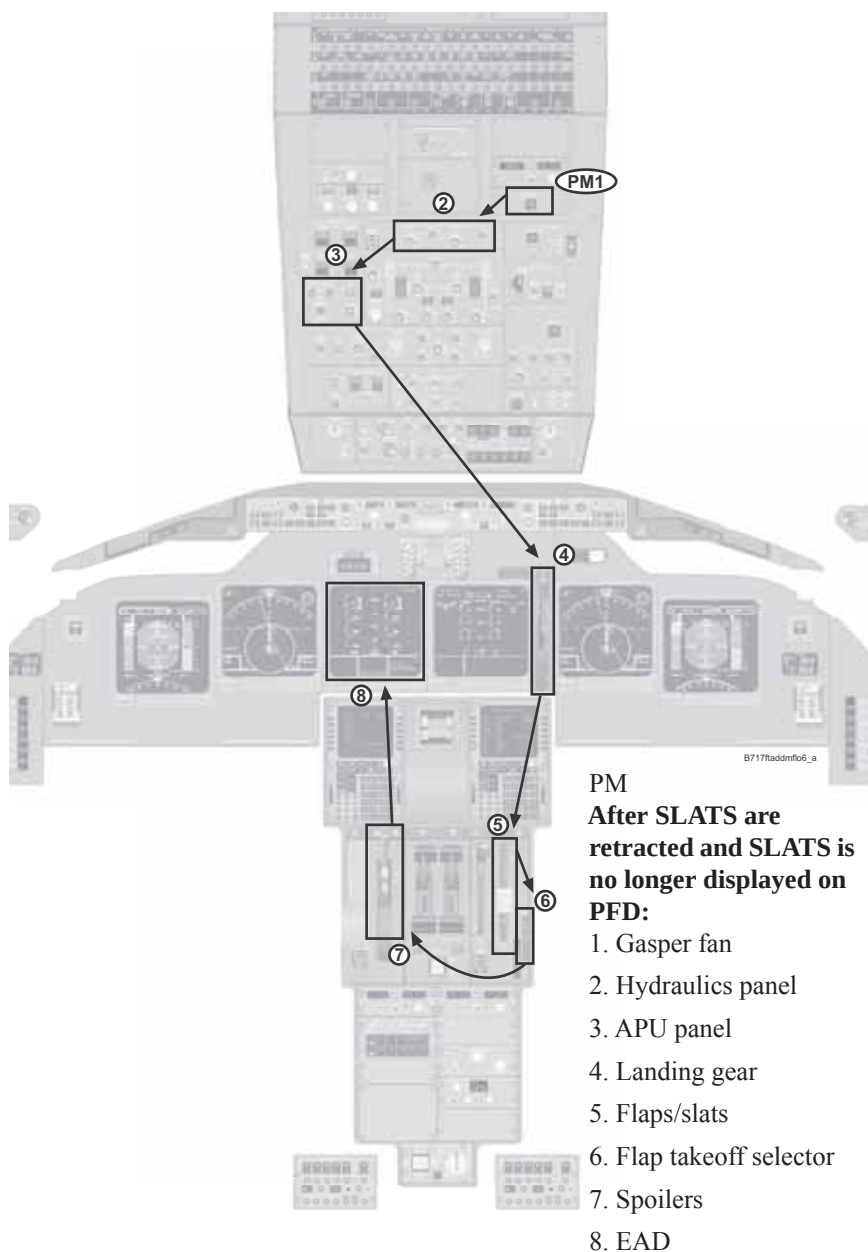
1. PFD
2. EAD and SD
3. MCDU

F/O

When in proximity to departure runway:

1. FCP
2. EAD and SD
3. PFD
4. MCDU
5. SDCP
6. Transponder
7. AUTOPILOT REL

After Takeoff

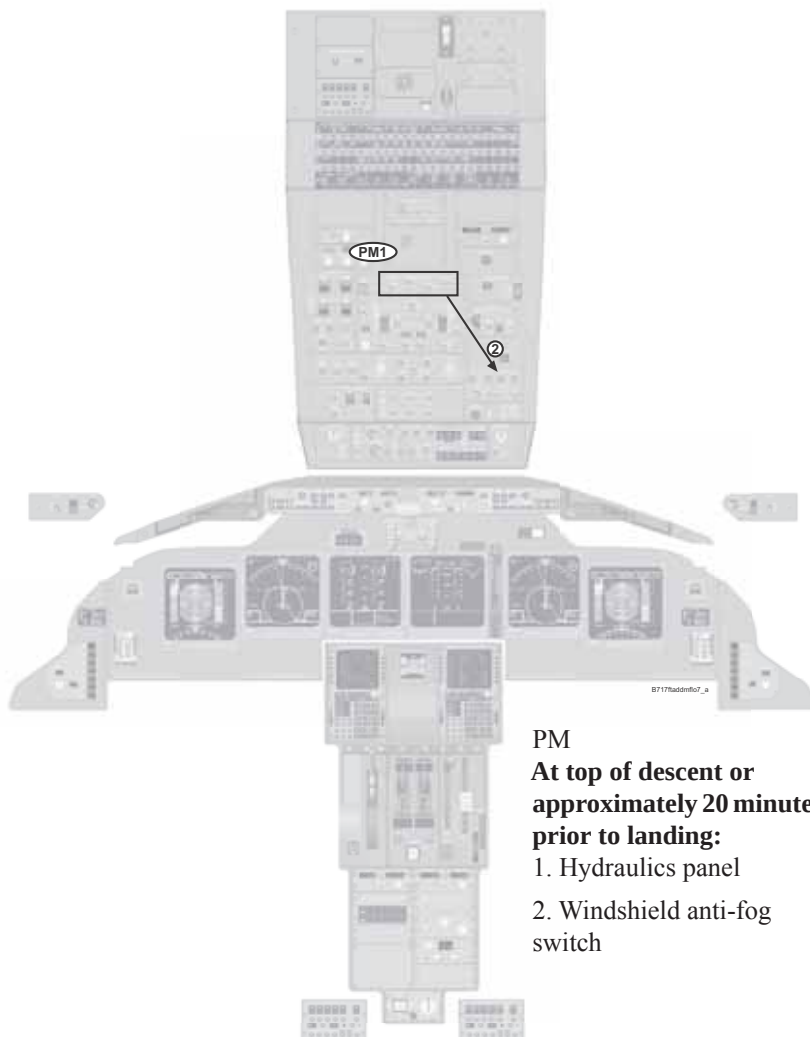


PM
After SLATS are retracted and SLATS is no longer displayed on PFD:

1. Gasper fan
2. Hydraulics panel
3. APU panel
4. Landing gear
5. Flaps/slats
6. Flap takeoff selector
7. Spoilers
8. EAD

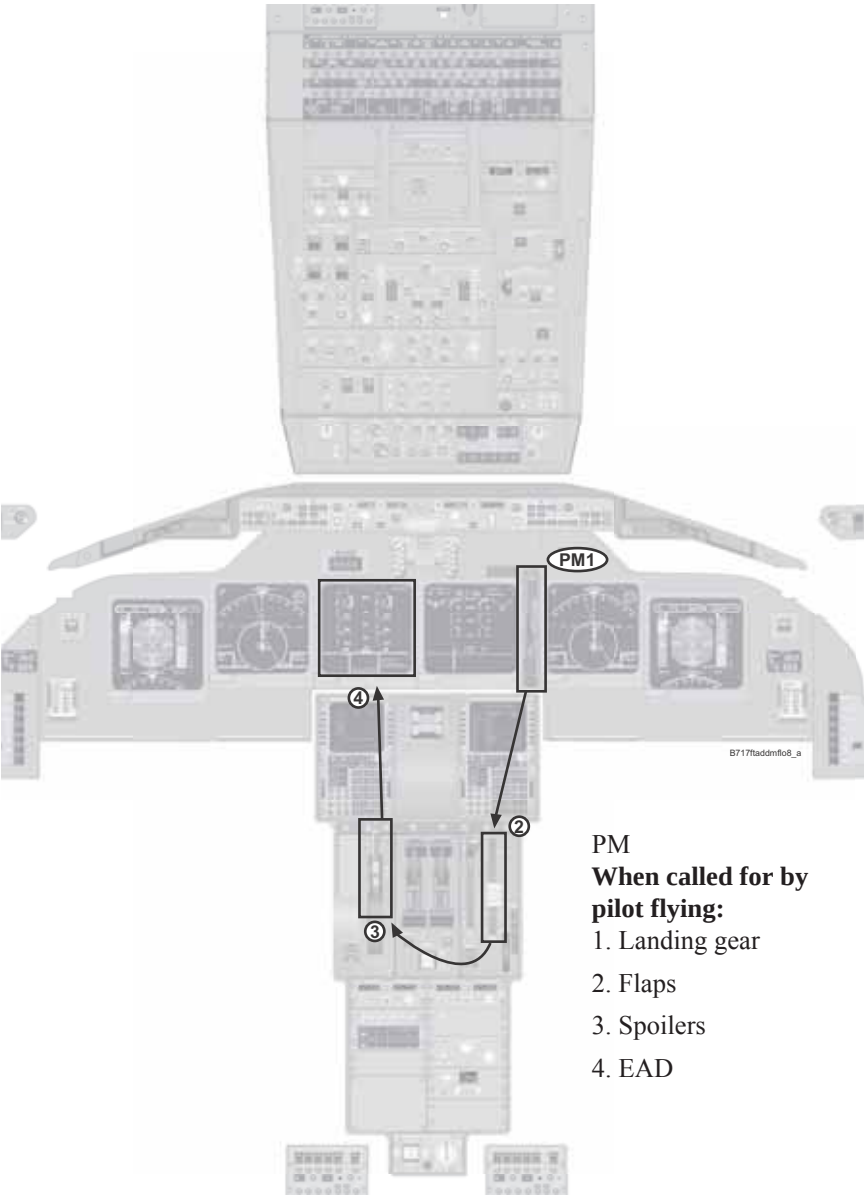
717 Flight Crew Training Manual

Descent



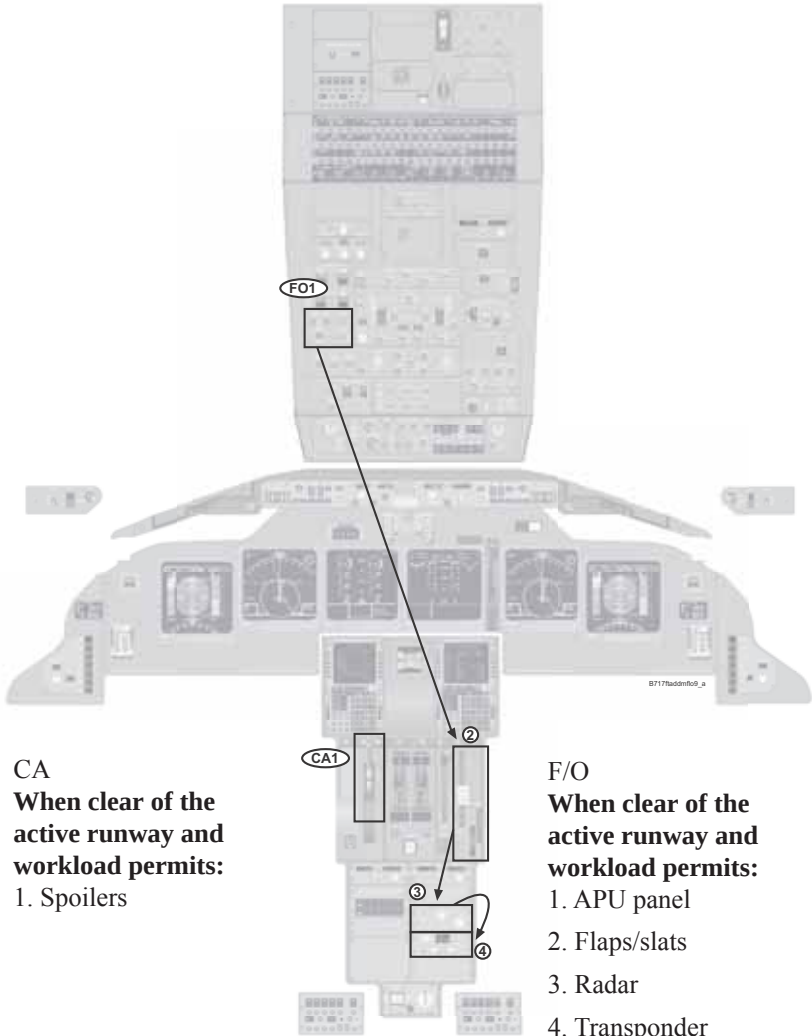
PM
At top of descent or approximately 20 minutes prior to landing:
 1. Hydraulics panel
 2. Windshield anti-fog switch

Landing

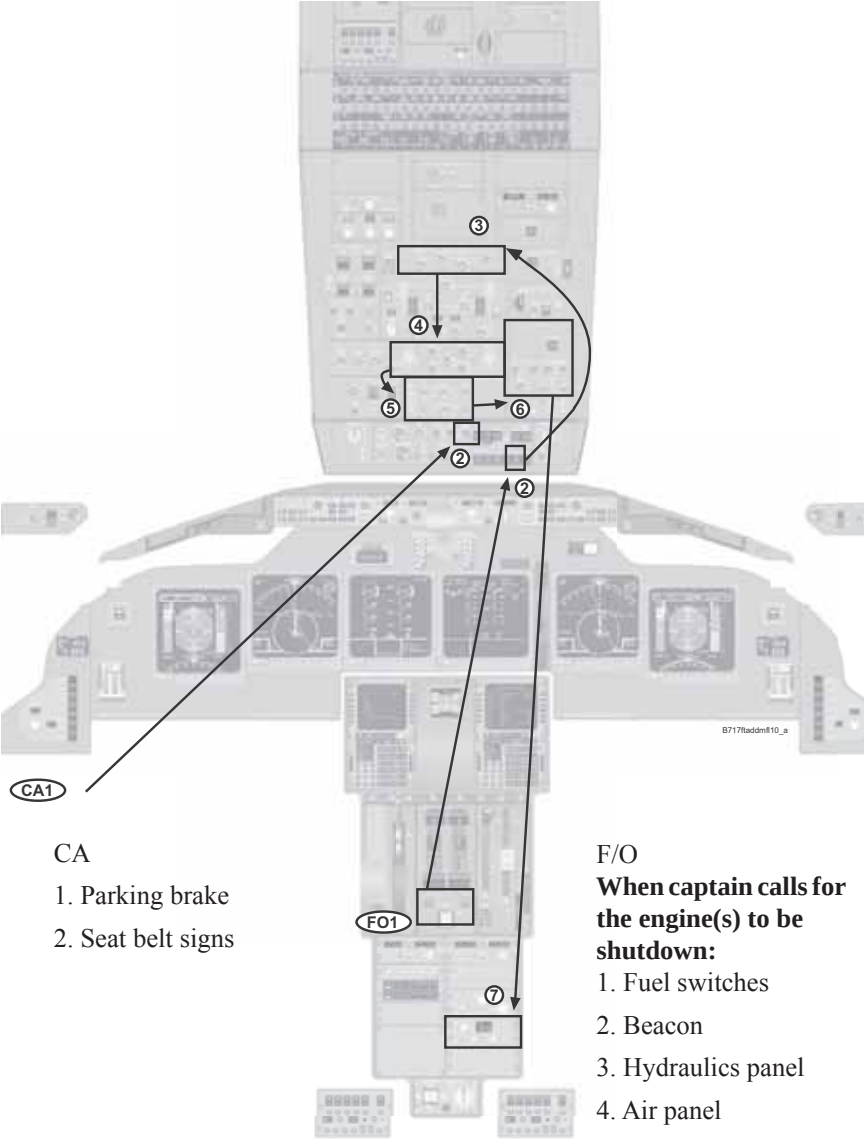


- PM
**When called for by
pilot flying:**
1. Landing gear
 2. Flaps
 3. Spoilers
 4. EAD

After Landing



Shutdown



CA1

- CA
- 1. Parking brake
 - 2. Seat belt signs

FO1

- F/O
- When captain calls for the engine(s) to be shutdown:**
- 1. Fuel switches
 - 2. Beacon
 - 3. Hydraulics panel
 - 4. Air panel
 - 5. Fuel panel
 - 6. Ice protection panel
 - 7. Transponder

717 Flight Crew Training Manual

System Display

SDs are provided as a means of assisting the flight crew in rapidly understanding the status of the aircraft systems. However, crews should not rely solely on the displays for determining aircraft status. The flight crew is encouraged to select a display any time they feel it is the most efficient way to get desired information. SDs should only be used as necessary to get the desired information. The clarity and simplicity of displayed information enables the flight crew to obtain necessary information from a brief scan.

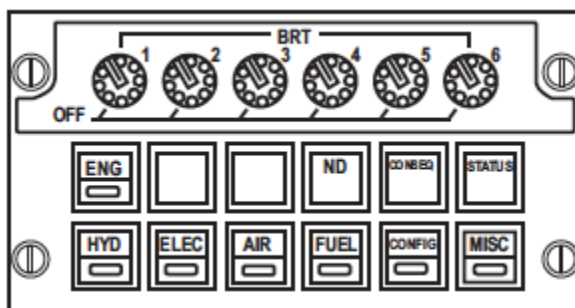
In addition, the SDs are an integral part of the 717 EIS Alerting System. The primary method of resetting the alerting system is to push the associated cue switch on the SDCP. This action will reset the MASTER WARNING or MASTER CAUTION light and display the appropriate synoptic on the system display.

Note: In the event of an engine fire warning, the SDCP ENG cue switch may be pushed, the red MASTER WARNING light may be pushed, or the associated fire handle pulled to silence the aural warning.

Note: If the MASTER WARNING light is reset by pressing the light itself (not by selecting the SDCP cue), the red alert message on the EAD and associated cue light will remain illuminated until the cue light can be selected to show the respective SD.

The QRH may direct the selection of certain SD pages to obtain information for Non-normal checklists.

Systems Display Control Panel



Flight Mode Annunciator

The Flight Mode Annunciator (FMA) is located at the top of the PFD. It displays current and armed flight modes for airspeed, roll and altitude. Familiarity with the FMA is key to understanding how the Flight Control Computers (FCCs) are controlling the airplane. FMA indications are discussed extensively in the FCTM. FMA information is displayed in both white and magenta. Identifying the color of a word or number on the FMA is critical to fully understanding its significance. Words indicate control modes, numbers indicate target values.



The window to the left is the speed window. It displays target speed and the speed control mode. The two primary control modes are PITCH and THRUST. PITCH (speed on pitch) indicates that the autopilot is controlling aircraft pitch to maintain target airspeed. THRUST (speed on thrust) indicates that the autothrottle is controlling engine thrust to maintain target airspeed. Refer to Vol. 2, 4.10, Flight Mode Annunciator.

A magenta speed control mode (i.e., PITCH, etc) indicates that FMS Speed mode is active; a white mode indicates that FCP Speed Select mode is active.

When operating in FMS Speed:

- Magenta speed values (i.e., numbers) indicate that the FMS target speed (ECON, MAX or EDIT) is +/- 4 knots of the FMS ECON speed.
- White speed values indicate that the FMS target speed is greater than +/- 4 knots of the FMS ECON speed.

717 Flight Crew Training Manual

When operating in FCP Speed Select:

- Magenta speed values indicate that the FCP selected speed is within +/- 4 knots of the active (large font) FMS speed mode (ECON, MAX, EDIT).
- White speed values indicate that the FCP selected speed is greater than +/- 4 knots of the active (large font) FMS speed mode (ECON, MAX, EDIT).

Note: The FMS uses the active FMS speed mode (large font) in its calculations. If you are operating in PROF and FCP Speed Select, the FMS will still use the active FMS speed to make its calculations. If your FCP Speed Selected airspeed differs substantially from the active FMS speed, this may result in path deviations.

Note: If operating with autothrottles or autopilot off, the ATS OFF and AP OFF boxes on the FMA shift positions. If operating in speed on THRUST mode the ATS OFF box will be in the airspeed window. During speed on PITCH mode the ATS OFF box moves to the altitude window.

The center window is the roll window. It displays the roll control mode (e.g., HEADING, NAV, LOC) and autopilot status. Armed roll modes (e.g., NAV ARMED) are displayed in smaller font in the upper part of the roll window. If the roll control mode (i.e., NAV) is displayed in magenta, it is FMC controlled. If displayed in white (i.e., HEADING), it is FCP controlled.

The window to the right is the altitude window. It displays target altitude and altitude control mode. Armed altitude modes are displayed in smaller font in the upper part of the altitude window.

A magenta altitude control mode (i.e., HOLD, V/S, etc) indicates that PROF mode is active. If the mode is displayed in white, an FCP mode is active. A magenta altitude value (i.e., number) indicates that the FCP altitude window selection is identical to the FMC defined value (e.g., Cruise altitude, programmed SID/APCH constraint). A white altitude value indicates that the FCP altitude window selection differs from the FMC defined target value.

Maneuver Speeds and Margins

Minimum Flap/Slat Retraction Speeds

The minimum flap/slat retraction speeds are calculated by the FMS and displayed on the PFD speed tape as an amber FR and SR. Flaps and slats should not be retracted prior to reaching their FMS calculated minimum retraction speeds, as indicated by the FR/SR airspeed tape markers changing from amber to green. These speeds are also displayed on the FMS TAKEOFF page just to the right of the V speeds as VFR, VSR/V3, and VCL (climb speed).



Maximum Flap/Slat Extension Speeds

Maximum flap/slat extension speeds are:

Configuration	Speed
Slats	280 KIAS / .57 M
Flaps 0-10	280 KIAS / .57 M
Flaps 11-20	240 KIAS / .57 M
Flaps 25	220 KIAS / .57 M
Flaps 40	200 KIAS / .57 M

717 Flight Crew Training Manual

These speeds can be found on a placard just outboard of each PFD. In addition, these maximum flap speeds are indicated on the PFD speed tape in green as SE, FE, F18, F25, F40.

Note: F13 is not depicted on the speed tape. Max flap speed for F13 and F18 is 240 knots.

These are maximum speeds. The minimum maneuver speed for the existing flap/slat configuration is VMIN. Normally, flaps/slats should be extended when slowing to maintain airspeed less than VMIN. The intent is to maintain as clean a wing as is possible prior to configuring for landing during the approach. The CLEAN MIN, SLAT EXT MIN, and FLAP 18 MIN speeds displayed on the FMS APPROACH page are the same as the VMIN speed (foot) displayed on the PFD speed tape. (See graphic below.)



Note: Extending speedbrakes will increase VMIN up to 10 knots. If operating at or near VMIN and increased drag is required, extend flaps/slats as necessary or increase speed to a minimum of VMIN + 10 prior to extending speedbrakes. If speedbrakes are extended and the current airspeed is below the new VMIN, the ATS will advance the throttles to the new VMIN + 5.

Minimum Operating Speed (VMIN)

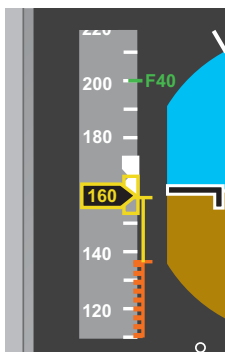
The FMS calculates minimum operating speed (VMIN) based on the existing airplane configuration. VMIN is depicted on the PFD speed tape as the top of the amber band (see below). The top of the amber band is also known as the “foot.” For approaches, VMIN is also VREF.

VMIN is the slowest speed that provides full maneuver capability, 1.3 g’s or 40° of bank (25° angle of bank and 15° overshoot) to stick shaker. As airspeed is decreased below the top of the amber band, maneuver capability decreases. The speed at the bottom of the amber band (top of the red band) corresponds to onset of stick shaker (VSS).

VMIN is not the recommended minimum operating speed. The minimum recommended operating speed is VMIN + 5. This speed (VMIN + 5) is also the lowest selectable airspeed in both FMS and speed select modes.

Note: Stick shaker is set to activate before actual stall. There is sufficient margin to recover from stick shaker without stalling.

Speed Tape Depiction of Flight at VMIN



717 Flight Crew Training Manual

Maximum Operating Speed (VMAX)

The FMS also calculates maximum operating speed (VMAX). VMAX is depicted on the PFD speed tape as the bottom of the upper amber band.

VMAX is the highest speed that provides full maneuver capability to high speed buffet. Full maneuver capability is defined as 1.3 g's or 40° of bank (25° angle of bank plus 15° overshoot) As airspeed is increased above the top of the amber band, maneuver capability decreases.

At altitudes below approximately 28,000 VMAX exceeds VMO and is not depicted on the speed tape. As the aircraft climbs above 28,000, VMAX (upper amber band) begins to extend below the VMO band.

VMAX is not the recommended maximum operating speed. The maximum recommended operating speed is VMAX - 5. This speed (VMAX - 5) is also the highest selectable airspeed in both FMS and speed select modes. ATS speed protection will prevent the aircraft from flying faster than VMAX - 5.

Note: FMS Cruise speed may be adjusted to greater than VMAX via edit or increasing cost index. This new speed will be displayed in the FMS PERF page, but the ATS will limit the aircraft speed to VMAX - 5.

Automatic Bank Angle Limits

The FMS also calculates the bank angle limits that are displayed on the PFD. The active bank angle limit varies with selected modes and aircraft conditions. The bank angle limits are displayed below as a white arc at the top of the ADI with a vertical line extending downward on each side of the arc at the calculated bank angle limit.

Bank Angle Limits



Command Speed

Command speed may be set by the pilot through the FCP or FMS and is displayed by a magenta ball (FMS) or white bow tie (speed select mode) on the PFD speed tape. When armed the magenta ball and white bow tie will be outlined. When selected, the magenta ball or white bow tie will be solid. If the commanded speed is outside the PFD speed tape display range, a digital indication of the commanded airspeed (white bow tie or magenta ball) appears at the top or bottom of the airspeed display as appropriate. In addition, the command speed will be displayed in magenta or white in the speed window of the FMA.

Takeoff

During the takeoff roll the command speed is V2 (solid white bow tie). The FCP selected airspeed (normally 250 knots) is displayed above the speed tape adjacent to a white shadow bow tie. As the aircraft accelerates through V2 the bow tie moves and then stops at V2 +10. If PROF is selected, FMS speed mode engages at 400 feet AGL and the white bow tie transitions to a magenta ball. When the aircraft reaches the thrust reduction and acceleration altitude, the FMS automatically transitions to the CLIMB phase of flight and the magenta ball advances to VCL (normally 250 knots).

Note: If takeoff flaps are greater than 10°, VCL will be 230 knots until the flaps are retracted.

If PROF is not armed for takeoff, Level Change must be selected at thrust reduction altitude to force the FMS into the CLIMB phase and reduce thrust to CLB THRUST. The command speed of V2+10 will remain active until FMS speed mode is selected or the airspeed is adjusted with speed select.

Note: If the flaps are not retracted as airspeed increases the solid white bow tie may turn solid amber indicating a potential overspeed.

Climb, Cruise and Descent

The FMS changes the climb 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. Command speed may be edited via the FMS or changed via the speed window on the FCP. To prevent overspeeds, crews may need to adjust the IAS/MACH or Cost Index to maintain an appropriate buffer from VMO/MMO and flap placard speeds.

Note: FMS speed edits made on the PERF CLB page will propagate to the PERF CRZ page. FMS speed edits made on the PERF CRZ page will NOT propagate to the PERF DES page.

Approach

If operating in FMS speed with ECON speed selected, the FMS approach speeds will step down from 245 knots to the VAPP speed. The first deceleration is to clean minimum speed $V_{MIN} + 20$ knots. On the PFD speed tape, the solid magenta speed target drops to that speed. Subsequently, as flaps are extended, the solid target drops to minimum speed $V_{MIN} + 20$ knots at flap angles less than 18 degrees. If the configuration is not changed, an open magenta ball is displayed at the minimum speed foot indicating that flaps or slats are needed to reduce to the ECON speed. With 18 degrees of flaps or greater, the target drops to $V_{MIN} + 5$ knots for the remainder of the approach.

Note: The $V_{MIN} + 20$ speeds calculated by the FMS will be displayed as magenta speed targets but are not min maneuvering speeds. The foot (V_{MIN}) is the minimum maneuvering speed for all flap/slat configurations.

Note: FMS calculated approach speeds will be displayed on the speed tape and the TO/APPR page. The last active FMS speed (ECON or EDIT) will be displayed on the PERF DES page.

During the approach, a full range of speed edits are available. If an FMS speed edit is used, the solid magenta speed ball is displayed at the selected edit speed and an open ball is displayed at the appropriate ECON speed. If using the ECON speed ($V_{MIN} + 20$ or VAPP), the solid magenta speed ball is displayed at the ECON speed on the speed tape. Additionally, speed select may be used to select command speed. This will be indicated by a solid white bow tie.

Note: While maneuvering prior to final approach it is recommended that speed and altitude be managed manually with speed select and level change on the FCP. FMS speed is normally used on final approach.

Landing

When using the autothrottles, position command speed to VAPP (VREF + 5). This can be accomplished either by selecting FMS speed or via speed select. Sufficient wind and gust protection is available with the autothrottles connected.

If the autothrottles are disconnected, or are planned to be disconnected prior to landing, the recommended method for approach speed correction is to add one half of the reported steady headwind component plus the full gust increment above the steady wind to the reference speed. The minimum command speed setting is VREF + 5 knots. One half of the reported steady headwind component can be estimated by using 50% for a direct headwind, 35% for a 45° crosswind, zero for a direct crosswind and interpolation in between. When making adjustments for wind additives, the maximum command speed should not exceed VREF + 20 knots. The following table shows examples of wind additives with a runway heading of 360°. In all cases, the gust correction should be maintained to touchdown while the steady headwind correction may be bled off as the airplane initiates the landing flare.

Reported Winds	Wind Additive	Approach Speed
360 at 16	8	VREF + 8 knots
Calm	0	VREF + 5 knots
360 at 20 Gust 30	10 + 10	VREF + 20 knots
060 at 24	6	VREF + 6 knots
090 at 15	0	VREF + 5 knots
090 at 15 Gust 25	0 + 10	VREF + 10 knots

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 VREF speed that also includes a speed additive such as $V_{REF} + 20$. When V_{REF} has been adjusted by a NNC, this becomes the VREF used for landing. This VREF does not include wind additives. For example, if a non-normal checklist specifies “Use flaps 40 and $V_{REF} + 20$ for landing,” the flight crew would select flaps 40 as the landing flaps and look up the VREF speed in the FMS or ODM and add 20 knots to that speed.

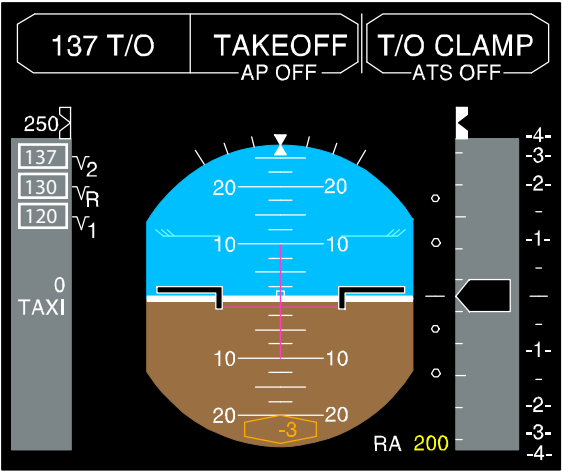
When using the autothrottles to touchdown, VAPP is NNC adjusted $V_{REF} + 5$ knots. Sufficient wind and gust protection is available with the autothrottles engaged that no further wind additives are needed.

If the autothrottles are disconnected, or are planned to be disconnected prior to landing, appropriate wind additives must be added to the NNC adjusted VREF to arrive at command speed, the speed used to fly the approach. For example, if the checklist states “use $V_{REF} + 20$ knots,” command speed should be positioned to $V_{REF} + 20$ plus wind additive (5 knots minimum, 20 knots maximum).

Reference Speeds

Takeoff

V speeds (V_1 , V_R , and V_2) are calculated by the FMS. If selected, they will appear on the PFD speed tape in magenta. However, Delta WDR V speeds take precedence and should be uplinked and inserted or manually entered into the FMS.



Note: When Delta WDR V-speeds are either uplinked and inserted or manually entered into the MCDU, they will appear in white on the PFD speed tape.

Approach and Landing

VREF (VMIN) and VAPP are calculated by the FMS. VREF cannot be changed by the pilot. VAPP is normally computed as VREF + 5 knots and can be changed by the pilot on the FMS TO/APPR page.

717 Flight Crew Training Manual

FMS Inoperative Reference Speeds

With FMS inoperative, foot (VMIN) unreliable, or FMS calculated speeds unreliable, use the Landing Reference Speeds, VREF table located in the ODM. Additionally, the following chart provides fixed speeds for operating without FMS calculated speeds.

Configuration	Speed
Clean	210
Slats	190
Flaps 13	160
Flaps 18	160

Thrust Management**Setting Thrust**

The term “set thrust” or “verify that thrust is set” is used in various places in the FCTM and the Vol. 1. The proper thrust setting is determined by the EPR indication. However, when setting or verifying the proper thrust is set, the flight crew's attention should not be focused on setting the exact indication at the expense of crosschecking that other engine indications are consistent with the EPR indication and maintaining situational awareness.

Maximum Thrust

The term “maximum thrust” is used in various places in the FCTM and the Vol. 1. Maximum thrust is obtained:

- By advancing the throttles fully forward to the maximum forward throttle (N1 mode) gate.

Note: If additional thrust is required the throttles may be advanced through the maximum forward throttle (N1 mode) gate to obtain “emergency thrust.”

Note: Advancing the throttles to emergency thrust should only be considered if terrain contact is imminent.

- When operating in N1 mode by advancing the throttles to the full rated takeoff or go-around limit by reference to the N1 and TGT display.

Note: Movement of the throttles beyond the maximum forward throttle (N1 mode) gate or selection of the FADEC MODE switches to ALTN commands the EEC to the alternate/N1 mode of thrust control. EPR will continue to be displayed, however, thrust management or throttle response will be based on N1 (not EPR).

Note: When operating in the N1 mode, the autothrottles will be inoperative.

Note: This definition of maximum thrust applies to all situations except when a fixed derate takeoff is accomplished. The fixed derate is considered a limitation for takeoff. Refer to chapter 3, Reduced Thrust Takeoff for further explanation of thrust limitations during a fixed derate takeoff.

Autothrottle Speed Protection

CAUTION: **ATS low speed protection may force a departure from altitude. ATS Protection will attempt to correct for under speed by adjusting thrust to the limits. If this does not suffice, then it will adjust pitch to maintain airspeed on or above the red foot. The aircraft will descend if airspeed reduces to the red foot (VSS).**

The ATS will always maintain airplane speed above stall speed and below maximum speed (VMO) for any configuration. If the ATS is off, it will automatically engage to provide speed protection.

The lowest selectable airspeed and recommended minimum airspeed is $VMIN + 5$.

The FMS will not command speeds less than $VMIN + 5$. With the ATS engaged, the FMS will prevent a speed below $VMIN + 5$ from being flown. If operating in speed select mode (ATS engaged) and a speed below $VMIN + 5$ is selected:

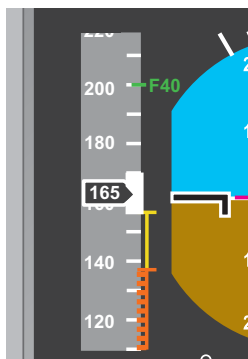
- The solid white bow tie will remain at $VMIN + 5$
- An amber bow tie outline will appear on the speed tape at the selected airspeed
- The ATS will maintain speed at $VMIN + 5$.

When a speed below VSS is selected, the amber bow tie will become solid red and appear at the selected airspeed. The ATS will not allow airspeed to decrease below $VMIN + 5$.

It is possible, with the ATS disengaged, to fly below $VMIN + 5$. This is not recommended. If the aircraft approaches VSS with the ATS disengaged, The ATS will automatically engage and advance the throttles to maintain $VMIN$.

717 Flight Crew Training Manual

Speed Tape Depiction of Flight at Lowest Selectable Airspeed



If selected speed is set higher than VMO, the white bug stops at VMO - 5 and a red reference bug will be depicted adjacent to the selected speed.

If selected speed is higher than the maximum flap/slat/gear extension speed, the white bug adjacent to the selected overspeed turns amber and the ATS will prevent the actual airspeed from exceeding the existing configuration speed limit.

Note: The ATS does not provide overspeed protection if descending in V/S. If descending in PROF or level change with throttles at idle the AFS will adjust pitch to maintain VMO - 5.

Flight Path Vector

The Flight Path Vector (FPV) displays Flight Path Angle (FPA) relative to the horizon line and drift angle relative to the center of the pitch scale on the attitude display. This indication uses inertial and barometric altitude inputs. The vertical flight path angle displayed by the FPV should be considered unreliable with unreliable primary altitude displays. The FPV can be used by the pilot in several ways:

- 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 crosscheck of the vertical flight path angle when established in a climb, descent, or on a visual final approach segment;

Note: When on final approach, the FPV does not indicate aircraft glide path relative to the runway. ILS glide slope, VASI/PAPI, or other means must be used for a proper glide path indication.

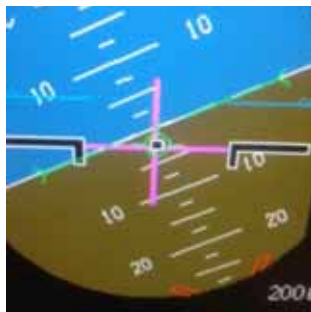
- In climbs or descents, radar tilt can be adjusted to an appropriate elevation based on the displayed FPA. Radar tilt, like the FPV, is referenced to the horizon. Example: Adjusting the radar tilt to the same angle relative to the horizon as the FPV during climb results in the radar beam centered on the existing flight path;
- As a qualitative indication of aircraft lateral drift direction if the map is not available. The FPV moves left or right of the pitch scale to indicate the relative position of the ground track to the present heading;
- As a cross-reference, when flying visual traffic patterns. On the downwind leg, the flight crew should position the FPV on the horizon line, in order to maintain level flight;
- On final approach it provides a trajectory that quickly indicates a downburst. In addition, the position of the FPV in relation to the aircraft symbol provides an indication of the wind direction; or
- As a reference by the pilot in maintaining proper flight path control with unreliable airspeed indications. Adjust pitch to establish desired flight path by placing the FPV just above, below, or on the horizon line.

Note: The FPV should not be used in reference to the PLI, which is a pitch attitude referenced display.

Flight Path Angle is selected by pressing the V/S - FPA select button on the FCP. When Flight Path Angle is selected “FPA” is displayed in the adjacent window alongside the FPA value and the Flight Path Vector is displayed as a green circle on both the Captains and First Officers PFD. When a descent or climb FPA is selected with the thumb wheel a green horizon reference appears on both PFD's. The green horizon reference depicts the selected FPA relative to the FPV.

In the example below, the aircraft is in a descending 2.5 FPA turn and the green horizon is co-located with the ADI horizon. The FPV is 2.5° below the green horizon.

Descending 2.5° FPA Turn



Recommended Rudder Trim Technique

This section describes two techniques for properly trimming the rudder. It is assumed that the aircraft is properly rigged and in normal cruise. The primary technique uses rudder trim only to level the control wheel and is an acceptable and effective method for trimming the aircraft. It is approximately equal to a minimum drag condition. This technique is usable for normal as well as many non-normal conditions. For some non-normal conditions, such as engine failure, this technique is the preferred method and provides near minimum drag.

The alternate technique may provide a more accurate trim condition when the roll is caused by a roll imbalance. In addition, this technique outlines the steps to be taken if the primary trim technique results in an unacceptable bank angle or excessive rudder trim. The alternate technique uses both rudder and aileron trim to neutralize a rolling condition using the bank pointer as reference.

Note: Large trim requirements may indicate the need for maintenance and should be noted in the aircraft logbook.

Drag Factors Due to Trim Technique

If the control wheel is displaced to the point of spoiler deflection a significant increase in aerodynamic drag results. Additionally, any rigging deviation that results in early spoiler actuation causes a significant increase in drag per unit of trim. These conditions result in increased fuel consumption. Small out-of-trim conditions affect fuel flow by less than 1%, if no spoilers are deflected.

Note: Aileron trim may be required for significant fuel imbalance, aircraft damage, or flight control system malfunctions.

Primary Rudder Trim Technique

It is recommended that the autopilot remain engaged while accomplishing the primary rudder trim technique (using rudder trim only). After completing this technique, if the autopilot is disengaged, the aircraft should maintain a constant heading.

The following steps define the primary rudder trim technique:

- Set symmetrical thrust
- Balance fuel if required

- Ensure the autopilot is engaged in HEADING HOLD or NAV and stabilized for at least 30 seconds
- Trim the rudder in the direction corresponding to the down (low) side of the control wheel until the control wheel indicates level. The indices on side of the control wheel should be used to ensure a level wheel condition. The aircraft is properly trimmed when the control wheel is level, (zero index). As speed, gross weight, or altitude change, trim requirements may also change. In a proper trim condition, there may be a slight forward slip (slight bank angle indicated on the bank pointer) and a slight deflection of the slip/skid indicator, which is acceptable.

Alternate Rudder Trim Technique

The alternate rudder trim technique is used if the primary trim technique results in an unacceptable bank angle, excessive rudder trim, or if a more accurate dual axes trim is required.

The following steps define the alternate rudder trim technique:

- Set symmetrical thrust
- Balance fuel if required
- Verify rudder trim is zero
- Ensure the autopilot is engaged in HEADING HOLD or NAV and stabilized for at least 30 seconds
- Trim the rudder in the direction corresponding to the down (low) side of the control wheel until the bank indicates level (no bank angle indicated on the bank pointer). Apply rudder trim incrementally, allowing the bank to stabilize after each trim input. Large trim inputs are more difficult to coordinate. The aircraft is properly trimmed when the bank angle on the bank pointer indicates zero. If the aircraft is properly rigged, the control wheel should indicate approximately level. The resultant control wheel condition indicates the true aileron (roll) trim of the aircraft being used by the autopilot.

After completing the alternate rudder trim technique, if the autopilot is disengaged the aircraft may have a rolling tendency. Hold the wings level using the bank pointer as reference. Trim out any control wheel forces using the aileron trim switches. If properly trimmed, the aircraft holds a constant heading and the aileron trim reading on the wheel/column agrees with what was seen while the autopilot was engaged. Aileron trim inputs require additional time and should be accomplished prior to final approach.

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.

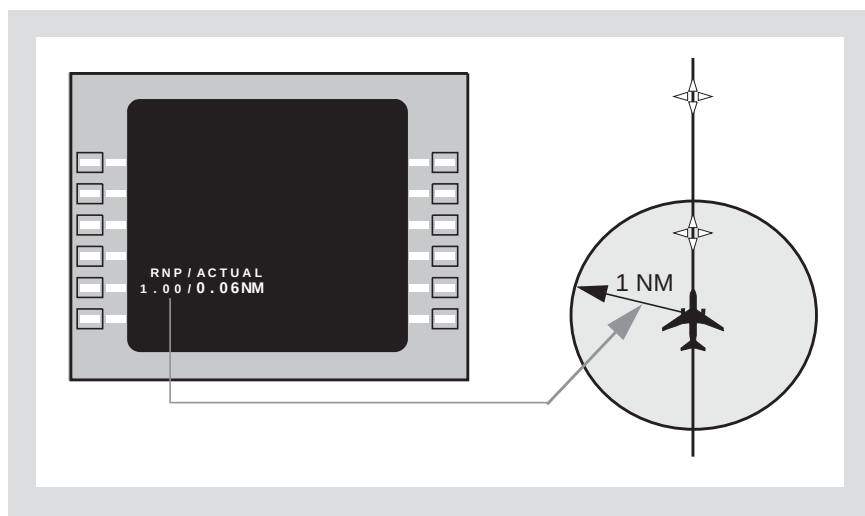
717 Flight Crew Training Manual

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

All FMSs are capable of performing RNAV operations. Regarding navigation accuracy, these FMSs differ only by demonstrated RNP capabilities and the ability to use GPS updating.

RNP and ANP 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.



Domestic en-route RNAV operations depend on the availability of radio updating (DME-DME) sources to support domestic RNP. The following domestic RNP operations are fully supported by any Boeing FMS with DME-DME or GPS updating active:

- USA and Canada - RNP 2.0 or higher, RNAV-1, and RNAV-2.

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

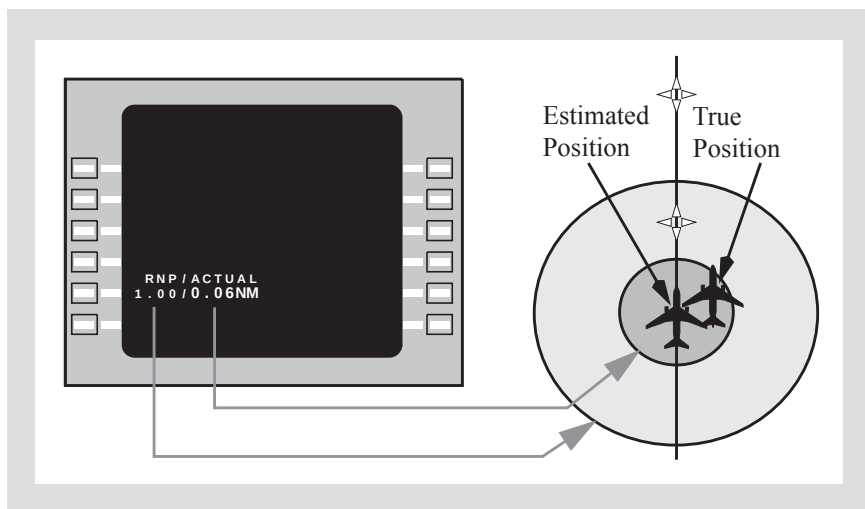
- USA and Canada - RNP 1.0 SIDs and STARs.

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's can be as low as 0.10 NM.

For approaches, all Boeing FMSs have RNP 0.5 capability with DME-DME updating active without GPS updating. See the Approach section of this manual for further details regarding the techniques for flying RNAV approaches.

717 Flight Crew Training Manual

ANP (Actual Navigation Performance) 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 NAV. There is a 95% probability that the aircraft is within the displayed ANP.



Basic RNP Concept

Note: The 717 is not currently authorized to fly RNAV (RNP) AR approaches.

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.

RNAV (RNP) AR (Authorization Required) procedures are RNP approaches that require special aircraft and aircrew authorization.

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).

The FMS calculates, monitors, and displays ANP as described in the Vol. 2. Crews should note that ANP is only related to the accuracy of FMS position.

Navigation Performance Scales (NPS)

During RNP operations other than approach, anytime the deviation exceeds the limit or an amber deviation alert occurs, the crew may have to select a different autopilot roll or pitch mode or manually fly aircraft back on 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 deviation alert occurs the crew should execute a missed approach unless suitable visual reference is already established. In the event of a missed approach, the crew may consider requesting an alternate clearance.

ANP Alerts

When ANP exceeds RNP, a level 1 alert UNABLE RNP message 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 ANP value.

717 Flight Crew Training Manual

If the alert occurs during RNP approach operations, the crew should execute a missed approach unless suitable visual reference is already established. 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 NAV course. Required width is determined by minimum terrain or traffic clearance requirements. The probability of exceeding this maximum deviation while in NAV with the autopilot engaged is very small. These minimum values vary depending on NAV, flight director and autopilot use, and whether GPS is the active source of position updating.

RNP operations require appropriate path tracking consistent with the RNP level. NAV together with the flight director and the autopilot may be required for certain low RNP operations. Use of the autopilot and NAV normally provide the required path tracking accuracy.

Radius-to-Fix (RF) Legs

Note: RF legs are not currently authorized for the 717.

RF legs are waypoints connected by a constant radius course similar to a DME arc. These are shown on terminal procedures as a curved track between two or more waypoints. Some considerations regarding 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 AFDS 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. 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.
- Intercept course to or direct to route modifications delete an RF leg if done to the second waypoint on an RF leg.
- If a go-around is executed while on an RF leg, it is important to immediately re-select NAV (or verify that NAV has re-engaged for aircraft equipped with the TO/GA to NAV feature) to avoid excessive course deviation. The pilot flying must continue to track the NAV course using the map display as a reference until NAV is re-engaged.

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. Maximum and minimum speed protection are among the features that can improve safety while using NAV, PROF, and instrument approaches using PROF 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. 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 the approach, the aircraft will turn outbound in the holding pattern instead of initiating the approach. At this point, the pilot may select HEADING and continue the approach while using other automated features. A second example, if the aircraft levels off unexpectedly during climb or descent with PROF engaged, level change or vertical speed may be selected to continue the climb or descent until the FMS can be reprogrammed.

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. After level off, set the desired altitude in the FCP, select an appropriate pitch mode, and re-engage the autopilot.

717 Flight Crew Training Manual

Recommended Pitch and Roll Modes

If the F-PLN page and map display reflect the proper sequence and altitudes, NAV and PROF are recommended. PROF is most effective when used to meet crossing restriction during arrivals and approaches. Level change idle power descents are preferred when being vectored off established routes for an approach. If NAV is not used, use an appropriate roll mode. When PROF is not used, the following modes are recommended:

- Level change is the preferred mode for altitude changes of 1,000 feet or more. V/S is preferred if the altitude change is less than 1,000 feet.
- If unplanned speed or altitude restrictions are imposed during the arrival, the continued use of PROF may induce an excessive workload. If this occurs, level change is the recommended mode for descent.

FCP Guidelines

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

Autopilot engagement should only be attempted when the aircraft is in trim, F/D commands (if the F/D is on) are essentially satisfied, and the aircraft flight path is under control. The autopilot is not certified or designed to correct a significant out-of-trim condition or to recover the aircraft from an abnormal flight condition and/or unusual attitude.

Autothrottle Use

Autothrottle use is recommended during all phases of flight. When in manual flight, autothrottle use is also recommended, however manual thrust control may be used to maintain pilot proficiency.

The 717 autothrottle system provides low speed and overspeed protection during all modes of operation provided it is functional.

Manual Flight

The PM should make FCP 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 SELECT 170". 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, the flight director should be turned off.



FCP Altitude Setting Techniques Using PROF

When using PROF for published instrument departures, arrivals, and approaches, the following recommendations should avoid unnecessary level-offs while ensuring altitude constraints are met. Once an altitude clearance has been received and read back, the altitude is set in the FCP altitude window, and confirmed. The crew should ensure that PROF or PROF TO is displayed on the FMA.

While climbing with PROF engaged the aircraft will not climb above an AT or an AT or BELOW constraint. While descending in PROF the aircraft will not descend below an AT or an AT or ABOVE constraint. In both climb and descent phases, ATC restrictions, aircraft performance, or environmental conditions can result in the aircraft failing to reach the constraint altitude by the waypoint listed. In that case the FMS will warn the crew with an FMS scratchpad message. Pilots must monitor PROF performance at all times (PERF page or FMS vertical deviation indicator on the ND), and respond promptly to FMS messages to ensure compliance with altitude constraints.

Pilots should fully understand the following:

- The FMS will comply with F-PLN altitude constraints in LARGE FONT. These active constraints also shape the calculated PROF path.
- The selection of a pitch mode other than PROF will result in a risk of violating procedure altitude constraints.

If given a clearance to “Descend Via” or “Climb Via”, the lowest/highest altitude on the procedure is set in the FCP altitude window.

Note: For climbs and descents in pitch modes other than PROF, the FCP altitude must be set at the next altitude constraint.

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.

The crew should consider starting the APU, if available, because it provides quick access to backup electrical power. Refer to the QRH, chapter 3, Severe Turbulence/Heavy Rain Ingestion for more information.

Turbulent Air Penetration

Severe turbulence should be avoided if at all possible. However, if severe turbulence is encountered, use the Severe Turbulence procedure listed in the Vol. 1, SP.16, Turbulence and the QRH, chapter 3, Severe Turbulence/Heavy Rain. Turbulent air penetration speeds provide high/low speed margins in severe turbulent air.

During manual flight, maintain wings level and smoothly control attitude. Use the attitude indicator as the primary instrument. In extreme updrafts or downdrafts, large altitude changes may occur. Do not use sudden or large control inputs. After establishing the trim setting for penetration speed, do not change pitch trim. Allow altitude and airspeed to vary and maintain attitude. However, do not allow the airspeed to decrease and remain below the turbulent air penetration speed because stall/buffet margin is reduced. Maneuver at bank angles below those normally used. Set thrust for penetration speed and avoid large thrust changes. Flap extension in an area of known turbulence should be delayed as long as possible because the aircraft can withstand higher gust loads with the flaps up.

Normally, no changes to cruise altitude or airspeed are required when encountering moderate turbulence. If operating at cruise thrust limits, it may be difficult to maintain cruise speed. If this occurs, select a higher thrust limit (if available) or descend to a lower altitude.

Ice Crystal Icing

The proper use of engine anti-ice will prevent the effects of 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 Ram Air Temperature (RAT) 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:

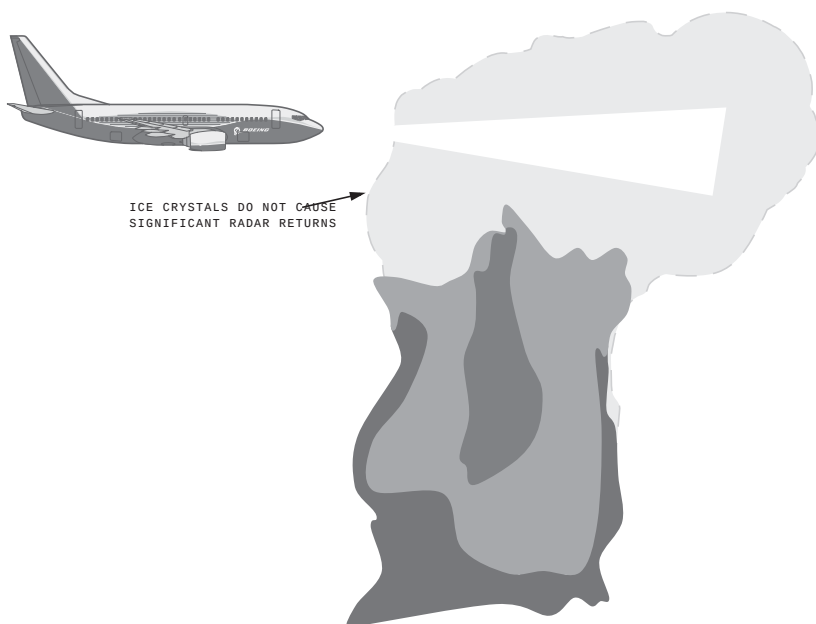
- Appearance of rain on the windshield at temperatures too cold for liquid water to exist. This is due to ice crystals melting on the heated windows (sounds different than rain)
- Airplane TAT indication remains near 0°C due to RAT probe icing
- Areas of light to moderate turbulence
- In IMC with:
 - 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: When flying in these conditions, 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 for anti-icing in flight. Use WING ANTI-ICE when icing is possible.

Ground Operations

Table of Contents

Chapter 2

Section TOC

Preflight	2.1
Flight Planning	2.1
Electrical Power Up	2.1
Preflight Procedure	2.1
FMS Uplinks	2.3
Pushback and Towing	2.4
Engine Start	2.4
Normal	2.4
Anomalies	2.5
Taxi	2.6
Taxi General	2.6
Using Runways as Taxiways	2.9
Thrust Use	2.9
Backing With Reverse Thrust	2.11
Single Engine Taxi	2.11
Taxi Speed and Braking	2.11
Antiskid Inoperative	2.13
Nose Wheel/Rudder Pedal Steering	2.13
Flight Deck Perspective	2.14
Turning Radius and Gear Tracking	2.16
Visual Cues and Techniques for Turning while Taxiing	2.18
Sharp Turns to a Narrow Taxiway	2.23
Taxi - Adverse Weather	2.24
Ground De/Anti-Icing	2.24
Definitions and Concepts	2.24
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
De/Anti-icing Checks	2.35
Communication Procedures	2.38
Holdover Times	2.39
Configuring the Aircraft for De/Anti-icing	2.43

Ground Operations

Chapter 2

Preflight

Flight Planning

The start sequence takes approximately two minutes from starter engagement to stable engine indications. Plan the second engine start so as to allow for the orderly completion of checklists prior to takeoff.

Electrical Power Up

Volume 1 Supplemental Procedures provide detailed information for establishing electrical power on the aircraft during preflight. If external power is not available and electrical power is initially established by starting the APU with battery power, be aware that:

- The initial fire warning test completed prior to APU start is incomplete (no FO MASTER WARNING light and no PODS TEST PASS). The fire warning test must be completed a second time after the APU has been started.
- If the APU is being started or if BATT CHARGING is displayed, the emergency power test will fail (EMER PWR TST FAIL displayed). A battery power APU start draws down the battery and BATT CHARGING may begin immediately after APU start. If the test fails, the emergency power selector should remain in ARM to provide fire detection for the APU. After BATT CHARGING is complete it will be necessary to retest the Emergency Power system.

Preflight Procedure

Flight and Navigation Instruments

CAUTION: Inadvertently selecting the AUTOFLIGHT switch on the FCP anytime after the IRUs are aligned will engage the ATS. If this occurs, the ATS off box in the altitude window of the FMA will be removed and T/O CLAMP will change to T/O THRUST. If the throttles are subsequently advanced beyond 1.2 EPR during taxi, the ATS will advance the throttles to takeoff power. Pilots should verify the ATS is not engaged until required when advancing the throttles for takeoff.

The Autopilot off box will remain amber until V-speeds are confirmed.

The ATS OFF box will remain amber until IRUs are aligned.

A/P NOT AVAIL alert will be displayed 2 minutes after automatic V-speeds are displayed on the FMS TO/APPR page if V2 has not been confirmed. This, along with an amber AP OFF box in the FMA and no pitch command bar on the PFD, are reminders to confirm V-speeds.

The UNABLE RNP message may appear until GPS has had time to enter NAV mode.

Center Tank Fuel Pumps

The center tank fuel pumps will be checked the first flight of the day only if the center tanks contain fuel.

All FUEL PUMP switches will be ON for engine start for all tanks containing fuel, including the center tank pumps. After the center pumps have been turned on, the absence of any fuel system alerts on the EAD is a sufficient check for the center tank pumps.

Aircraft and Equipment Cooling

CAUTION: Ensure that avionics cooling airflow is not interrupted. If the aircraft is to be left unattended with the APU Air in use for any length of time, ensure that at least one pack is selected OFF. This switch logic commands the instrument cooling fan to operate and protects the avionics in the event of an inadvertent APU shutdown. Both packs may be switched ON after the flight deck is manned.

External air is normally the best way to cool the aircraft on the ground. When external air is connected and the packs are off, PACK L/R FLO DISAG EAD messages indicate that the external air is on. External air may be augmented with the gasper booster fan.

The 717 is susceptible to condensation issues in the cabin. Two circumstances that lead to condensation in the cabin are: 1) extended ground use of the APU at very cold settings; and 2) use of the ram air valve. Do not use the ram air valve for cooling.

The gasper booster fan may be used to enhance any cooling airflow on the ground. However, it requires an associated air source (APU, ENG, or external air).

When the APU air switch is ON, the packs operate in HIGH flow.

APU Operations

After starting the APU a two minute warm-up occurs before APU pneumatic air is available. The APU air switch and one of the packs may be turned on prior to completion of the two minute warm-up. The instrument cooling fan will continue to run as long as one pack remains off.

After an unsuccessful start of the APU, do not attempt another start until after the APU information block on the SD ENG display is not displayed. This will provide time for any unburned fuel to drain out of the combustion chamber. Move the MASTER switch to OFF prior to attempting another start.

717 Flight Crew Training Manual

Passenger Address (PA) System

CAUTION: When making PA announcements with the boom mike (or oxygen mask) and the PA button on the ACP, the flight deck speakers will be muted. At least one pilot must be wearing a headset to hear ATC communications during the PA announcement.

There are three methods for making passenger announcements from the flight deck:

- Using the pedestal handset and the PA switchlight on the overhead panel (this method provides the best sound quality and is recommended for most PAs),
- Using the pilot headset boom mike and the PA button on the Audio Control Panel (ACP) (this method is recommended for quick PAs of a routine nature, e.g. "Flight Attendants prepare the cabin for departure."), or
- Using the oxygen mask microphone and the PA button on the ACP.

Potable Water

Head pressure for the potable water system is supplied by aircraft pneumatics. Head pressure is lost whenever the system is serviced or may decrease gradually whenever the pneumatic system is not pressurized (between flights, overnight).

If potable water is not available during preflight, it may be restored by starting the APU and selecting the APU air switch and either pack ON. If water is still not available after pneumatics have been applied, check the potable water service panel to ensure there is water in the tank and the fill switch is OFF.

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, performance initialization data, and takeoff performance data. Data is uplinked to the aircraft through VHF-3 and sent directly to the AOC COMM section of the FMS. Uplinked data is formatted and displayed for flight crew review.

Receipt of uplinked data is indicated by CDU message lights and an MCDU scratchpad message. Once data is received, crews should INSERT the data, which transfers it from the AOC COMM buffer directly into the FMS. Refer to Vol. 1, NP.20, Preflight Procedure - Pilot Flying and Taxi Procedure.

During Preflight, sending the ACARS INIT REQUEST message will initiate the flight plan data (ROUTE, PERF, and WINDS) uplink process. Flight plan uplinks are NOT sent to the ACARS. They are sent directly to the FMS AOC COMM “buffer.” Inserting the uplinks on the AOC COMM page transfers the data from the buffer into the FMS. A similar process occurs during the receipt of the WDR. The WDR message is sent directly to the ACARS, but the takeoff performance uplink data is, again, sent to the FMS AOC COMM buffer, from which it can be inserted into the FMS.

In the event of FMS DATALINK system failure, procedures for manual FMS entries are contained in Volume 1, SP. 11, Flight Management, Navigation.

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
- 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 accomplished with the nose wheel steering bypassed.

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:

- EPR - 1.0
- N1 - 20
- TGT - 400
- N2 - 60
- FF - 600-700
- ENG OIL PRESS - 45.

717 Flight Crew Training Manual

Normal Engine Start Considerations

CAUTION: After engine start, confirm that the fuel switch is latched in the ON position by gently jiggling and pressing down on the switch. Failure to do so could result in an inadvertent engine shutdown.

FOs normally start the engine at the Captain's direction. FOs should not be engaged in other duties during engine start. If necessary, captains may monitor the engine start if the FO needs to accomplish other tasks, i.e. review WDR.

- There is no requirement to check manifold pressure prior to a normal engine start (IGNITION switch in AUTO or ON).
- FO should start the clock after pulling ENG START switch.
- Throttles should be at idle for all engine starts to prevent unintended acceleration.
- The EEC will command a minimum of 30 seconds of dry motor before fuel is commanded to ON.
- Keep hand on engine FUEL switch while observing RPM, TGT, and fuel flow until the engine is stabilized.
- Wait for TGT to peak and the red TGT line to disappear before calling for the After Start / Delayed After Start checklist.
- If fuel is shutoff inadvertently (by moving the FUEL switch to OFF) do not re-select the FUEL switch to ON in an attempt to restart the engine.

Anomalies

CAUTION: If tailwind component is 10 knots or greater, delay moving fuel switch to ON position until there is an indication of increasing N1 rotation. Failure to do so may result in an engine fire.

CAUTION: If tailwind component is greater than 30 knots, the aircraft must be positioned into the wind (+/- 10°). Failure to do so may result in an engine fire.

If a START AIR PRES LO alert is displayed after the ENG START switch has been pulled, confirm the correct position of the Air Control and APU panel switches. If the configuration is correct, closely monitor the start for TGT exceedance and/or a hung start.

Engines may be started with no N1 indication if:

- The start valve has been open for a minimum of one minute and
- The tailwind component is less than 10 knots. Refer to Vol 1, Supplemental Procedures.

If the tailwind component exceeds 10 knots and there is no N1 indication, ground crew verification that the engine is rotating (counter-clockwise as viewed from front of engine) is sufficient to select the FUEL switch to ON and continue engine start. If no N1 is indicated and ground crew are not available (e.g. crossbleed start away from gate), the aircraft must be turned to eliminate the tailwind component prior to engine start.

Note: In many instances, N1 will not be indicated during crossbleed start. If planning a crossbleed start away from the gate, take prevailing winds into consideration.

Taxi

Taxi General

Loss of situational awareness and not following ATC instructions may 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.

Note: Slow speed taxi over an arresting cable prior to takeoff or after landing is considered acceptable. If required, accomplish the Operating Over a Raised Arresting Cable procedure in Vol. 1, SP.14.

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 the correct aircraft position is in the FMS.
- Brief applicable items from airport diagrams and related charts to include the location of hold short lines and hot spots.
- 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.

717 Flight Crew Training Manual**During Taxi**

- Exercise increased awareness when taxiing between parallel runways.
- Reference the heading indicator to assure turns are being made in the correct direction and you 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,
- TOPR the runway with the current winds,
- 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.

Flight Controls

CAUTION: During the control check, the control wheel, column, and rudder pedals must move freely from stop to stop with no binding or sticking. When released, the control wheel and column should return to their neutral positions. This check should provide a smooth full displacement of control wheel, column, and rudder pedal travel. Any evidence of binding during this check requires maintenance action prior to takeoff. Performing a flight controls function check in crosswind or tailwind conditions may result in a column disconnect. If resistance is encountered, move the column slowly with a constant steady force to allow elevator surfaces to respond.

When conducting the flight control check of the elevator, pull back on the yoke first, then push forward. This will minimize inadvertent control column disconnects.

After the flaps have been set for takeoff and the takeoff flap value has been confirmed in the FMS and on both PFDs, differences of up to 2° are acceptable between the PFDs or between either PFD and the SDCP CONFIG page flap values.

717 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.

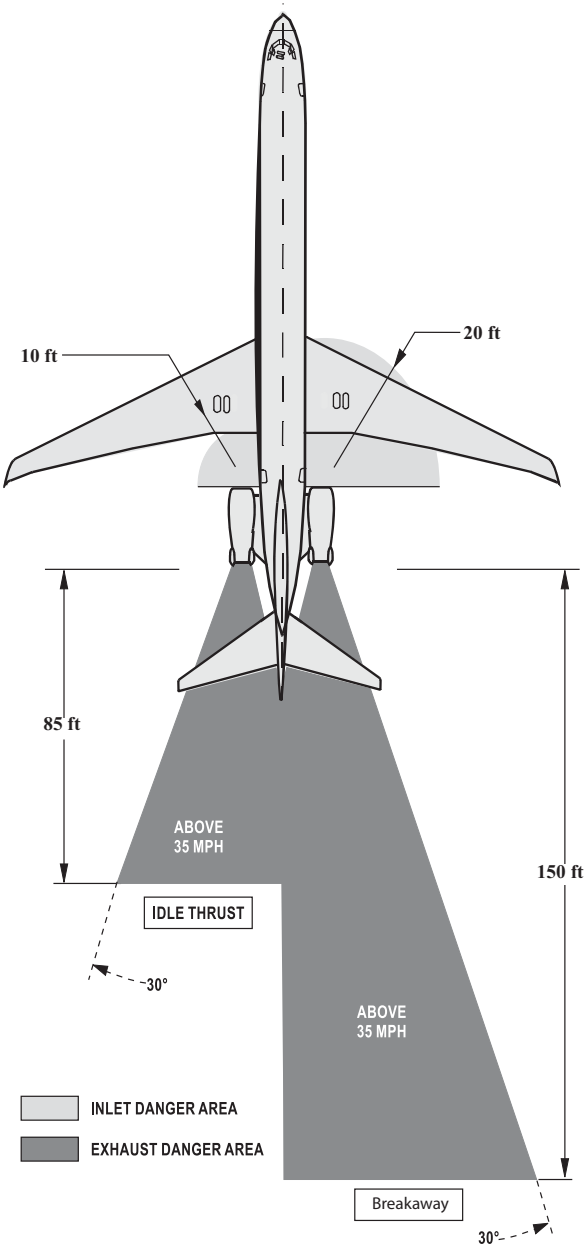
Thrust Use

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 throttle movement is slow, particularly at high gross weights. Engine noise level in the flight deck is low and not indicative of thrust output.

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

717 Flight Crew Training Manual



Backing With Reverse Thrust

Backing with reverse thrust is not recommended and restricted by Delta Operations Specifications. (See FOM chapter 6, Reverse Thrust for further guidance).

Single Engine Taxi

High bypass engines require warm up prior to applying takeoff thrust and cool down prior to shutting down. If the engine has been shutdown for more than two hours, operate the engine for a minimum of three minutes at as low a thrust setting as practical 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 flight instruments may be used to determine actual taxi speed. The appropriate taxi speed depends on turn radius and surface condition.

Note: Some taxi speeds, usually between 10 and 20 knots, can cause an increase in aircraft vibration, especially on rough taxiways. If this occurs, a slight increase or decrease in speed reduces or eliminates the vibration and increases passenger comfort.

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.

During taxi, the momentary use of idle reverse thrust may be needed on slippery surfaces for aircraft control. Use caution as spoilers may deploy if armed. The use of reverse thrust above reverse idle is not recommended due to the possibility of foreign object damage and engine surge. Consider having the aircraft towed rather than relying on the extended use of reverse thrust for aircraft control.

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.

Steel Brakes

Avoid prolonged brake application to control taxi speed as this causes high brake temperatures and increased wear of brakes. Steel brake wear is directly proportional to the kinetic energy absorbed by the brakes. Maximum steel brake life can be achieved during taxi by using a large number of small, light brake applications, allowing some time for brake cooling between applications. High airplane gross weights and high brake application speeds tend to reduce steel brake life because they require the brakes to absorb a large amount of kinetic energy.

717 Flight Crew Training Manual

Brake Temperatures

During preflight, crews should observe and monitor brake temperatures on the SDCP (Config) page. Postflight, the brakes will reach their maximum temperature approximately 10 minutes after block in. Releasing the parking brake at the gate after the wheels are chocked will help lower brake temps.

If brake temperatures exceed 260°C or the BRAKE OVERHEAT message is displayed, a waiting period and a visual inspection of tire inflation is required. Prompt use of brake cooling fans or external cooling air will expedite brake cooling. Refer to ODM, Abnormal section.

Max brake temperature for takeoff charts are located in the ODM, Abnormal section. If brake temperature exceeds 115°C prior to takeoff, the ODM must be reviewed to ensure that brake temperature is within limits.

Crews shall take all necessary action during preflight and taxi to ensure that brake temperatures are within limits for takeoff.

Brakes will also cool from airflow during taxi out. It is not uncommon to see brake temps decrease 20-30°C prior to reaching the runway.

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.

Note: If antiskid is inoperative, dispatch is prohibited for most flights. Refer to the MEL for specific procedures and requirements.

Nose Wheel/Rudder Pedal Steering

The captain's position is equipped with a nose wheel steering wheel. The nose wheel steering wheel 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 wheel 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 with the captain's right heel.

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.

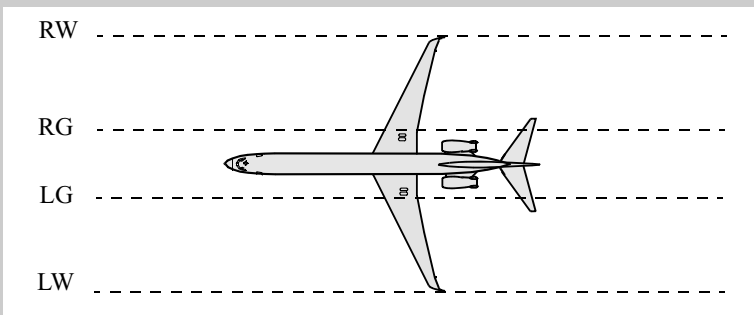
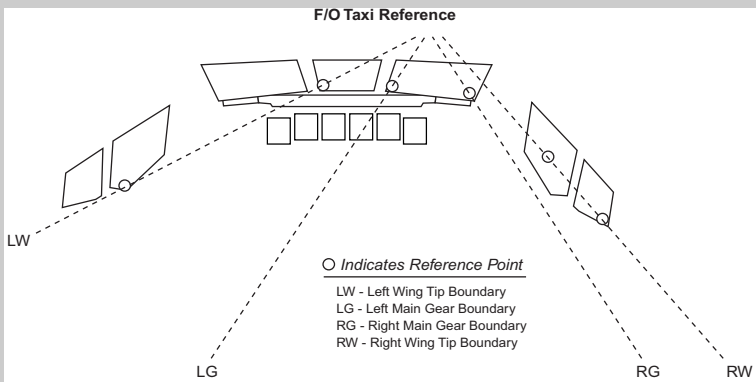
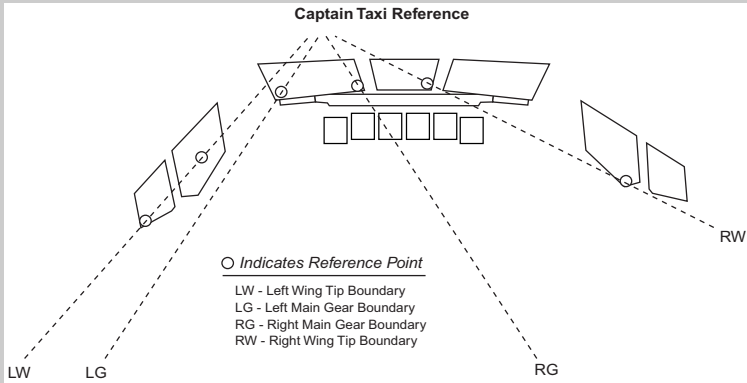
During taxiing, the pilot's heels should be on the floor, sliding the feet up on the rudder pedals only when required to apply brakes to slow the taxi speed, or when maneuvering in close quarters on the parking ramp.

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.

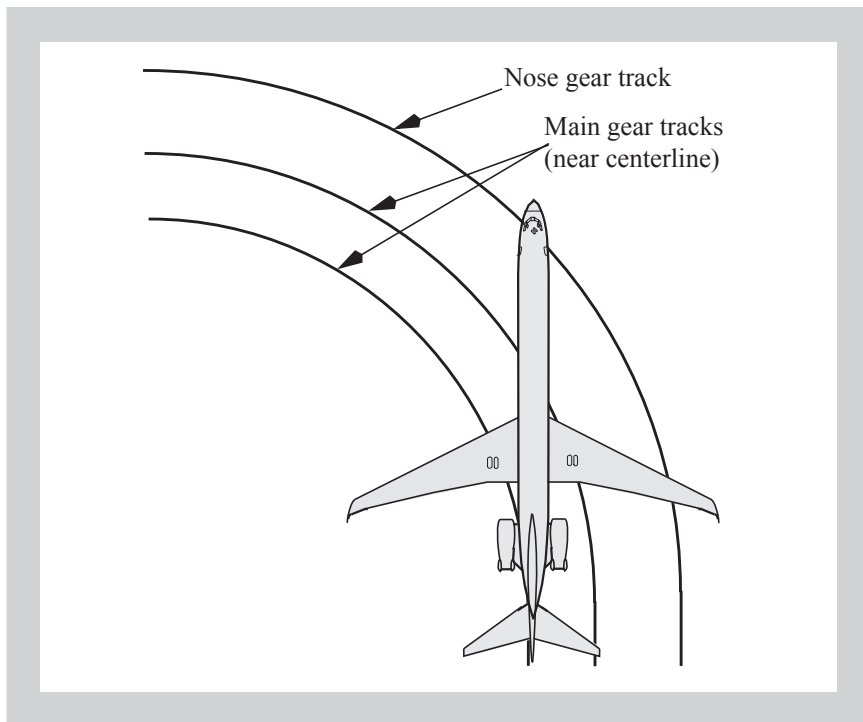
717 Flight Crew Training Manual



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 slightly aft of the nose wheel and forward of the 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).



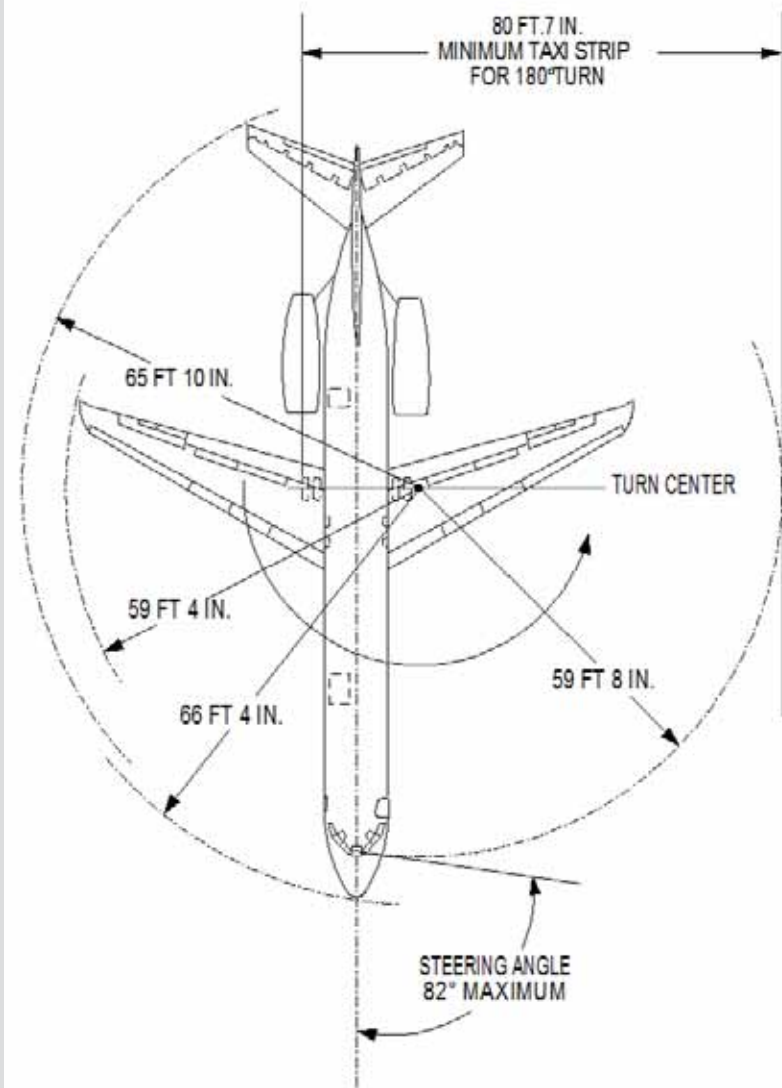
Turning Radius Diagrams

CAUTION: Do not attempt to make a turn away from an obstacle that is within 68 feet of the aircraft.

The following illustration show the minimum turn radius capability. The nose swings the largest arc while turning and determines the minimum obstruction clearance path. All other portions of the aircraft are within this arc. The tail swings a larger arc than the wing tip, therefore, wing tip clearance does not guarantee tail clearance.

Note: Minimum width of pavement for 180° turn is 80 feet 7 inches.

717 Flight Crew Training Manual



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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 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 some distance behind the nose wheels, causing them to track inside the nose wheels during turns. The pilot position forward of the main gear is depicted in the table below.

Model	Pilot Seat Position (forward of main gear feet (meters))
717	56 (17.2)

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

Initiate the turn after overshooting the intersecting taxiway centerline (or intended exit point) and the nose gear is approaching the edge of the taxiway. Initially use approximately full nose gear steering wheel displacement. Adjust the handwheel input as the aircraft turns to keep the nose wheels 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 nose gear steering wheel input as the aircraft lines up with the intersecting taxiway centerline or intended taxi path.

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.

717 Flight Crew Training Manual

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.

Approach the edge of the taxi surface at a shallow angle until the outboard side of the main gear wheels are near the edge.

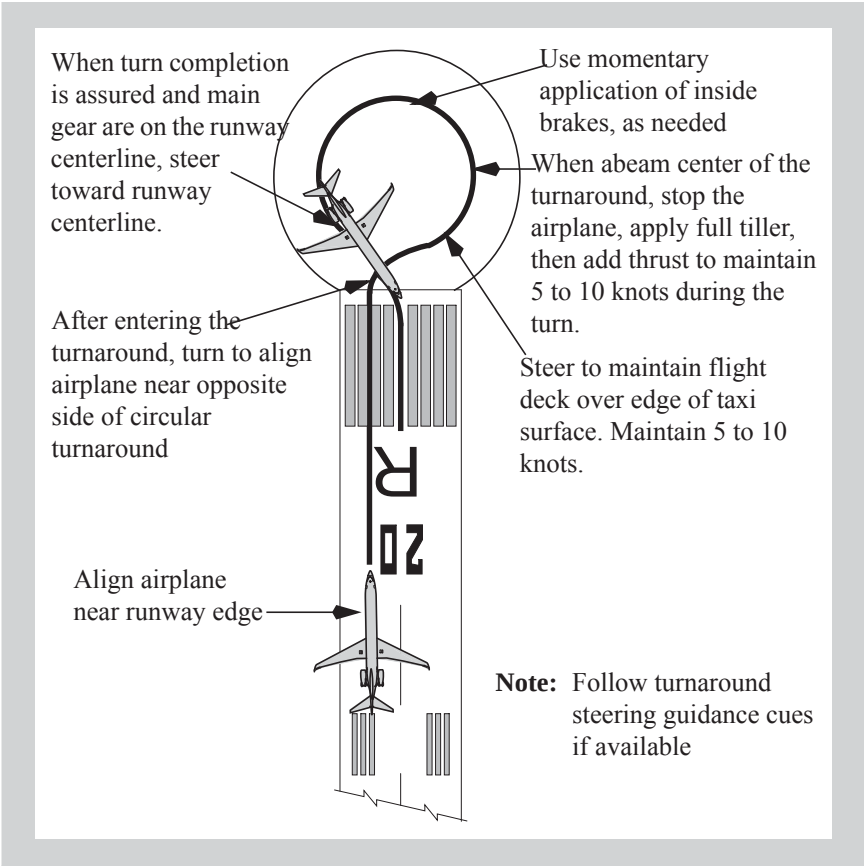
Note: Painted runway markings are slippery when wet and may cause skidding of the nose gear during the turn.

Turning radius can be reduced by following a few specific taxi techniques. Taxi the aircraft so that the main gear tires are close to the runway edge. This provides more runway surface to make the turn. Stop the aircraft completely with the thrust at idle. Hold the nose wheel steering wheel to the maximum steering angle, release the brakes, then add thrust on the outboard engine. Only use the engine on the outboard side of the turn and maintain 5 to 10 knots during the turn to minimize turn radius. Light intermittent braking on the inside main gear helps decrease turn radius. Stopping the aircraft in a turn is not recommended unless required to reduce the turn radius. As the aircraft passes through 90° of turn, steer to place the main gear approximately on the runway centerline, then gradually reduce the nose wheel steering wheel input as required to align the aircraft with the new direction of taxi.

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.

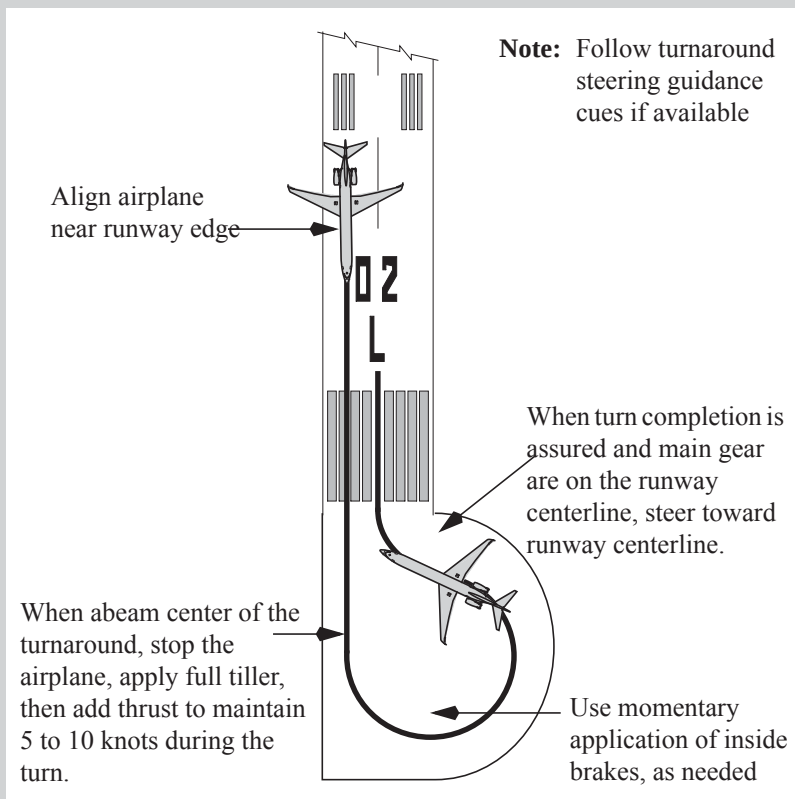
The following diagrams show suggested aircraft ground tracks for minimum radius 180° turns with various runway turnaround configurations. These ground tracks provide the best maneuver capability while providing the maximum runway length available for takeoff at the completion of the turn.

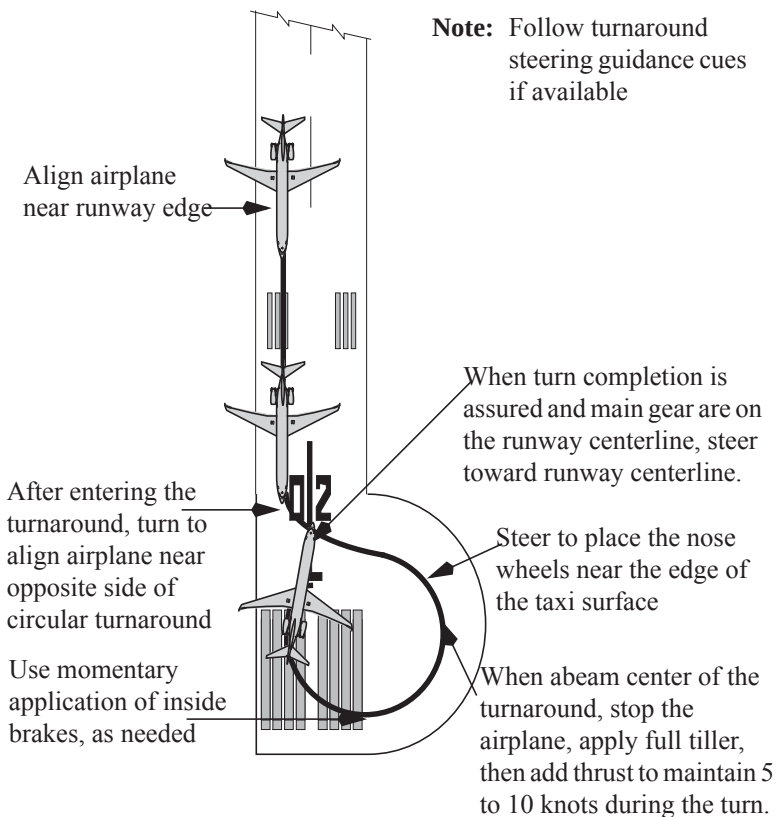
Techniques when using a Circular Turnaround



717 Flight Crew Training Manual

Techniques when using a Hammerhead Turnaround



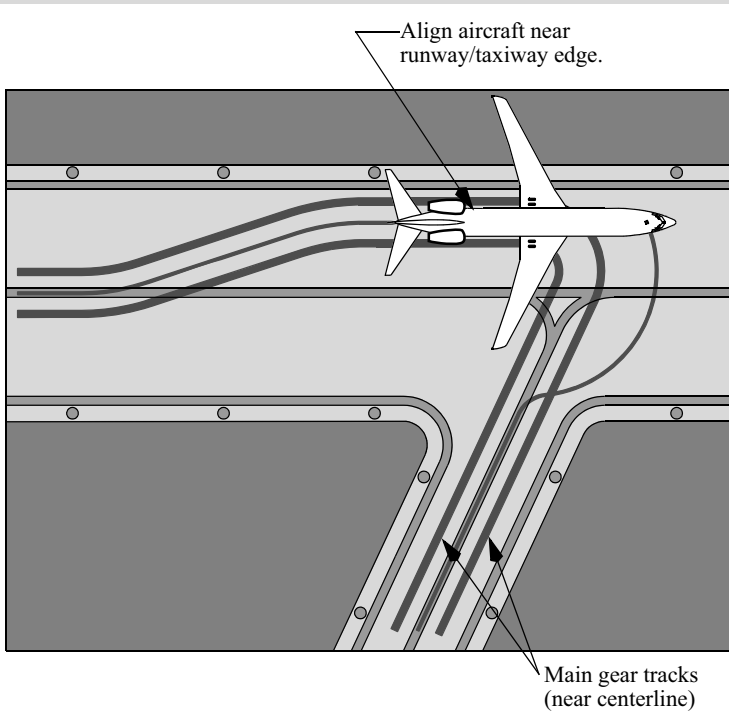
Techniques when using a Hammerhead Turnaround

717 Flight Crew Training Manual

Sharp Turns to a Narrow Taxiway

When making a sharp turn from a runway or a wide taxiway to a very narrow taxiway, consider displacing the aircraft to the far side of the runway or taxiway before initiating the turn. This allows more room for the inboard gear to stay on the taxi surface during the turn, and ensures a more accurate centerline alignment entering the narrow taxiway.

Note: Be aware of wing clearance, engine clearance, and the possibility of FOD ingestion on the side of the aircraft that may be displaced over an unpaved surface.



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, the De/Anti-Icing Guide and the Airway Manual (AM). 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.

717 Flight Crew Training Manual

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
- Radome.

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
- Radome.

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

- Wing area upper surfaces
- Wing leading edges
- Engine inlets.

717 Flight Crew Training Manual

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:

- 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 De/Anti-Icing Guide, AM, Weather, Hazardous Weather, 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.

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.

717 Flight Crew Training Manual

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, Company pages, or noted in the Airport Remarks section of the flight plan.

De/Anti-Icing/Overnight Protection

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

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.

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

717 Flight Crew Training Manual

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 Company pages. 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 or 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.

717 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

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.

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

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 Company 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;



717 Flight Crew Training Manual

-
- 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.

717 Flight Crew Training Manual

External Check (Alternative Pre-Takeoff Contamination Check)

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.

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.

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.

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, Company 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 Company 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.

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.

717 Flight Crew Training Manual

- 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.

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.

717 Flight Crew Training Manual

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	3.2
Rotation and Liftoff - All Engines	3.5
Effect of Rotation Speed and Pitch Rate on Liftoff	3.6
Center-Of-Gravity Effects	3.7
Crosswind Takeoff	3.7
Takeoff Crosswind Guidelines	3.7
Directional Control	3.7
Rotation and Takeoff	3.8
Gusty Wind and Strong Crosswind Conditions	3.8
Reduced Takeoff Thrust (Less Than Full Power)	3.9
Assumed Temperature Method (ATM)	3.9
Derated Takeoff Thrust (Fixed Derate, T/O 1, T/O 2)	3.10
Thrust Control	3.10
Low Visibility Takeoff	3.11
Post De/Anti-Icing Takeoff	3.11
Adverse Runway Conditions	3.11
Takeoff Performance Limit Weights	3.12
Rejected Takeoff Decision	3.13
Rejected Takeoff Maneuver	3.15
Go/Stop Decision Near V1	3.17
Tail Strike	3.18
Takeoff Risk Factors	3.18

Initial Climb - All Engines	3.19
Immediate Turn after Takeoff - All Engines	3.19
Roll Modes	3.20
Pitch Modes	3.21
Autopilot Engagement	3.22
Flap Retraction Schedule	3.22
Normal Takeoff Profile (Distant/ICAO NADP 2)	3.23
Special Takeoff Profile (Close-In/ICAO NADP 1)	3.26
Noise Abatement Takeoff	3.28
 Takeoff - Engine Failure	 3.29
General	3.29
Engine Failure Recognition	3.29
Rotation and Liftoff - One Engine Inoperative	3.30
Initial Climb - One Engine Inoperative	3.31
Immediate Turn after Takeoff - One Engine Inoperative	3.32
Autopilot Engagement - One Engine Inoperative	3.32
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 Takeoff Thrust (Fixed Derate, T/O 1, T/O 2)	3.37

Takeoff and Initial Climb**Chapter 3****Takeoff**

Normal takeoff procedures (NADP 2 profile) satisfy typical noise abatement requirements. Some airports may have special procedures (NADP 1 profile or Company pages) which require modification of the takeoff profile.

Takeoff - General

Review the TAKEOFF page to ensure the entries are correct. Ensure 250 KIAS is set on the FCP. The map display, map range, and F-PLN page sequence should be consistent with the departure procedure.

Ensure that V1, VR and V2 are entered in the FMS and displayed on the PFD speed tape.

NAV (if required) and PROF should be armed on the ground prior to takeoff. Verify NAV ARMED and PROF ARMED in magenta on the FMA.

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.

The PF normally displays the takeoff reference page on the MCDU. Display of the takeoff reference page allows the crew to have immediate access to V-speeds during takeoff in the event that V-speeds are inadvertently removed from the airspeed display. However, to reduce heads down activity, climb constraint modification immediately after takeoff should normally be accomplished on the FCP. Modify the F-PLN page when workload permits. The PM normally displays the DIR INTC page during takeoff and departure to allow timely route modification if necessary.

During RNAV departures the DATA switch should be selected on both the captain's and first officer's ECPs so that crosstrack error may be monitored on the ND in white numbers below the aircraft symbol. If DATA is selected and no numbers are visible, the aircraft is on track.

Initiating Takeoff Roll

Autothrottle and flight director use is recommended for all takeoffs. However, do not follow F/D commands until after liftoff.

Note: When setting takeoff power autothrottles will not engage until the throttles have advanced past the throttle angle which corresponds to approximately 1.2 EPR. Autothrottle engagement is based on throttle position angle not EPR. However, autoflight selection will be based on 1.2 EPR as throttle angle is not easily measured.

Rolling Takeoff

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 nose wheel steering is released and apply takeoff thrust by advancing the throttles to 1.2 EPR (minimum), ensure symmetry as engines spool up, select AUTOFLIGHT and then follow the throttles through ATS application of takeoff thrust.

Note: When selecting AUTOFLIGHT, autothrottle engagement can be confirmed by the removal of the white ATS OFF box on the FMA.

Note: When the thrust exceeds 1.2 EPR the FMA thrust indication changes from T/O CLAMP to T/O THRUST.

Static Takeoff

A static takeoff is accomplished by holding in position on the assigned runway. Ensure the nose wheel steering 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.

Note: During icing conditions, the requirement to do an engine run up prior to takeoff and a standing takeoff may be combined by setting 50% N1 for 10 seconds prior to takeoff.



Standing Takeoff

A standing takeoff is accomplished by holding the brakes until the engines are stabilized at or above 50% N1.

Ensure the nose wheel steering wheel is released, then gently release the brakes and promptly select AUTO FLIGHT and follow the throttles through autothrottle application of takeoff thrust.

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 exact initial setting is not as important as setting symmetrical thrust. If thrust is to be set manually, smoothly advance throttles toward takeoff thrust.

Note: During tailwind conditions, slight EPR fluctuations may occur on some engines before 5 knots forward airspeed.

Note: Allowing the engines to stabilize for more than approximately 2 seconds before advancing throttles to takeoff thrust may adversely affect takeoff distance.

By 60 knots the PM should verify that takeoff thrust has been set and at 80 knots verify CLAMP is engaged and displayed in the FMA. Once CLAMP annunciates, the autothrottle cannot change throttle position, but throttles can be positioned manually. The CLAMP mode remains engaged until another thrust mode is selected.

If PROF is used for takeoff, the T/O CLAMP mode remains engaged until it automatically changes to CLB THRUST at the FMS programmed thrust reduction altitude. If PROF is not used for takeoff, level change must be selected to change the ATS from T/O CLAMP to CLB THRUST.

Note: Takeoff into headwind of 20 knots or greater may result in T/O CLAMP before the autothrottle can make final thrust adjustments. If the throttles clamp prior to takeoff EPR, advance the throttles manually.

Ensure the target EPR is set by 60 knots. Minor increases in thrust may be made immediately after 60 knots to reach the target EPR. After takeoff thrust is set, a small deviation in N1 or EPR between the engines should not warrant a decision to reject the takeoff unless this deviation is accompanied by a more serious event. Due to variations in thrust settings, runway conditions, etc., it is not practical to specify a precise tolerance for EPR differences between the engines.

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

The T/O CLAMP mode protects against throttle movement if a system fault occurs. Lack of the T/O CLAMP annunciation means the protective feature may not be active. If T/O CLAMP annunciation does not appear, no crew action is required unless a subsequent system fault causes unwanted throttle movement. As with any autothrottle malfunction, the autothrusters should then be disconnected and desired thrust set manually.

Light forward pressure is held on the control column. 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 throttles until V1 in order to respond quickly to a rejected takeoff condition. After V1, the captain's hand should be removed from the throttles.

The PM should monitor engine instruments 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 green speed trend line is near the top of the PFD airspeed tape during aircraft acceleration. 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 on the ND. 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.

DELTA
717 Flight Crew Training Manual

Rotation and Liftoff - All Engines

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 WDR or ODM are developed to provide adequate tail clearance.

Above 80 knots, relax the forward control column pressure to the neutral position. At VR, commence a smooth, continuous rotation (approximately 2.5° per second) to attain a speed of $V_2 + 10$ knot, limiting pitch to 20°. Slow or fast rotation will significantly degrade takeoff performance. After liftoff use the flight director as the primary pitch reference, cross checking indicated airspeed and other flight instruments.

Note: As the aircraft accelerates past V_2 , the white bowtie will move to $V_2 + 10$. At 400 feet, PROF (if armed) will engage FMS Speed and the white bowtie will change into a magenta ball.

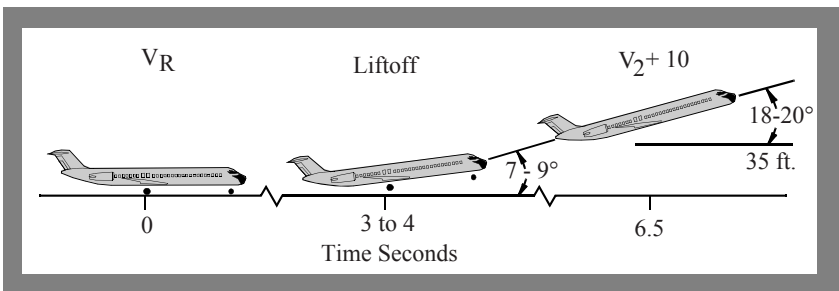
The flight director tends to lag during initial climb. Following the flight director may result in lower than optimum pitch attitudes and airspeeds far in excess of $V_2 + 10$. At light weights, airspeed may still exceed $V_2 + 10$ at 20° pitch. This is acceptable. Do not exceed 20° of pitch.

Note: The flight director pitch command is not used for rotation.

Using the technique above, resultant rotation rates vary from 2° to 3° per second. Liftoff attitude is achieved in approximately 3 to 4 seconds, depending on aircraft weight and thrust setting.

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.

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.

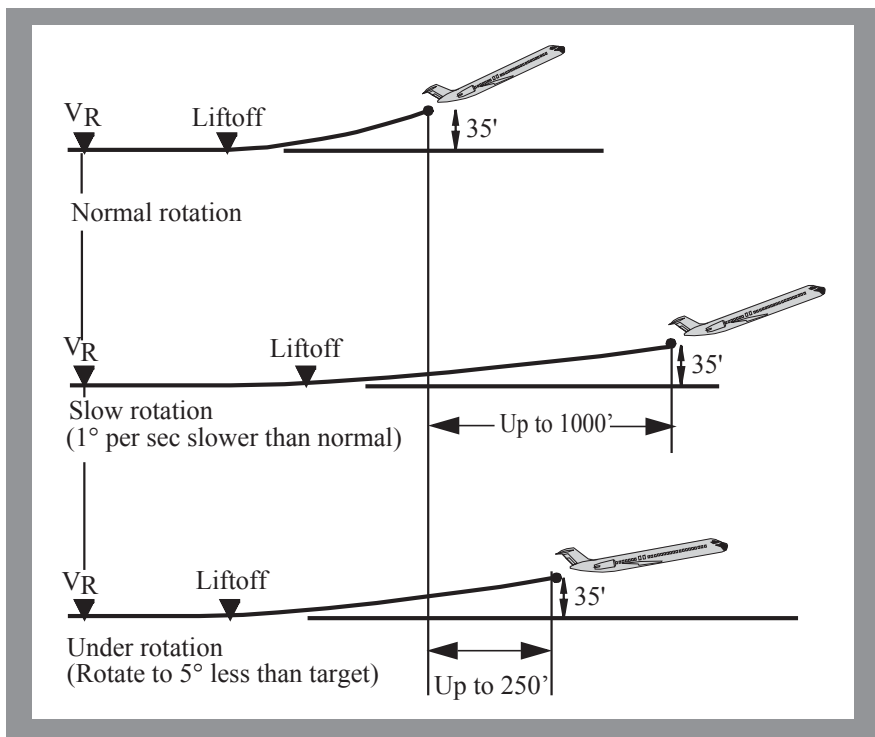
Effect of Rotation Speed and Pitch Rate on Liftoff

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.

An improper rotation can have an effect on the command speed after liftoff. An earlier liftoff does not affect the commanded initial climb speed. However, either case degrades overall takeoff performance.

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. With CG at or near the aft limit, maintain forward pressure on the control column until 80 knots to increase nosewheel steering effectiveness. Above 80 knots, relax the forward control column pressure to the neutral position. 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.

Crosswind Takeoff

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 or static 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 Volume 1, SP.16, Guidelines for Takeoff on Contaminated Runways or Landing with Braking Action Less than Good, Crosswind Guidance.

Directional Control

Initial runway alignment and smooth symmetrical thrust application result in good crosswind control capability during takeoff. Light forward pressure on the control column during the initial phase of the takeoff roll (below approximately 80 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 combined with small control wheel inputs result in a normal takeoff with no overcontrolling. Large control wheel inputs (greater than five degrees of yoke displacement) can have an adverse effect on directional control near VMCG due to the additional drag of the extended spoilers.

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 control wheel approximately centered. Throughout the takeoff roll, gradually increase control wheel displacement into the wind only enough to maintain approximately wings level.

Note: Excessive control wheel 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 control wheel and rudder pedals after liftoff.

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 thrust settings close to or at maximum takeoff thrust. 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 control wheel input to that required to keep the wings level. Use of excessive control wheel 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 control wheel 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 TGT, improves engine reliability, and extends engine life.

Takeoff thrust reduction can be achieved using Assumed Temperature Method (ATM) or derated takeoff thrust (fixed derate). Takeoff with less than full rated takeoff thrust using any of these methods complies with all regulatory takeoff performance requirements. The thrust reduction authorized by most regulatory agencies is limited to 25% below any certified takeoff thrust rating. At any time during takeoff, throttles 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 Company 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
- 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, throttles 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.

Note: For ATM takeoffs, slightly more back pressure may be needed during rotation and initial climb.

Derated Takeoff Thrust (Fixed Derate, T/O 1, T/O 2)

Derated takeoff thrust (fixed derate) is a certified takeoff thrust rating lower than full rated takeoff thrust. In order to use derated takeoff thrust, takeoff performance data for the specific fixed derate level is required. Derated takeoff thrust is obtained by selection of a fixed takeoff derate in the FMS. Derated takeoff thrust T/O 1 represents a 12% derate and T/O 2 represents a 25% derate.

When using derated takeoff thrust, the takeoff thrust setting is considered a takeoff operating limit since minimum control speeds (VMCG and VMCA) and stabilizer trim setting are based on the derated takeoff thrust.

Throttles should not be advanced unless conditions are encountered during the takeoff where additional thrust is needed on both engines, such as a windshear condition. If an engine failure occurs during takeoff, any thrust increase beyond the fixed derate limit could result in loss of directional control.

Note: Derated takeoff thrust (fixed derate) may be used for takeoff on a wet runway and on a runway contaminated with standing water, slush, snow, or ice.

Derated takeoff thrust (fixed derate) may permit a higher takeoff weight when performance is limited by VMCG, such as on a runway contaminated with standing water, slush, snow, or ice. This is because derated takeoff thrust allows a lower VMCG.

Thrust Control

When conducting an ATM takeoff, if more thrust is needed (up to maximum thrust) when thrust is in T/O CLAMP mode, throttles must be advanced manually. 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 the throttles to the maximum forward throttle gate, which is maximum thrust. If additional power is required the throttles may be advanced beyond the maximum forward throttle (N1 mode) gate to the mechanical stop, which is emergency thrust.

Note: Movement of the throttles beyond the maximum forward throttle (N1 mode) gate commands the EEC to the alternate/N1 mode of thrust control. EPR will continue to be displayed, however, thrust management or throttle response will be based on N1 not EPR. Autothrottles will not be available.

Maximum thrust should be sufficient to survive windshear encounters. However, if the airplane performance is such that ground contact is imminent, the throttles should be advanced through the maximum forward throttle (N1 mode) gate to emergency thrust.



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.

Note: Consider APU power for electrical backup.

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

Refer to the Airway Manual, Ops Specs, Takeoff Minima.

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. Takeoff operations with reduced thrust (ATM or fixed derate) are permitted provided takeoff performance accounts for the runway surface condition. 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 and, if required, slight differential thrust.

Forward pressure on the control column during the initial portion of the takeoff roll (below approximately 80 knots) 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.

Note: Climb limit weight (CLW) is shown as CLIMB on the WDR.



717 Flight Crew Training Manual

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 FMS alerting messages informing them that the takeoff speeds have been deleted. 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.

Note: If V-speeds are deleted due to runway changes or other performance changes and takeoff is initiated, the last selected V2 speed will still be displayed next to a magenta ball silhouette on the speed tape.

The takeoff should be rejected for the following:

Event	Prior to 80 knots	80 knots to V1	Above V1
Activation of the Master Caution or Warning	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

Refer to chapter 7, Windshear.

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

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



717 Flight Crew Training Manual

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
- 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.

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

Rejected Takeoff Maneuver Table

Captain	First Officer
Without delay: • Retard throttles to IDLE • Apply maximum wheel brakes • Apply maximum reverse thrust consistent with conditions.	Verify actions as follows: • Ensure throttles to IDLE • Verify maximum wheel brakes applied. • Verify reverse thrust applied
Extend ground spoilers (if not deployed)	Verify SPEED BRAKE lever aft Call “SPOILERS UP” If SPEED BRAKE lever not aft, Call “NO SPOILERS”
Continue maximum braking until certain 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 reverse idle detent by taxi speed.	Call “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. 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.

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.

Tail Strike

Tail strike occurs when the lower aft fuselage or tail skid (as installed) 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.

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.

Trimming during Rotation

The pilot flying may easily lose the feel of the elevator while the trim is running which may result in an excessive rotation rate.

Excessive Rotation Rate

The amount of control input required to achieve the proper rotation rate varies from one aircraft to another. When transitioning to a new aircraft, flight crews may not realize that it does not respond to pitch input in exactly the same way as their previous aircraft.

Improper Use of the Flight Director

The flight director provides accurate pitch guidance only after the airplane is airborne. With the proper rotation rate, the airplane reaches 35 feet with the desired pitch attitude of about 18-20°. However, an aggressive rotation into the pitch bar at takeoff is not appropriate and can cause 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, the flight director commands pitch to maintain an airspeed of $V_2 + 10$ knots until another pitch mode is engaged.

$V_2 + 10$ knots is the optimum climb speed with takeoff flaps. It results in the maximum altitude gain in the shortest distance from takeoff. Acceleration to higher speeds reduces the altitude gain. If airspeed exceeds $V_2 + 10$ knots during the initial climb, stop the acceleration but do not attempt to reduce airspeed to $V_2 + 10$ knots (maximum nose up pitch of 20°). Crosscheck indicated airspeed for proper initial climb speed.

Retract the landing gear after a positive rate of climb is indicated on the altimeter. 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: After takeoff when the heading select knob is pulled, the airplane will turn in the direction indicated by the white dashed lines leading to the heading bug on the outer radius of the expanded compass rose on the ND and PFD. Prior to pulling the heading select knob ensure the direction of the dashed lines comply with the clearance. If necessary, push heading hold and then heading select to reset the direction of turn.

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 AGL) and maintain $V_2 + 10$ knots with takeoff flaps.

Note: The FMS will calculate and display the bank angle limit on the PFD. Maintain airspeed above the top of the minimum maneuver speed amber band (foot) on the PFD speed tape to ensure full maneuver margin capability.

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

NAV

If NAV is required for the departure it may be selected prior to departure. Once selected, a magenta NAV ARMED message will appear in the roll control window of the FMA. NAV cannot be armed until at least one engine is running. At liftoff with NAV ARMED the FMS will initially command runway heading. At 100 feet AGL flight director NAV guidance is available and a magenta NAV1 or NAV2 is displayed in the FMA roll control window. At 400 feet AGL, NAV is fully engaged. If NAV is armed prior to takeoff the autopilot will not engage prior to 400 feet AGL.

Heading

If NAV is not required for the departure a heading may be pre-selected prior to departure. However, the FMS will command actual aircraft heading at liftoff. The FCP heading select knob must be pulled to activate the selected heading.

Note: For preselected turns greater than 60° from runway heading, the heading bug will “park” on the edge of the outer radius of the expanded compass rose and the selected heading will be displayed in white just below it.

Note: If NAV is inadvertently selected and NAV ARMED is displayed in the FMA roll window, NAV can be disarmed by pushing the FMA heading select switch and re-selecting the appropriate heading, as necessary.



Pitch Modes

PROF

PROF operates in conjunction with the FMS to ensure vertical crossing restrictions are met. PROF is normally armed on the ground prior to departure. Once selected, the magenta PROF ARMED message will appear in the altitude control window of the FMA. PROF may be armed with at least one engine running and will engage at 400 feet AGL.

When PROF is armed on the ground or prior to the thrust reduction altitude, it will automatically transition the FMS from Takeoff to Climb mode, and engage CLB THRUST and FMS speed.

FMS Speed mode may be selected independently from the PROF mode. However if PROF is armed prior to departure, FMS speed mode will also engage at 400 feet AGL.

Note: If PROF is selected during the takeoff phase of flight, PROF and FMS speed will engage.

PROF will not engage if the following information is not entered into the FMS: Gross Weight, ZFWCG, Cost Index, CRZ level, and V2 Speed.

The use of FMS modes of PROF and FMS speed are prohibited during flights when barometric altitude is referenced to a QFE altimeter setting.

NO PROF

PROF is the recommended departure mode but is not required for takeoff. Once PROF ARMED is displayed in the FMA altitude window, it may be disarmed by pushing the FCP altitude select knob. PROF may be deselected by pushing or pulling the FCP Altitude preselect knob, rotating the vertical speed wheel, by engaging Go-Around, or when GS captures.

If conducting a NO PROF takeoff, level change must be selected at thrust reduction altitude to transition from Takeoff mode to Climb mode. Once Level Change is selected, T/O CLAMP will change to CLB THRUST in the FMA altitude window. A momentary transition through T/O THRUST may be observed. When selecting level change at the thrust reduction altitude the current airspeed will become active. Pulling the FCP Speed Select knob activates the pre-selected airspeed (usually 250 knots for departure). FMS SPD may also be selected, which will restore the FMS climb speed schedule.

Autopilot Engagement

The minimum altitude for autopilot engagement is 200 feet AGL.

Note: If NAV is selected prior to takeoff, the autopilot will not engage until 400 feet AGL.

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

The minimum altitude for flap retraction is 400 feet AFE.

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 acceleration height, lead the flight director and lower the pitch to 8-10°. As airspeed increases, selection of the next flap/slat position is initiated when the FR or SR speed indicator on the speed tape indication changes from amber to green.

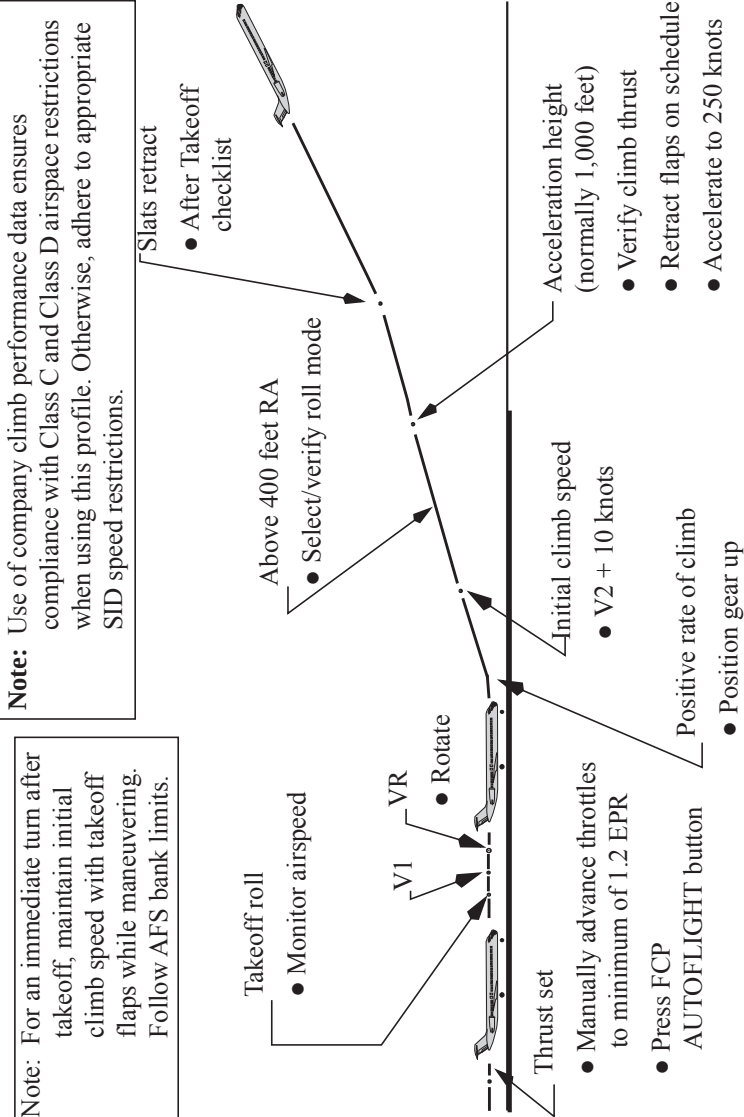
This pitch attitude will allow the aircraft to accelerate to 250 knots while climbing. If the pitch attitude generates a climb in excess of 1,000 fpm, maintain pitch and accept the added performance.

Note: Especially at heavy weights, the green speed trend line should display an acceleration before retracting flaps to the next setting.

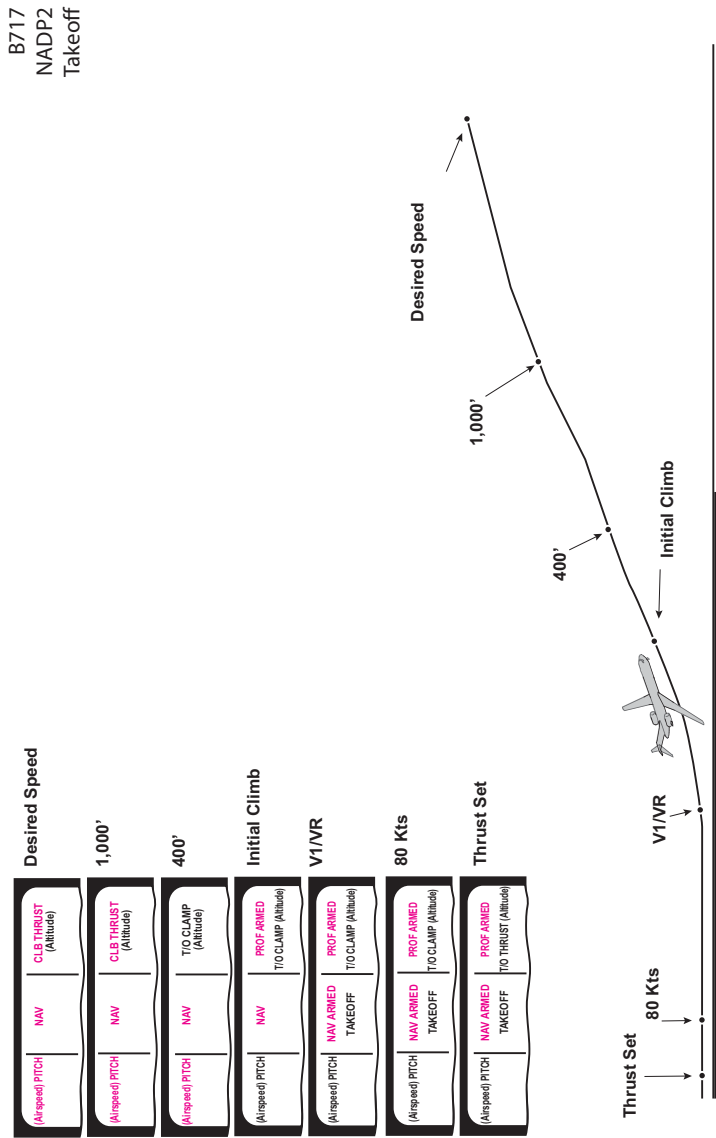
Note: Consider delaying flap retraction while maneuvering, heavy weight or in turbulence. At heavy weights, delaying flap retraction may result in speeds approaching flap placard limits. Prevent flap overspeeds by monitoring flap placard speeds, PFD maximum speed (red zipper) and AFDS pitch guidance.



Normal Takeoff Profile (Distant/ICAO NADP 2)



FMA Progression Profile



NAV ARMED
TAKEOFF

PROF ARMED
T/O CLAMP (Altitude)

(Airspeed) PITCH

NAV ARMED
TAKEOFF

PROF ARMED
T/O CLAMP (Altitude)

(Airspeed) PITCH

NAV ARMED
TAKEOFF

PROF ARMED
T/O THRUST (Altitude)

(Airspeed) PITCH

Desired Speed

1,000'

400'

Initial Climb

V1/VR

80 Kts

Thrust Set

80 Kts

Desired Speed

1,000'

400'

Initial Climb

V1/VR

80 Kts

Thrust Set

80 Kts

**Normal Takeoff (Distant/ICAO NADP 2)**

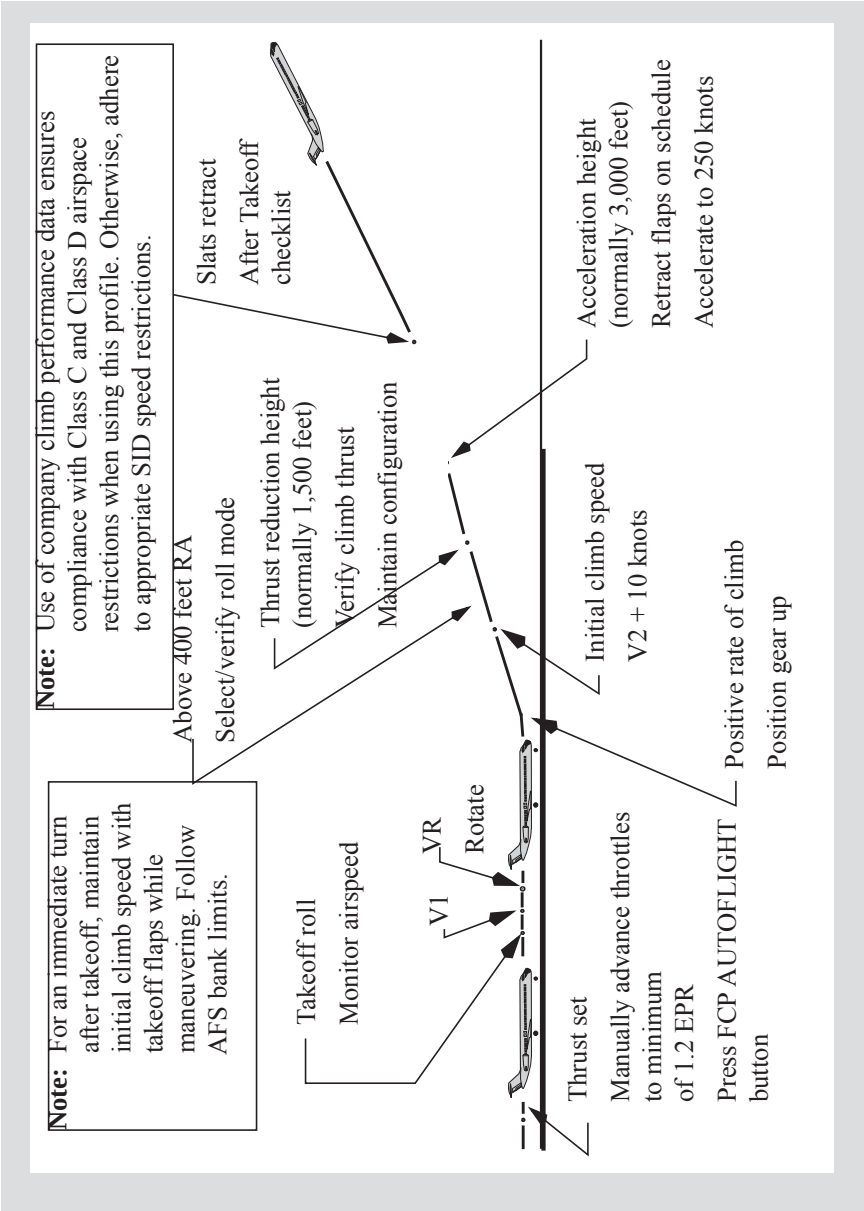
The Normal Takeoff profile (Distant/ICAO NADP 2) is the normal takeoff procedure but is not the default FMS profile. The Distant/ICAO NADP 2 reduces noise slightly for communities that are not within the immediate vicinity of the runway end.

The Close-In/ICAO NADP 1 is the default FMS profile. CLB THRUST, ACCEL, and EO ACCEL altitudes are pre-programmed in the FMS TAKEOFF page. These altitudes should be modified to or verified to be 1,000 feet AGL for the normal NADP 2 profile.

- 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.

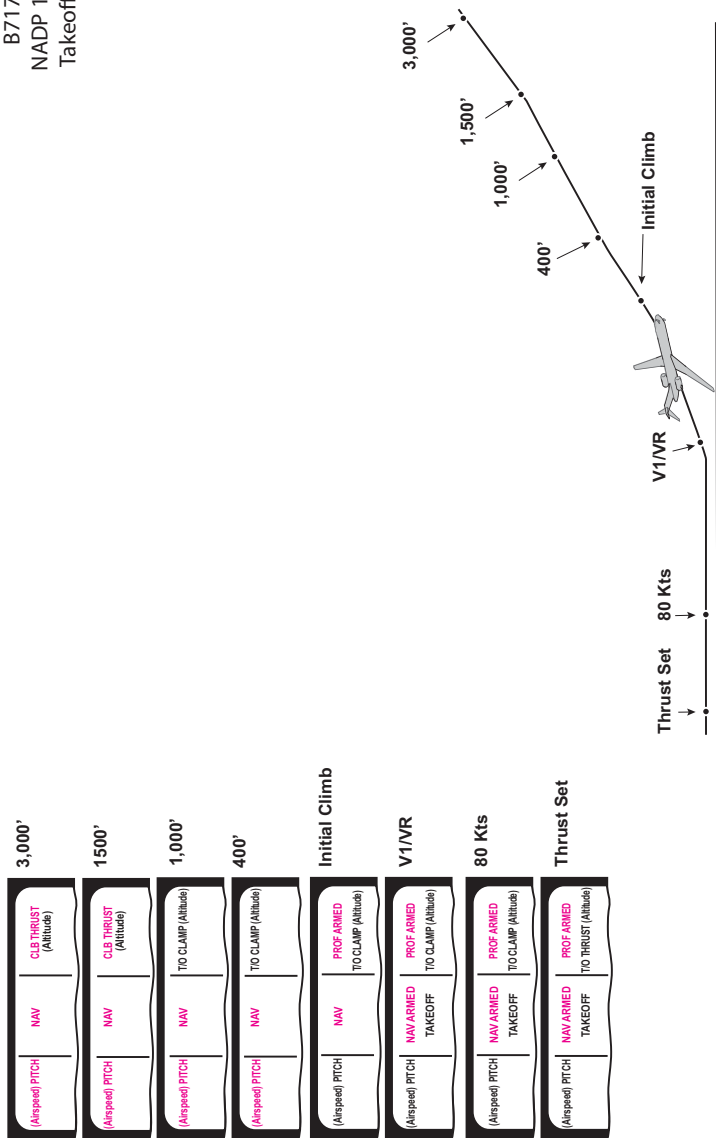
Note: AFDS will command appropriate pitch for acceleration segment.

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



FMA Progression

B717
NADP 1
Takeoff



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. CLB THRUST, ACCEL and EO ACCEL altitudes are pre-programmed on the FMS TAKEOFF page. Unless other altitudes are specified for the NADP 1 profile, these altitudes should be modified or verified to be 1,000 feet AGL for the EO ACCEL, 1,500 feet AGL for CLB THRUST and 3,000 feet AGL for ACCEL altitude.

- Take off using AWABS generated takeoff power and flaps setting.
- At 1,500 feet AFE reduce thrust to climb power, maintain takeoff flaps.
- Continue (at 1,500 feet AFE) to fly commanded airspeed.
- 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.

Note: Specific local airport procedures should be followed.



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 is the best indicator of the correct rudder pedal input. To counter the thrust asymmetry due to an engine failure, stop the yaw with rudder. Flying with lateral control wheel displacement or with excessive aileron trim causes spoilers to be raised.

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 18-20° 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 12.5°. The rate of rotation with an engine inoperative is also slightly slower (1/2° per second less) than that for a normal takeoff. After liftoff adjust pitch attitude to maintain the desired speed of V2 to V2 +10. When the flight director pitch bar decreases from approximately 18-20° to the 12-15° range, transfer the pitch reference to the flight director and follow it to EO ACCEL altitude.

If the engine failure occurs at or after liftoff apply rudder and aileron to control heading and keep the wings level. In flight, correct rudder input approximately centers the control wheel. To center the control wheel, rudder is required in the direction that the control wheel is displaced. This approximates a minimum drag configuration.

Note: Index marks on the inboard side of each control column may be helpful in determining if the control wheel is centered (pilots should look at the opposite control column).

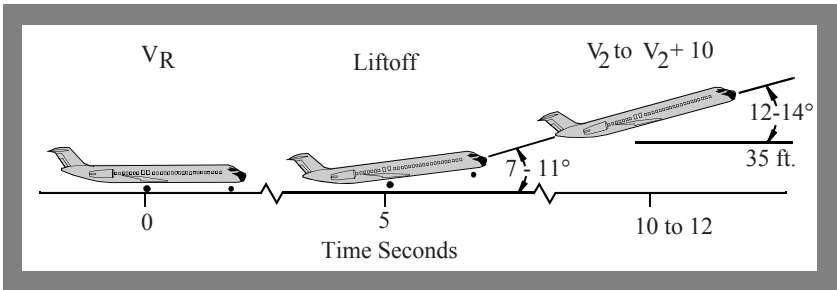
During takeoff the FMS engine out speed target is obtained at the time of engine out detection. Prior to reaching V2, the speed target will be V2. If the airplane speed is between V2 and V2 + 10, the speed attained at engine loss will be maintained. If above V2 + 10, the speed will be reduced to V2 + 10 and maintained. In each of the three cases, the speed will be maintained until EO ACCEL altitude has been reached.



717 Flight Crew Training Manual

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 $V_2 + 10$ knots.



Retract the landing gear after a positive rate of climb is indicated on the altimeter. Retract flaps in accordance with the technique described in this chapter.

Initial Climb - One Engine Inoperative

The initial climb attitude should be adjusted to maintain an airspeed between V_2 and $V_2 + 10$. 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 $V_2 + 10$.

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

If NAV was selected prior to departure, the flight director will command runway heading until NAV engagement at 100' AGL. If NAV ground track is not consistent with desired flight path select heading hold or heading select to achieve the desired track.

Trim the rudder as required. Relieve the rudder pedal pressure by trimming the rudder towards the good engine. Use the slip skid indicator to assist with setting the required trim. The primary indication that the aircraft is in trim is a level control wheel. Full rudder trim and some aileron trim may be required to maintain a level control wheel.

Retract the landing gear after a positive rate of climb is indicated on the altimeter. The initial climb attitude should be adjusted to maintain a minimum of V_2 . If an engine fails at an airspeed between V_2 and $V_2 + 10$, climb at the airspeed at which the failure occurred. If engine failure occurs above $V_2 + 10$, increase pitch to reduce airspeed to $V_2 + 10$ and maintain $V_2 + 10$ until reaching acceleration height.

Indications of an engine fire, impending engine breakup, or approaching or exceeding engine limits should be dealt with as soon as possible. Accomplish the appropriate memory checklist items as soon as the aircraft is under control, the gear has been retracted, and a safe altitude (minimum 400 feet AGL) has been attained. Due to asymmetric thrust considerations, it is recommended that the PF retard the affected throttle after the PM confirms that the PF has identified the correct engine. Accomplish the non-normal checklist items as conditions permit. If an engine failure has occurred during initial climb, accomplish the appropriate non-normal checklist as conditions permit.

Immediate Turn after Takeoff - One Engine Inoperative

Obstacle clearance or departure procedures may require a special engine-out departure procedure. Refer to Airway Manual, 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). Maintain V₂ to V₂ + 10 with takeoff flaps while maneuvering.

Note: The FMS will calculate and display the bank angle limit on the PFD. Fly at speeds greater than the minimum maneuver speed amber band (foot) on the PFD speed tape to ensure full maneuver margin capability.

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

Autopilot Engagement - One Engine Inoperative

After establishing the climb above 1,000 feet AFE and at 180 knots or more with the aircraft in trim, the autopilot may be engaged.

Note: Although the autopilot may be engaged at 200 feet (400 feet with NAV armed), excessive trim forces may cause the autopilot to disengage. Ensure the aircraft is in trim prior to autopilot engagement.



Flap Retraction - One Engine Inoperative

The FMS normally transitions from takeoff mode to climb mode at thrust reduction to climb power. With an engine out and PROF selected the FMS will not transition to climb mode until the slats have been retracted and airspeed is greater than V3.

When the FCC detects an engine failure during takeoff the ENG OUT prompt will be displayed on the FMS. The FMS will offer the options to CONFIRM or CLEAR the ENG OUT prompt. If the CONFIRM ENG OUT prompt is selected prior to EO ACCEL altitude and PROF is armed or engaged, the FMS will direct the aircraft to level off at EO ACCEL altitude and accelerate to V3. If the CONFIRM ENG OUT prompt is selected at or above the EO ACCEL altitude, with PROF engaged, the aircraft will level off and accelerate to V3 prior to resuming climb. In either case the acceleration to V3 cannot be overridden by speed select. The only way to exit the programmed engine out vertical profile is to exit PROF mode by selecting another vertical mode (level change, altitude hold, V/S or FPA).

The standard altitude to initiate acceleration and flap retraction with an engine inoperative is 1,000 feet AFE. However, some combinations of high gross weight, takeoff flap selection, and airport elevation may require initiating flap retraction as low as 400 feet after takeoff with an engine failure.

The following procedures are designed to prevent an unintended acceleration to V3 until it is determined that the best course of action is to accelerate, clean up and proceed to an alternate airport.

If an immediate return to the point of departure is planned:

- At EO ACCEL altitude, set 180 KIAS in the speed select window and pull the speed select knob
- Set desired altitude in FCP altitude window and select level change (takes the aircraft out of PROF mode)
- Follow F/D command bars and accelerate to 180 knots
- Engage the autopilot
- Coordinate a return to the airport
- Complete the normal and non-normal checklists
- Do not select PROF.

Note: When turning the autothrottles back on during the QRH Non-Normal checklist, turn them on using AUTOFLIGHT (for both AP and ATS on) or AUTOFLIGHT while holding down the A/P disconnect switch (for ATS only). Selecting PROF to engage the autothrottles after the CONFIRM ENG OUT prompt has been selected will cause the aircraft to level off and accelerate to V3.

If it is determined that the best course of action is to proceed to a different airport:

- At EO ACCEL altitude set 250 KIAS in the speed select window and pull the speed select knob
- Set desired altitude in FCP altitude window and select level change (takes the aircraft out of PROF mode)
- Accelerate to 250 knots
- Retract flaps and slats
- Engage the autopilot
- Complete the normal and non-normal checklists
- Coordinate further plans with ATC and Flight Control
- After slats retracted and aircraft enters FMS climb mode, PROF may be used as necessary.

If the flight director is not being used at acceleration height, decrease pitch attitude to maintain approximately level flight while accelerating. Retract flaps on the takeoff flap retraction speed schedule.

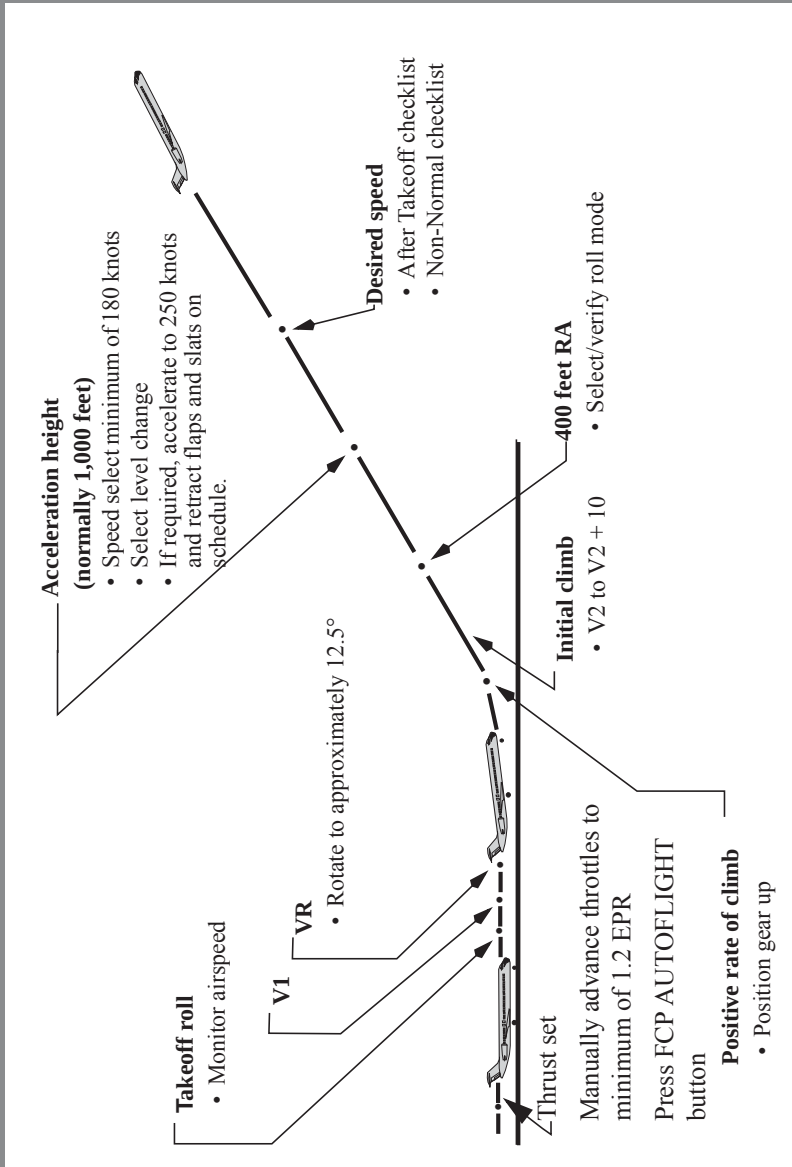
As the aircraft accelerates and flaps are retracted, adjust the rudder pedal pressure to maintain the control wheel centered and trim to relieve rudder pedal pressure.

Flaps Up - One Engine Inoperative

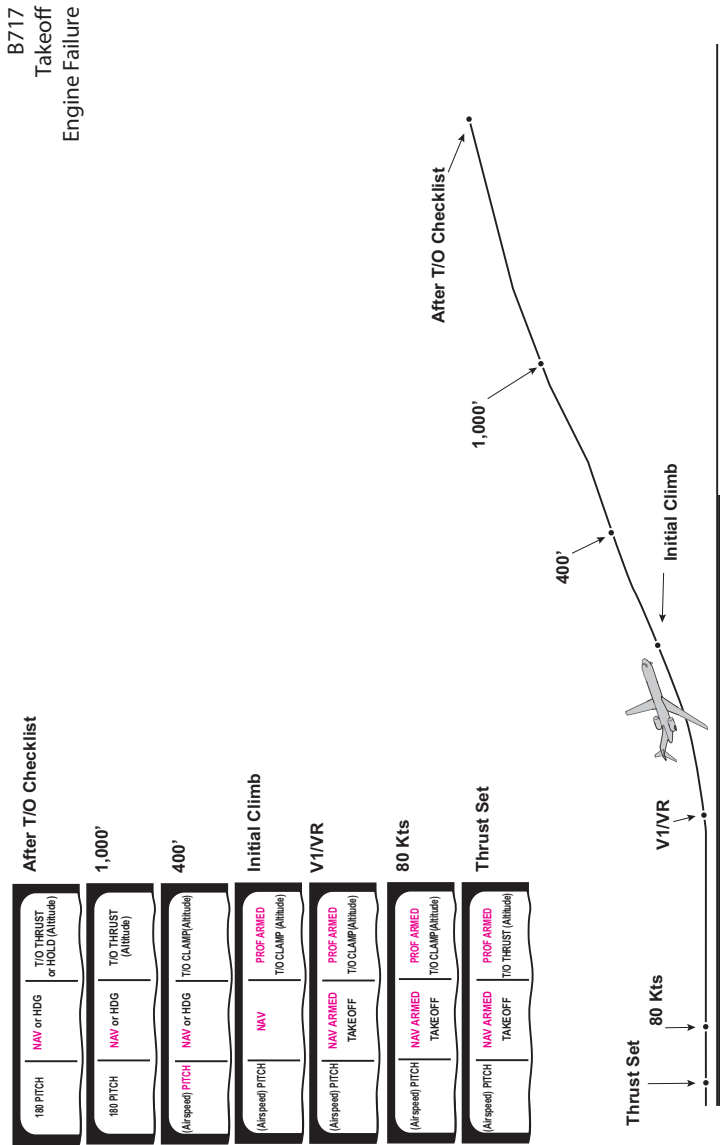
Note: When an engine failure occurs after takeoff, noise abatement is no longer a requirement.



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 full rated takeoff thrust by manually advancing the throttle to maximum forward throttle gate. This is because the takeoff speeds consider VMCG and VMCA at the full rated takeoff thrust.

Increasing thrust on the operating engine to full rated takeoff thrust 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 Takeoff Thrust (Fixed Derate, T/O 1, T/O 2)

During a fixed derate takeoff, a thrust increase following an engine failure could result in loss of directional control and should not be accomplished unless, in the opinion of the captain, terrain contact is imminent. This is because the takeoff speeds consider VMCG and VMCA only at the fixed derate level of thrust.

Intentionally
Blank

Climb, Cruise, Descent and Holding

Table of Contents

Chapter 4

Section TOC

Climb	4.1
Reduced Thrust Climb.	4.1
Climb Modes	4.1
Climb Constraints	4.3
Low Altitude Level Off.	4.4
Transition to Climb	4.4
Climb Speed Determination	4.5
Engine Icing During Climb	4.6
Economy Climb.	4.6
Economy Climb Schedule - FMS Data Unavailable.	4.7
FMS CLIMB Wind Entries	4.7
Maximum Angle Climb.	4.7
Engine Inoperative Climb	4.7
Cruise	4.9
Cruise Speed Definitions.	4.10
Cruise Speed Determination	4.11
Maximum Altitude	4.13
Optimum Altitude	4.14
Cruise Altitude Changes	4.15
FMS Wind Entries.	4.17
Low Fuel Temperature	4.18
Cruise Performance Economy.	4.20
Engine Inoperative Cruise/Driftdown	4.21
High Altitude Performance	4.23
ETOPS.	4.24
Descent	4.25
Descent Planning	4.25
Descent Speed Determination	4.27

Descent Path	4.30
Descent Constraints	4.33
Descent Rates.	4.42
Speedbrakes	4.42
Flaps and Landing Gear.	4.43
Engine Icing During Descent.	4.43
Holding.	4.44
Holding FMS Entries	4.44
Holding Airspeeds	4.47
Holding Pattern Exit	4.48

Climb

Reduced Thrust Climb

Engine service life may be extended by operating the engines at less than full climb rated thrust.

The FMS provides two reduced thrust climb selections on the THRUST LIMITS page. Climb derate is armed with takeoff derate selected (CLB1 with T/O1 or CLB2 with T/O2). If using FLEX or T/O, CLB1 or CLB2 must be manually selected.

- CLB 1 is a 10% derate of climb thrust
- CLB 2 is a 20% derate of climb thrust.

Note: During preflight, CLB1 or CLB2 is selected on the THRUST LIMITS page. Selecting CLB1 or CLB2 a second time, while they are already displayed in large font, will engage the manual thrust limits (CLB1 or CLB2 will be displayed in white on the EAD). FMS thrust limits can be restored by selecting the AUTO THRUST LIMITS prompt (4R) on the AUTO THRUST LIMITS page.

Climb Modes

There are four climb modes available: PROF, Level Change, V/S, and FPA. PROF is the normal climb mode. In all climb modes, airspeed may be controlled by the FMS or manually with the Speed Select knob.

PROF

When PROF is armed for takeoff the FMS enters CLB mode at the thrust reduction altitude.

PROF mode enables the airplane to comply with FMS altitude and airspeed constraints. PROF is selected with the PROF switch on the FCP. PROF can be deselected by selecting any other vertical mode (level change, altitude hold, V/S, or FPA).

PROF may be used with or without the ATS engaged.

When climbing in PROF, CLB THRUST is displayed in magenta in the altitude window of the FMA. The selected altitude in the FMA altitude window will be displayed in white, unless it is an FMS programmed altitude in which case it will be displayed in magenta. During intermediate level offs, the FMA altitude mode will change from magenta CLB THRUST to magenta HOLD.

In this example, the aircraft is climbing to FL350 at 320 knots with PROF, FMS speed (ECON), and NAV engaged. A/P is on.



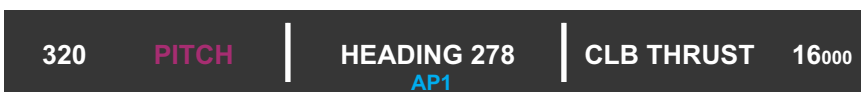
LEVEL CHANGE

A level change climb is engaged by selecting a higher altitude in the altitude select window and pulling the altitude select knob. The aircraft will climb at the selected climb thrust limit.

Level change climb ignores any climb restrictions programmed in the FMS.

When climbing in level change, CLB THRUST is displayed in white in the altitude window of the FMA. The selected altitude in the FMA altitude window will be white unless it is the FMS cruise altitude in which case it will be displayed in magenta. During intermediate level offs, the FMA altitude mode will change from white CLB THRUST to white HOLD.

In this example, the aircraft is climbing to 16,000 in level change, with an FMS speed edit of 320 knots, and heading select engaged. A/P is on.



V/S or FPA

CAUTION: Ensure airspeed does not decay while attempting to maintain too high a V/S climb rate or too steep climb angle.

Vertical Speed or FPA mode is engaged by rotating the pitch wheel. A push button on the FCP allows selection of either V/S or FPA.

When the pitch wheel is rotated the window above the pitch wheel opens with the current value of either V/S or FPA. Climb rate or angle may be adjusted up or down via the pitch wheel.

When climbing in V/S or FPA, V/S or FPA is displayed in white in the altitude window of the FMA. The selected altitude in the FMA altitude window will be white unless it is an FMS cruise altitude in which case it will be displayed in magenta. During intermediate level offs, the FMA altitude mode will change from white CLB THRUST to white HOLD.

In this example, the aircraft is climbing to 16,000 in V/S, in Speed Select 320, where the value of 320 is within 4 knots of the active FMS climb speed. NAV is engaged. A/P is on.

320

THRUST

NAV1
AP1

V/S 16000

The Vertical Speed (V/S) or Flight Path Angle (FPA) climb mode may be used when a specific climb rate or climb angle is desired (e.g., “Be level at FL 250 in four minutes or less.”).

Climb Constraints

Note: Some FMS departures and arrivals contain waypoints with two altitude restrictions (for example at or above 10,000 and below 12,000). The altitude constraints can be viewed on the vertical revision page. These restrictions should not be modified. If the altitude restriction is modified on the F-PLN page or the vertical revision page, one altitude restriction will be deleted and cannot be reentered without reloading the departure or arrival.

Climb constraints are automatically entered in the F-PLN route if they are programmed in the selected departure procedure (SID). Climb constraints may also be manually entered directly on the right side of the F-PLN page or on the VERT REV page for the appropriate fix. All intermediate constraints must be displayed in LARGE FONT on the F-PLN page.

When climbing in PROF with altitude or airspeed constraints present on the F-PLN page, the FMS will attempt to meet those constraints. The clearance limit altitude should be set in the FCP altitude window. The climb should be monitored to ensure compliance with all constraints.

If climbing in a mode other than PROF and given a Climb Via clearance, each altitude restriction must be set in the FCP altitude window to ensure proper altitude alerting and constraint compliance.

When relieved of constraints by ATC, use level change or V/S. In level change or V/S mode the aircraft will ignore (not delete) any constraints in the F-PLN and climb to the altitude set in the FCP altitude window. If PROF climb is preferred any constraints that are no longer required should be deleted from the F-PLN.

Low Altitude Level Off

Occasionally a low altitude climb restriction is required after takeoff. This altitude restriction should be set in the FCP altitude window. If operating in PROF and altitude capture occurs before the ACCEL altitude, the autothrottles may retard slightly to maintain FMS airspeed until reaching ACCEL altitude, at which time FMS airspeed and autothrottles will both advance. Ensure proper acceleration and level off at the assigned altitude.

Note: With FCP altitude set lower than ACCEL or CLB THRUST altitude, the ACCEL and/or CLB THRUST altitude values are edited to the FCP altitude when the FCC transitions into altitude capture. Upon altitude capture, the FMS speed target becomes the climb speed target VCL. Thrust reduction occurs when the FCC enters altitude HOLD mode.

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.
- 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.

Transition to Climb

Maintain VMIN + 5 knots 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

Climb airspeed can be controlled through the FMS or with Speed Select on the FCP. The flight control computers will maintain the selected airspeed by adjusting pitch or thrust.

In climb, the color of the airspeed value and the color of the control mode (PITCH or THRUST) in the FMA airspeed window indicate which speed mode is active:

- ECON - both the airspeed value and the control mode are magenta.
- EDIT (or MAX) - the airspeed value is white and the control mode is magenta.
- Speed select - both the airspeed value and the control mode are white.

Note: When operating in FMS EDIT mode, and the EDIT speed is within 4 knots of the ECON speed, the value in the FMA speed control window will be magenta. When operating in Speed Select with an airspeed within 4 knots of the active FMS speed, the speed value in the FMA speed control window will also be magenta.

Note: Using speed select while climbing in PROF is not recommended. The FMS will continue to use the active FMS speed to make its calculations. This may create problems in making crossing restrictions.

Note: During intermediate level offs during climb, the FMS will remain in CLB mode, but the speed control mode will change from PITCH to THRUST.

The PERF CLB page displays three FMS speed modes: ECON, MAX, and EDIT. The active FMS speed mode is displayed in large font. The FMS speed mode may be changed by line selecting the desired mode on the PERF CLB page. ECON and MAX speeds are calculated by the FMS. EDIT speeds can be modified prior to or during the climb by line selecting the desired airspeed on the EDIT line of the PERF CLB page. FMS speed EDIT's can also be made by selecting the desired airspeed on the FCP and pushing the FMS SPD switch within 10 seconds.

Note: EDIT speeds can be modified but not cleared.

When speed select is engaged, the active FMS speed will be the speed the FMS uses for its vertical path calculations. When the FMS SPD switch is re-selected, the active speed mode (ECON, EDIT, MAX) will resume control of the airspeed.

Note: If EDIT or MAX is the active speed mode when FMS SPD is selected, a second push of the FMS SPD switch will change the FMS speed mode to ECON.

The ECON climb speed is a constant speed/constant Mach schedule optimized 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.

Normally, upon completion of the initial climb segment, accelerate without delay to VCL, which is normally 250 knots. When departing on a heading away from the destination airport, the selection of climb speed becomes an item of pilot judgment. Here are some considerations for selecting climb speed:

- If ATC needs distance before they can turn the flight on course, complete the normal noise abatement procedures and accelerate to 250 knots.
- If ATC needs altitude prior to the turn, maintain MAX CLB to that altitude.
- Once the aircraft is vectored on course and is above 10,000 feet MSL, accelerate promptly to the ECON climb speed. Enroute climb speed is displayed on the PERF CLB page. It is also displayed on the PFD speed tape.

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 airspeed decay, 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 windshield 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.

Economy climb speed normally exceeds 250 knots for all gross weights. FMS climb speed is limited to 250 knots or VMIN + 5, whichever is greater, below 10,000 feet. 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 or VMIN + 5, whichever is higher
- Above 10,000 feet - Climb at 310 knots until transitioning to flight planned cruise Mach (approximately 27,000 feet). Transition to flight planned cruise Mach at this time by reselecting the IAS/MACH select button on the FCP.

FMS CLIMB Wind Entries

Entries on the CLIMB FORECAST wind page are used to compute the climb portion of the flight plan by linear interpolation. If desired, climb winds may be entered manually on the CLIMB FORECAST page. Climb winds are not uplinked.

Maximum Angle Climb

Maximum angle climb speed is normally used for obstacle clearance, minimum crossing altitude, or reaching a specified altitude in a minimum distance. Selecting MAX CLB on the FMS performance climb page gives the recommended speed for best angle of climb. This speed schedule is slightly above VMIN and is approximately 1.4 V_{stall}. Selecting MAX CLB, when at high speed in ECON or EDIT, provides the opportunity to exchange speed for altitude.

Engine Inoperative Climb

The recommended engine inoperative climb speed is FMS generated and varies with gross weight and altitude.

When the FCC detects an engine failure the ENG OUT prompt will be displayed on the FMS. The FMS will offer the options to CONFIRM or CLEAR the ENG OUT prompt. Select the CONFIRM prompt to display the ENG OUT FMS data. If the CONFIRM ENG OUT prompt is not displayed, select the ENG OUT key to display the prompt and then select the CONFIRM prompt. If the ENG OUT prompt is displayed inadvertently, select CLEAR.

T/O or GA thrust limit changes to MCT limit on the EAD when the FCC detects an engine out or the pilot confirms the ENG OUT prompt and:

- The aircraft is above the EO ACCEL altitude
- Airspeed is V₃ or greater
- Slats are retracted.

The FMS ENG OUT mode predicts engine out performance.

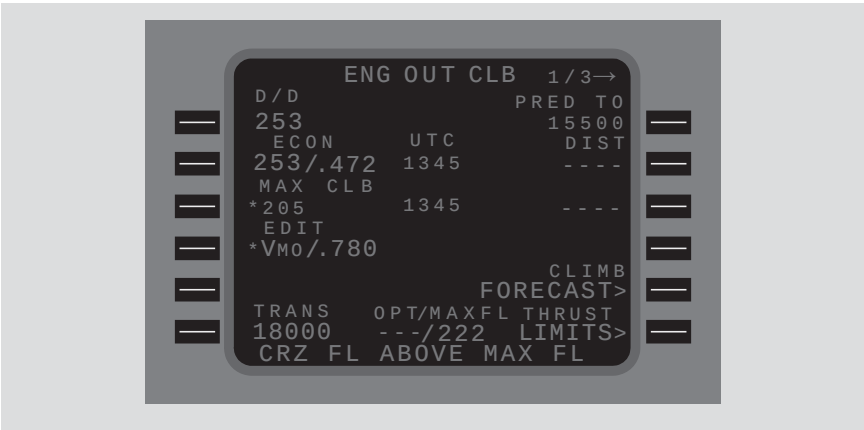
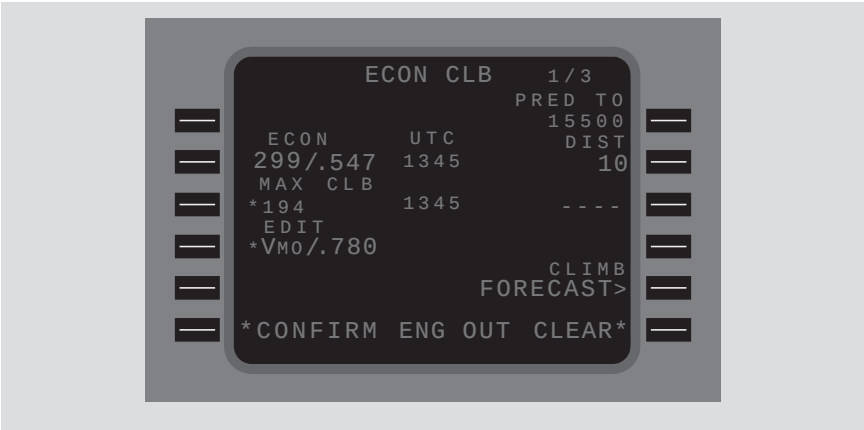
If the CONFIRM ENG OUT prompt is selected, the FMS calculates ENG OUT maximum altitude, and new MAX CLB, MAX END, and ECON speed targets. The climb/descent paths and fuel consumption predictions are also recomputed and displayed.

 DELTA

717 Flight Crew Training Manual

If the CONFIRM ENG OUT prompt is selected the ENG OUT CLB page is displayed on the MCDU.

Note: The message CRZ FL ABOVE MAXFL in the scratchpad indicates the all engine CRZ FL was above the recomputed single-engine MAXFL. Single-engine MAXFL is that altitude maintained with one engine operating at maximum continuous thrust with a 100 fpm climb rate available.





Cruise

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

When the following three altitudes agree, the FMS will transition from the CLB to CRZ mode:

- The FCP selected altitude
- The lowest INIT page CRZ altitude
- The altimeter altitude.

There are only two cruise modes available: PROF or Altitude Hold. When cruising in PROF, HOLD will be displayed in magenta in the FMA altitude window. If in Altitude Hold, HOLD will be displayed in white.

PROF is the normal cruise mode. The advantage of cruising in PROF is that it prepares the aircraft for descents, especially “at pilot discretion” descents. When operating in PROF and a lower altitude is set in the FCP, the aircraft will automatically initiate a descent when it reaches the calculated TOD. If operating in Altitude HOLD mode, the airplane will fly past the calculated TOD and remain at the cruise altitude until the crew intervenes.

Note: If minor corrections are made to the cruise altitude when operating in CRZ mode, e.g. altimeter change, CRZ THRUST may be momentarily displayed in the FMA altitude window during the correction.

Once the FMS is established in CRZ mode, it remains in CRZ until it reaches the calculated TOD.

Note: While climbing in PROF and the TOD is sequenced prior to the FMS entering CRZ mode, the aircraft will enter DES mode and level off at the current altitude.



Cruise Speed Definitions

Maximum Endurance (MAX END)

- Calculated by the FMS
- Minimum drag speed
- Maximum time aloft

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)

- 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
 - 717 is optimized for flight between M0.74 and M0.78
 - 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

Climb airspeed can be controlled through the FMS or with Speed Select on the FCP. The flight control computers will maintain the selected airspeed by adjusting thrust.

In cruise, the color of the airspeed value and the color of the control mode (THRUST) in the FMA airspeed window indicate which speed mode is active:

- ECON - both the airspeed value and the control mode are magenta.
- EDIT (or MAX) - the airspeed value is white and the control mode is magenta.
- Speed select - both the airspeed value and the control mode are white.

Note: When operating in FMS EDIT mode, and the EDIT speed is within 4 knots of the ECON speed, the value in the FMA speed control window will be magenta. When operating in Speed Select with an airspeed within 4 knots of the active FMS speed, the speed value in the FMA speed control window will also be magenta.

Note: Using speed select while cruising in PROF is not recommended. The FMS will continue to use the active FMS speed to make its calculations. This may create problems in making crossing restrictions.

The PERF CRZ page displays three FMS speed modes: ECON, EDIT, and MAX. The active FMS speed mode is displayed in large font and included in the title of the PERF page e.g. “EDIT CRZ.” The FMS speed mode can be changed by line selecting the desired mode on the PERF CRZ page. ECON and MAX speeds are calculated by the FMS. EDIT speeds can be modified prior to or during cruise by entering the desired airspeed on the EDIT line of the PERF CRZ page. FMS speed EDITs can also be made by selecting the desired airspeed on the FCP and then pushing the FMS SPD switch within 10 seconds.

Note: EDIT speeds can be modified but not cleared.

When speed select is engaged, the active FMS speed (large font) will be used by the FMS for its vertical path calculations. When the FMS SPD switch is re-selected, the active speed mode (ECON, EDIT, MAX) will resume control of the airspeed.

Note: If EDIT or MAX is the active speed mode when FMS SPD is selected, a second push of FMS SPD switch will change the FMS speed mode to ECON.

Note: FMS speed edits made on the PERF CLB page will propagate to the PERF CRZ page. FMS speed edits made on the PERF CRZ page will NOT propagate to the PERF DES page.



ECON cruise speed is a function of gross weight, cruise altitude, cost index, and headwind or tailwind component. It is calculated to provide minimum operating cost for the entered cost index. If you are forced to cruise below your flight planned altitude, insert the new flight level in the INIT 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.

MAX END is the cruise speed calculated by the FMS, which provides minimum drag and hence maximizes endurance (time aloft).

Required Time of Arrival (RTA) speed is generated to meet a time required at an RTA specified waypoint on the FMS RTA Progress page.

Note: The FMS will adjust the speed in order to arrive at the waypoint at the RTA. 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 999 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 within ten miles of the top of descent.

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 than 5% or 10 knots from the planned Mach Number/TAS, inform the appropriate controlling agency.



Maximum Altitude

Note: Increasing Cost Index or airspeed during cruise may lower the FMS calculated MAX and OPT altitudes.

Maximum altitude (MAXFL) is the highest altitude at which the aircraft can 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 Maximum Recommended Initial Cruise Altitude 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 1.3g maneuver margin exists prior to buffet onset (minimum 0.25g for FAA). These specific margins provide 33° of bank angle protection to buffet.

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

The minimum maneuver speed (VMIN) indication on the airspeed display does not guarantee the ability to maintain level flight at that speed. Decelerating the aircraft to the amber foot 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.

VMAX is the highest speed that provides full maneuver capability to high speed buffet. Full maneuver capability is defined as 1.3 gs or 40° of bank. As airspeed is increased above the top of the amber band, maneuver capability decreases.

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 FMS UFOB on the WEIGHT INIT page matches the actual fuel onboard.

Turbulence at or near maximum altitude can momentarily increase the aircraft's angle-of-attack and activate the stick shaker. When flying at speeds near the lower amber foot, any maneuvering increases the load factor and further reduces the margin to buffet onset and stick shaker.

FMS fuel predictions are not available above the FMS maximum altitude and are not displayed on the MCDU. PROF is not available above FMS maximum altitude. Fuel burn at or above maximum altitude increases. Flight above the FMS maximum altitude is not recommended.

Optimum Altitude

The optimum altitude 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 optimum altitude. 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 PERF page. The PERF 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.

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.

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.



717 Flight Crew Training Manual

- 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.

Cruise Altitude Changes

Step Climb

CAUTION: If operating in CRZ mode with PROF engaged and a new, **HIGHER** altitude is selected on the FCP, the FMS will immediately transition to CLB mode and initiate a climb to the new altitude. When operating in PROF, do not set a higher altitude in the FCP without clearance to climb.

During cruise it may become necessary to climb to a higher altitude than the CRZ FL. If step climbs are planned for the flight, the step climb altitudes may be entered on the INIT page in the boxes after the initial cruise altitude.

In flight, the FMS will calculate the point at which the step climb should be initiated.

When cleared for the step climb and operating in PROF, select the new altitude on the FCP. A PROF TO message along with the S/C altitude will appear above HOLD and the current altitude in the altitude window of the FMA. When the S/C point is reached, PROF TO will be replaced by a flashing VERT ALERT message for 5 seconds and then HOLD will change to CLB THRUST and the aircraft will climb to the new altitude. Selected FMS cruise airspeed (ECON, MAX END, EDIT) will remain unchanged.

.751	THRUST	NAV1 AP1	PROF TO 35000 HOLD 31000

.751	PITCH	NAV1 AP1	VERT ALERT HOLD 31000

.751	PITCH	NAV1 AP1	CLB THRUST 35000

If a new altitude is not entered into the FCP at the step climb point, the step distance on the PERF page will continue to reset and the S/C symbol will continue to move ahead of the airplane on the ND. This action reminds the crew that the airplane is ready to climb to the new flight level as soon as the FCP altitude is set.



Where an S/C exists and an immediate climb is required prior to the S/C point, the pilot must select the new altitude on the FCP and enter it into the FMS INIT page. This will delete the S/C and allow the aircraft to climb to the new cruise altitude.

The FMS has the capability to constrain the airplane to an altitude at a waypoint in cruise. The format is /SFLXXX or /SXXX, which is entered on the F-PLN page adjacent to the desired waypoint. This FL must be equal to one of the FLs on the INIT page. This capability applies primarily in step climb operation between FLs defined in the FMS. Once the airplane sequences the waypoint which has the constraining altitude and sequences the S/C point for that altitude, a vertical alert will be provided and the aircraft will begin to climb, provided the FCP altitude has been changed to the new cruise level.

Note: Altitude constraints should not be used to adjust a cruise level downward. The FMS will transition to a descent flight phase for the remainder of the flight.

Entry of an altitude constraint during cruise flight will relocate the associated S/C to that constrained waypoint. For example, entering S330 as an altitude constraint (direct F-PLN or VERT REV entry) will move the optimum FL330 S/C from the optimum position in the F-PLN to the newly constrained waypoint. However, only FLs entered on the INIT page may be constrained in this manner. The pilot, upon nearing the altitude constrained waypoint and S/C, should preselect the S/C altitude on the FCP and, if necessary (flashing VERT ALERT not observed on the FMA or airplane does not begin to climb), pull the FCP altitude knob. The aircraft will climb to the step climb altitude. If the FCP altitude knob was pulled, the PROF button must be pushed to reengage FMS PROF.

Fuel for Enroute Climb

The additional fuel required for a 4,000 foot enroute climb varies from 300 to 500 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.

Cruise Descent

If a lower cruise altitude is desired (e.g., winds, turbulence, as directed by the flight plan, etc.) the FMS must temporarily transition to DES mode. The descent may be initiated from either the FCP ("out of PROF"), or on the FMS INIT page ("in PROF").



Out of PROF Descent

Initiate a re-cruise descent from the FCP by entering the new altitude (e.g. 31000) in the altitude window, selecting a V/S or level change descent, reselecting PROF, and then entering the new altitude (31000) or a "1" on the FMS INIT page. The FMS will enter DES mode and descend at the selected V/S (or IDLE if level change was selected). The FMA will display magenta V/S and white 31000. 31000 will remain white until the aircraft reaches FL310. When all three altitudes (FCP, INIT page and Altimeter) agree, the FMA changes to a magenta HOLD 31000 and the FMS re-enters CRZ mode.

In PROF Descent

The other option is to initiate the re-cruise descent by setting the new altitude (e.g. 31000) in the FCP and then entering the new altitude (31000) or a "1" on the FMS INIT page. The FMS will remain in PROF and initiate a descent to FL310. The FMA will display a magenta V/S and a white 31000 and the FMS will descend at a default rate of 750 fpm to FL310. To adjust the vertical speed, select a new V/S with the thumb wheel and re-engage PROF. PROF will honor the new vertical speed. As with the FCP method, when the aircraft reaches FL310 and all three altitudes (FCP, INIT page, and altimeter) agree, the FMA changes to magenta HOLD 31000 and the FMS re-enters CRZ mode.

Note: When operating in FMS EDIT speed and initiating a cruise descent, the desired speed must be entered into the PERF DES page. Upon level off, the aircraft will continue to fly that edited speed. However, upon resuming descent, the FMS EDIT speed must be entered into the PERF DES page again.

FMS Wind Entries

Cruise wind values should be uplinked or entered into the FMS for all cruise segment waypoints during preflight. If uplinks are not available and time limitations permit, enter as many wind values as feasible. The remaining entries can be completed as workload permits.

Wind and temperature values propagate along the route; therefore, when making manual wind entries, enter new wind values only when a difference exceeding 10° or 10 knots exists from the previous waypoint. Additionally, enter a new temperature value for subsequent waypoints only when a difference of +/-2° exists.

Note: Cruise waypoint wind entries or changes can be made by a vertical revision to F-PLN page 2. Push the right LSK adjacent to the cruise waypoint with the scratchpad empty. The VERT REV page 1/2 is displayed. Push the PAGE key to display the VERT REV page 2/2. Wind and temp data are entered on this page.

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.

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.

**717 Flight Crew Training Manual**

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
- Speed faster than planned or appreciably slower than long range cruise speed when long range cruise was planned
- Stronger headwind component
- Fuel imbalance
- Improperly trimmed aircraft
- Excessive throttle adjustments.

Cruise fuel penalties can be approximated using the following guidance:

- ISA + 10° C: 1% increase in trip fuel
- 2,000 feet below optimum altitude: 1% to 2% increase in trip fuel
- 4,000 feet below optimum altitude: 4% to 5% increase in trip fuel
- 8,000 feet below optimum altitude: 12% 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 0.76 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

WARNING: The aircraft will not depart the clearance altitude with FMS PROF and FMS SPD engaged until the FCP altitude is lowered. However, AFS speed protection is available. If airspeed decays below VMIN, FMS PROF and SPD will disengage. AFS speed protection will engage at VMIN – 10 and the airplane will depart the clearance altitude in order to maintain VMIN speed.

If an engine failure occurs during cruise, apply rudder and trim to level the control wheel. This allows the autopilot to remain engaged. The autothrottles remain active with one engine inoperative. Once the aircraft is stabilized, refer to the Driftdown Checklist in the QRH or on the Quick Reference Card Contingency Guide.

The Driftdown procedure directs the crew to select the CONFIRM ENG OUT prompt. Once selected, the FMS will then display engine out data, the thrust limit will transition to MCT, and the FMS will remain in ALT HOLD / FMS SPD.

Note: The CONFIRM ENG OUT and ENG OUT CLEAR prompts should be automatically displayed when the FCCs detect an engine failure. If these prompts are not automatically displayed after an engine failure, select the ENG OUT key on the MCDU.

Note: ENG OUT selection will not clear previously selected EDIT or MAX speeds.

When the target speed can no longer be maintained in ALT HOLD / FMS SPEED, the mode will transition to ALT HOLD/MAX THRUST and the target speed will become the D/D speed. The airplane will remain in level flight until the D/D speed is reached and the FCP altitude is set to a lower altitude.

Note: The FCP altitude should be lowered to the single-engine maximum altitude (rounded down to the nearest 500 feet) or a lower altitude if desired.

When the FCP altitude is properly set and the D/D speed is reached, the airplane will enter a D/D ENG OUT DES to the FCP altitude with D/D speed as the target. Driftdown descent is accomplished with speed on pitch and throttles at MCT thrust.

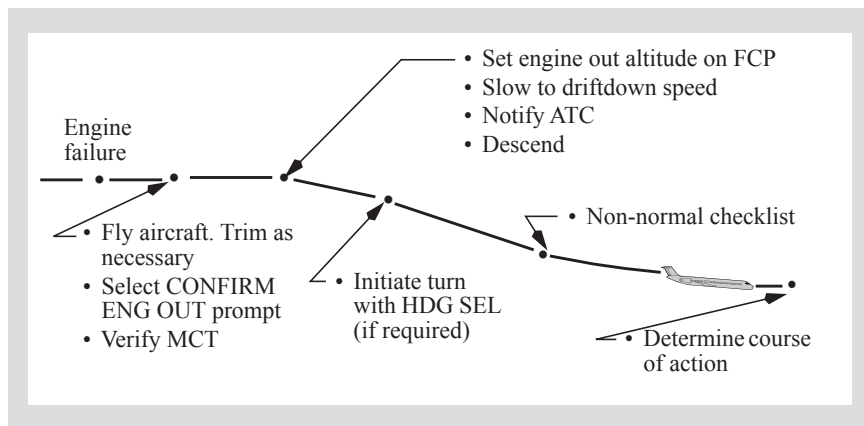
Note: The D/D speed is displayed on all PERF pages adjacent to 1L, and the engine out ECON speeds are displayed in their appropriate positions.

When the descent rate reaches less than 100 fpm for 60 seconds prior to reaching the single engine maximum altitude, the FMS mode will change from D/D to a V/S mode of 100 fpm. The V/S rate may be edited via the FCP and PROF reengaged. The MCDU D/D ENG OUT DES page then changes to ENG OUT DES.

If the FCP altitude is lowered below the single engine maximum altitude, the vertical speed will increase to 750 fpm. The FMS speed target will remain D/D until one of the following occurs:

- Aircraft achieves cruise level operation
- Aircraft captures the descent path
- Pilot performs any speed mode activity via the FCP or MCDU.

Upon completion of the Driftdown procedure with the aircraft stabilized in descent or level at the single engine max altitude, complete the appropriate non-normal checklist.



Note: If the aircraft is at or below maximum ENG OUT altitude when an engine becomes inoperative, select the ENG OUT prompt and maintain ENG OUT CRZ ECON speed.



High Altitude Performance

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.

Mach buffet and Mach tuck are associated with the formation of shock waves on the airfoil during transonic flight. Small, weak shock waves are formed on the wing at Mach 0.75. Although shock waves form much earlier, noticeable buffeting does not occur on the aircraft until approaching MMO. At this Mach number, shock waves become quite large and strong, and move rapidly fore and aft on the wing, causing a gentle high frequency buffet.

Pressure distributions are affected when these shock waves occur, and this affects the aircraft's lift, drag, and pitch characteristics. Mach tuck will become noticeable at Mach 0.80, and the pulling force required to maintain level flight increases linearly up to Mach 0.85, then remains constant. Therefore Mach trim compensation is needed above Mach 0.80.

Note: Maximum airspeed with malfunctioning or inoperative Mach Trim is 0.78 Mach.

Flight Control Sensitivity at High Speed and High Altitude

An understanding of flight control sensitivity at high speed and high altitude is necessary for operators of modern day aircraft. There have been reports of passenger injuries due to over-controlling the aircraft during high altitude, high airspeed flight when overriding the control column with the autopilot engaged or after disengaging the autopilot with the disconnect switch.

Pilots should understand that, in general, the aircraft is significantly more sensitive in pitch response (load factor) to column movement at cruise than it is at lower speeds associated with takeoff and landing. Similarly, for a given attitude change, the change in rate of climb is proportional to the true airspeed. For example, an attitude change at 290 knots KIAS at sea level that results in a 500 fpm rate of climb would result in approximately a 900 fpm rate if done at 290 knots KIAS at 35,000 feet. This is because 290 KIAS is equivalent to a TAS of approximately 290 knots at sea level and 490 knots at 35,000 feet. This characteristic is essentially true for small attitude changes, such as the kind used to hold altitude.

Other factors such as gross weight and CG also affect flight control sensitivity and stability, but as long as the CG is in the allowable range the handling qualities will be adequate. However, to avoid over-controlling the flight controls during high altitude high airspeed flight, smooth and small control inputs should be made after disengaging the autopilot.



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, EPR, and fuel flow.

Should the aircraft slow below acceptable airspeeds, 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 an enroute descent, ensure there is a waypoint and altitude constraint on the F-PLN page that provides a valid T/D point for a descent to the terminal area. If expecting a STAR or R/D (runway dependent) STAR, select the STAR, APPR and TRANS as specified in Vol. 1, SP.11. 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 is changed comply with procedures in Vol. 1, SP.11. If a change is made to a runway dependent arrival, lateral revisions should normally be made at or after the crossing restriction and at or before the last common point for the runway. If the arrival is not runway dependent lateral revisions should be made prior to the discontinuity.

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.



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.

Note: When cleared for an unexpected altitude/airspeed crossing restriction, enter the crossing restriction altitude in the FCP window first, then do a quick 3:1 descent calculation to determine the proximity to the new top of descent point. If approaching the TOD, initiate descent prior to entering the waypoint restriction in the FMS. Failure to make a good 3:1 calculation may result in a failure to comply with the crossing restriction.



Descent Speed Determination

Descent airspeed can be controlled by the FMS or with speed select on the FCP. FMS ECON is the recommended descent speed mode.

The flight control computers will maintain the selected airspeed by adjusting pitch or thrust. PROF descents are normally speed on thrust. However, when the FMA altitude window displays magenta IDLE (for above path PROF descents, or PROF descents initiated with level change), the PROF descent is speed on pitch. Level Change descents are speed on pitch while V/S or FPA descents are speed on thrust.

During descent, the color of the control mode (PITCH/THRUST) in the FMA airspeed window indicates which speed mode is currently active:

- ECON - both the airspeed value and the control mode are magenta.
- EDIT (or MAX) - the airspeed value is white and the control mode is magenta.
- Speed select - both the airspeed value and the control mode are white.

Note: When operating in FMS EDIT mode and the EDIT speed is within 4 knots of the ECON speed, the speed value in the FMA airspeed window will be magenta. When operating in speed select and the selected airspeed is within 4 knots of the active FMS speed the speed value in the FMA airspeed window will be magenta.

Note: Using speed select while descending in PROF is not recommended. The FMS will continue to use the active FMS speed (large font) to make its calculations.

The PERF DES page displays the three FMS speed modes: ECON, MAX and EDIT. The active FMS speed mode is displayed in large font. The active FMS speed mode can be changed by line selecting the desired mode on the PERF DES page.

ECON and MAX airspeeds are calculated by the FMS. ECON is the most economical descent rate and MAX is the maximum rate of descent. EDIT airspeeds can be modified prior to or during the descent by line selecting the desired airspeed on the EDIT line of the PERF DES page. FMS airspeed can also be edited by selecting the desired airspeed on the FCP and then pushing the FMS speed switch within 10 seconds.

Note: EDIT airspeeds can be modified but not cleared.

When speed select is engaged, the active FMS speed will be the speed that the FMS uses for its vertical path calculations. When the FMS SPD switch is re-selected, the active speed mode (ECON, EDIT, MAX) will resume control of the airspeed.

Note: If EDIT or MAX is the active speed mode when FMS SPD is selected, a second push of the FMS SPD switch will change the FMS speed mode to ECON.

Note: When operating in speed select in the terminal area, any FMS speed EDITS should be cleared (re-select ECON) so the FMS can use ECON speed for its calculations. This also sets up normal speed sequencing during final approach.

250/10,000 DES SPD Limit

When descending in FMS speed (ECON, EDIT or MAX) the airplane will begin to the transition to 245 knots at 12,000 feet MSL. If this speed reduction is not desired, use speed select to maintain a higher airspeed. The 250/10,000 DES SPD LIMIT is located on the F-PLN FROM point on the vertical revision page. The 250/10,000 value can be modified, however, making changes is strongly discouraged. Changes to the DES SPD LIMIT are not cleared when the FMS resets between legs.

F-PLN Speed Limits

The FMS will comply with an airspeed constraint programmed on the F-PLN or VERT REV page. After the speed constrained waypoint has been sequenced and becomes the FROM waypoint, that airspeed becomes the maximum speed limit for the FMS. Speeds greater than this maximum speed cannot be edited in the FMS (ECON or EDIT) until the speed is cleared from the FMS. This is accomplished by selecting the VERT REV page of the FROM waypoint and selecting the CLEAR SPD prompt (2L).

Note: When a speed constraint has been entered at a waypoint, as the airplane approaches that waypoint, the FMA airspeed window will look like an FMS speed EDIT (white speed value, magenta THRUST). However, once that waypoint has been sequenced and it becomes the FROM waypoint, the speed limit value will become magenta. The FMA airspeed window will look like it is in ECON, but it is not.



Policy Speed

In DES mode only, ECON speed can be changed to a POLICY speed by entering a value on the ECON line of the PERF DES page. Use of POLICY speed is not recommended. POLICY speed is a fixed value and is displayed on the FMA like ECON. However, POLICY overrides the normal FMS ECON speed computations during approach. FMS SPD will not be available for the transition to VREF on final approach. The only way to restore ECON is to use the CLR key to remove POLICY. POLICY is not reset to ECON when the FMS resets between legs. It will remain in the FMS until manually cleared.

Note: FMS speed edits made on the PERF CLB page will propagate to the PERF CRZ page. FMS speed edits made on the PERF CRZ page will NOT propagate to the PERF DES page. If given a clearance to descend from a cruise altitude and at the same time to reduce airspeed, initiate the descent first and then reduce airspeed. This puts you in DES mode first and your speed EDIT will be a DES speed EDIT. If you reduce airspeed first you are making a CRZ speed EDIT and not a DES speed EDIT. When you subsequently initiate descent your speed EDIT will be lost as you transition to ECON DES speed.

Note: When descending in PROF or level change and a speed greater than VMO is selected on the FCP a white bug will remain at VMO-5 and the selected speed bug will turn red. The ATS will maintain VMO-5, if the ATS is off it will automatically reengage to maintain VMO-5. During descent with the throttles at idle the ATS will adjust the pitch to maintain VMO-5. There is no overspeed protection when descending in V/S mode.

Descent Path

CAUTION: During descent, if actual conditions vary significantly from forecasts or if improper inputs are made in the FMS, it is possible for PROF to miss a crossing restriction. All PROF descents should be closely monitored on the FMA and PERF DES page. It is good technique to frequently back up the FMS PROF path with mental 3:1 calculations.

PROF is an FMS function that does an excellent job of calculating and tracking descent paths and making crossing restrictions. The FMS calculated PROF path is usually the most economical descent method. The PROF path will comply with all altitude and airspeed restrictions that are programmed into the FMS. Use of PROF during descents with crossing restrictions is strongly encouraged.

The 1L line on the PERF DES page displays the airplane deviation from the FMS PROF path. The vertical deviation is first displayed in feet followed by the horizontal deviation in NMs. The values indicate the position of the airplane with the respect to the calculated FMS PROF path.

When the FMS calculates the PROF path, the path to the first crossing restriction is an optimum path. This optimum path approximates an idle path, but it is actually a speed on thrust descent. It is typical for the ATS to adjust power throughout the descent to maintain the calculated PROF path.

Note: The FMS will “look across” a route discontinuity to find an altitude restriction from which to build the PROF path. Be aware of the constraint the FMS is using to create your TOD point.

The FMS uses many factors to calculate the optimum PROF path. Only three of these are pilot selectable: forecast descent winds, planned descent speed and the forecast ANTI-ICE prompt.

Descent winds should be loaded into the DESCENT FORECAST page. Strong forecast headwinds will increase the slope of the PROF path, moving the TOD closer to the destination. Similarly strong forecast tailwinds will decrease the slope of the PROF path, moving the TOD farther away from the destination. Differences in forecast and actual winds will not change the PROF path but may cause the ATS to adjust power to maintain the PROF path.



717 Flight Crew Training Manual

ECON is the default descent speed that the FMS uses to calculate the PROF path. If an airspeed other than ECON is desired for the descent, it should be pre-selected and activated on the PERF DES page. Changes to the descent speed will force the FMS to recalculate the PROF path. Increases in descent speed will result in a steeper PROF path (TOD closer to destination), while decreases in descent speed will result in a shallower PROF path (TOD farther from destination). If descending on an optimum PROF path and ATC directs a change in airspeed, the change should be made via FMS speed EDIT so the FMS can calculate a new path based on the new speed.

Use of engine and/or airfoil anti-ice causes the engines to operate at high idle. This will result in significantly decreased descent rates and may affect the FMS' ability to make crossing restrictions. There are a number of ways to manage this threat. One of these is to select the ANTI-ICE prompt on the DESCENT FORECAST page to ON. This is a descent planning tool which creates a new TOD and PROF path based on the HIGH IDLE power setting. If anticipating icing conditions during descent, the ANTI-ICE prompt should be turned ON during cruise, well before the TOD.

Note: If the descent is initiated with the ANTI-ICE prompt OFF and icing conditions are subsequently encountered, it is neither required nor recommended that the ANTI-ICE prompt be turned ON. Re-calculating the PROF path during descent with the Anti-Ice prompt ON may cause overcorrection by the FMS, resulting in decreased fuel efficiency.

Note: Use of the ANTI-ICE prompt in the absence of icing conditions to create a “pad” to comply with crossing restrictions is not recommended.

Note: The engine anti-icing system should be ON whenever icing conditions exist or are anticipated. During all phases of flight, air foil anti-ice should be used if icing conditions exist.

Power on Paths

If there is more than one crossing restriction in the FMS, the descent to the first restriction will be an optimal path. The descent to each subsequent waypoint restriction will be a “straight line,” or power-on, path descent. This is common with many “descend via” clearances. Although this may not be the most economical descent, PROF does an excellent job managing the descent and decreasing cockpit workload.

The slope of each power on path segment is defined by the distance and altitude difference between the two waypoints. As each waypoint is sequenced, its data is deleted and no longer used in making FMS calculations. Therefore, if descending on a power on path and something happens that forces the FMS to recalculate (or refresh) the path, the FROM point data is no longer available and the FMS cannot re-create the current power on path segment. In this case the FMS creates a new optimum path to the next waypoint restriction.

This FMS refresh occurs with a new route clearance. For example, if while descending on a shallow, power-on path, you are cleared to a subsequent waypoint, the FMS will recalculate a new optimum path to that new active waypoint. With this recalculation, the aircraft will transition from a descent ON the shallow, power-on path to being well BELOW the new optimum path. PROF will remain active, the FMA will display a magenta V/S, and the descent rate will default to approximately 750 fpm.

There are situations when it may be beneficial to intentionally “refresh” the FMS and move from a PROF power path to the PROF optimum path. This refresh can be accomplished in a number of ways. Re-entering the cost index is one method, but anything that forces the FMS to recalculate will suffice.

For example, the flight has been cleared to cross a waypoint altitude restriction. After complying with the restriction and no further descent clearance is received, the aircraft will begin to go above the shallow power on PROF path. Although there is plenty of distance to make the next restriction while not actually high on a 3:1 descent path, the FMS will show you high. Refreshing the FMS by re-entering the cost index removes the old power on PROF path and replaces it with a new optimum PROF path. The aircraft will then transition from being above to below path.



Descent Constraints

Note: If the altitude for a waypoint with two altitude restrictions (e.g. at or above 10,000 and below 12,000) is modified one of the altitudes will be deleted and cannot be reentered without reloading the departure or arrival.

Descent constraints may be automatically entered in the route when selecting an arrival procedure, or manually entered directly on the F-PLN page or the VERT REV page. The aircraft will attempt to meet these constraints as long as PROF mode is being used.

For descents in pitch modes other than PROF path, the FCP altitude must be set at the next altitude constraint, or as published in the Vol. 1 for an instrument approach.

Shallow vertical path segments may result in the autothrottle supplying partial thrust to maintain the target speed. Vertical path segments steeper than an idle descent may require the use of speedbrakes for speed control. Deceleration requirements below cruise altitude (such as at 10,000 MSL) are accomplished based on a rate of descent of approximately 500 fpm. When a deceleration is required at top of descent, it is performed in level flight.

Note: The ADD DRAG message may indicate speed brakes are required to make the target altitude.

If PROF is used for descent, the lowest altitude restriction may be set in the FCP 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 PROF to any other descent mode (level change, V/S, or FPA), the next altitude restriction must be reset in the FCP 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 FMS will transition into DES mode at TOD. If operating in PROF and a lower altitude has been selected in the FCP, the FMS will initiate descent at TOD. The FMS can be placed into DES mode prior to the TOD by manually initiating the descent with level change, V/S or FPA.

There are four descent modes: PROF, Level Change, V/S and FPA. PROF is the recommended descent mode if altitude and/or airspeed crossing restrictions are programmed in the FMS. V/S or Level Change is recommended in the terminal area once all descent constraints have been sequenced.

When descending in any of the four descent modes, the altitude value in the FMA altitude window will be magenta if that altitude is present in the F-PLN page AND it is the FMS Active Waypoint AND it is set in the FCP. Otherwise, the altitude value in the FMA altitude window will be white.

PROF Descent

PROF is selected with the PROF switch on the FCP. PROF can be deselected by selecting any other vertical mode (level change, altitude hold, V/S, or FPA).

PROF may be used with or without the ATS engaged. FMS speed (ECON, MAX or EDIT) is recommend for PROF descents.

When descending in PROF, the FMA altitude window will display either PROF, V/S or IDLE in magenta. During PROF descent intermediate level offs, the FMA altitude window will display HOLD in magenta.

In this example, the aircraft is descending in PROF to 12,000 feet at an FMS speed of 310 knots, with NAV engaged. A/P is on.





717 Flight Crew Training Manual

Level Change Descent

Pulling the altitude select knob after selecting a lower altitude on the FCP will initiate a level change descent. The autothrottles will retard to idle and IDLE CLAMP will be displayed in white in the altitude window of the FMA. The descent rate can be changed by adjusting the throttles after IDLE CLAMP is displayed. FMS altitude constraints are not honored in Level Change.

In this example, the aircraft is descending in Level Change to 16,000 feet at a selected speed of 336 knots, with NAV engaged. A/P is on.

336	PITCH	NAV1 AP1	IDLE CLAMP 16000

Note: When hand flying with the ATS on and IDLE CLAMP displayed, speed will not be maintained by ATS Thrust. Selecting a speed on THRUST descent mode (V/S or FPA) is a better technique.

Note: During a Level Change descent, airspeed can still be controlled by the FMS (ECON, MAX DES or EDIT). When flying a level change descent in FMS speed, the aircraft will slow to 245 knots between 12,000 and 10,000 feet, IDLE CLAMP will be displayed in white, and 245 PITCH will be displayed in magenta in the speed window of the FMA.

Vertical Speed Descent

In the Vertical Speed descent mode, the FCP commands pitch to maintain the selected vertical speed and varies the thrust to maintain the target airspeed. When descending in vertical speed, the FMA altitude will display V/S in white.

The V/S mode is useful for flying a constant descent rate or for making small altitude changes (less than 1,000 feet).

In the V/S mode, FMS altitude and speed constraints are not honored.

The V/S mode may be used anytime during the flight. A V/S descent is initiated by selecting a lower altitude in the FCP altitude window and rotating the pitch wheel to the desired vertical speed.

In this example, the aircraft is descending to 16,000 at 293 knots with V/S, speed select and heading engaged. A/P is on.

293	THRUST	HEADING 278 AP1	V/S 16000

Note: A V/S descent will depart the existing FCP selected altitude.

Note: During a V/S descent, airspeed can still be controlled by the FMS (ECON, MAX DES, or EDIT). If flying a V/S FMS speed descent, the FMS speed will decrease to 245 knots between 12,000 and 10,000 feet. However the commanded V/S will take priority over the speed reduction and the aircraft may not decelerate.

When determining the 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 wind conditions during the descent and monitor the airspeed to comply with any constraints.

If V/S or FPA Mode is used, the autopilot will maintain the speed set in the airspeed window only within the limits of available thrust. Once the throttles reach idle, the aircraft will accelerate as necessary to maintain the commanded V/S or FPA.

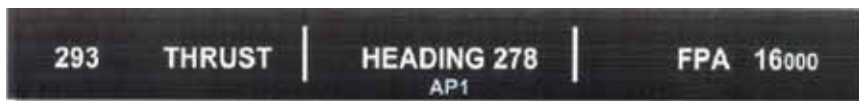
Note: The ATS does not provide overspeed protection if descending in V/S or FPA.

Flight Path Angle

Flight Path Angle (FPA) mode is selected by pressing the FPA - V/S select switch. In FPA descent mode, the FMS will command a pitch to maintain the selected flight path angle. When descending in FPA, the FMA altitude mode will display FPA in white. 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.

In this example, the aircraft is descending to 16,000 at 293 knots with FPA, speed select and heading engaged. A/P is on.



Note: If the target airspeed is being maintained with FPA or V/S selected, extending the speedbrakes will not increase the descent rate or slow the aircraft. The speedbrakes are useful in FPA and V/S only if the target airspeed cannot be maintained.



717 Flight Crew Training Manual

Descent Paths Using PROF

Normally the initial stages of the descent will be conducted in PROF. However, level change is recommended while on vectors in the terminal area. PROF is highly recommended for RNAV arrivals and approaches with multiple crossing restrictions.

On Path Descent

When PROF and FMS speed modes are engaged and when cleared for descent, the pilot should set the lower altitude in the FCP altitude window without pulling the altitude select knob. This removes the existing FCP altitude constraint, and allows the airplane to descend at the TOD point.

When the new lower altitude has been set on the FCP, a magenta PROF TO will be displayed in small text along with the FCP selected altitude in the upper portion of the FMA altitude window. If the selected FCP altitude corresponds with an FMS vertical constraint the FMA target altitude is displayed in magenta. Otherwise it will be displayed in white.

When the TOD point or subsequent altitude constraint waypoint is reached, PROF TO will be replaced by a flashing VERT ALERT message for 5 seconds and then HOLD will change to PROF and the aircraft will descend to the new altitude.

The examples below show a descent initiated at the TOD from FL240 to 14,000 feet.

305	THRUST	NAV1 AP1	PROF TO 14000 HOLD 24000

.305	THRUST	NAV1 AP1	VERT ALERT HOLD 24000

305	THRUST	NAV1 AP1	PROF 14000

As the aircraft descends the magenta PROF in the altitude control window indicates the aircraft is in an FMS PROF descent AND on the optimum descent path.

Note: The PERF DES page or VDI should be closely monitored during descent to ensure that the airplane continues to track the PROF path.



CAUTION: During descent, if an altimeter BARO change of more than .20 IN (~6.8 HP) is made within 2000 feet of an FMS PROF mode constraint altitude, FMS PROF mode may be unreliable for vertical guidance and level-off, unless the altitude restriction is also selected in the FCP altitude window. Subsequent FMS PROF mode operation will be normal.

Note: During descent, increasing the captain's BAROSET may initially cause the airplane to slightly accelerate above the current speed target.

Below Path Descent

CAUTION: Failure to re-select PROF after adjusting the descent rate may result in missing the crossing restriction.

In order to initiate a below path PROF descent, a manual descent mode (level change, V/S or FPA) must be selected. This takes the FMS out of PROF and transitions the FMS from CRZ mode to DES mode. Once the DES has been initiated, PROF should be re-engaged. PROF will continue the descent at the previously selected rate. Changes may be made to the selected descent rate by adjusting the pitch wheel or selecting level change. In either case, re-select PROF after adjusting the descent rate.

Note: In a below path descent, a magenta open circle with the symbol I/P next to it on the ND magenta track line indicates the point at which the optimum PROF path will be intercepted.

If the descent was initiated with V/S, a white V/S will be displayed in the FMA altitude window. After PROF is re-selected, the V/S will turn magenta. The descent airspeed mode will be speed on THRUST, and the FMA airspeed window will display a magenta THRUST. The magenta V/S indicates that the airplane is currently descending below the optimum path with PROF mode active. This indicates that when the airplane intercepts the optimum path, it will join it and descend via that path to make the crossing restriction.

If the descent was initiated with Level Change, a white IDLE CLAMP will be displayed in the FMA altitude window. After PROF is re-selected, the FMA altitude window will display a magenta IDLE. The descent airspeed mode will be speed on PITCH and the FMA airspeed window will display a magenta PITCH. In this case the airplane is in an IDLE (speed on pitch) descent. In this situation, it is likely that the airplane will continue to descend below the optimum PROF path and reach the crossing restriction altitude early. However, if conditions changed (airspeed decrease, ANTI-ICE ON) and the airplane intercepted the optimum PROF path it would join and descend via that path.



717 Flight Crew Training Manual

A typical early descent in PROF mode would occur as follows. Prior to TOD, clearance to descend to FL240 is received. The FCP altitude is preselected to the cleared altitude and the V/S wheel is used to select 1,000 fpm descent. PROF mode is reengaged causing the FMS to fly 1,000 fpm until the descent path is intercepted and flown.

This example shows a below path descent in PROF to FL240, an FMS speed of 290, and NAV selected. A/P is on.



During descent is not uncommon for situations to change that require the FMS to recalculate the optimum PROF path. Typically these are airspeed changes. For example, descending on the optimum PROF path at 310 knots with a crossing restriction of 250 knots and 12,000 feet programmed in the FMS. ATC advises to delete the speed restriction. When the 250 knot restriction is removed a new PROF path is calculated which has a steeper slope and the airplane is suddenly below path.

When the PROF path is recalculated and the airplane transitions from on path to below path, the FMA altitude window will change from magenta PROF to magenta V/S and the rate of descent will default to 750 fpm. The intent of the FMS is to slow the descent rate and rejoin the optimum PROF path.

Shadow Path

Strategically using level change to initiate IDLE power below path descents is referred to as a shadow path. The intent of a shadow path is to anticipate conditions that might cause the airplane to go ABOVE the optimum PROF path (e.g. an early speed reduction or the need for anti-ice). If such conditions exist, it is acceptable to initiate a shadow path 5-7 miles prior to TOD. Again, while using the shadow path, continue to monitor the PERF DES page, adjusting the descent rate and re-selecting PROF as necessary.

Above Path Descent

Upon reaching the TOD, the FMS will transition from CRZ to DES mode. If a lower altitude has not been set in the FCP, the airplane will continue at cruise altitude in an above path condition.

There are several indications the airplane is still in cruise and above path:

- The value in the FMA altitude window changes from magenta to white, indicating that the FMS has transitioned to DES mode and the current altitude is no longer desired altitude.
- The PERF DES page shows the airplane is long and high (above path)



- The Vertical Deviation Indicator on the ADI appears and shows the airplane to be high.
- The DECEL* prompt appears on the F-PLN page at 1R.

After receiving a descent clearance and setting the new lower altitude in the FCP, the airplane will begin an above path idle descent. The ATS will retard to idle, the FMA altitude window will display a magenta IDLE, and the FMA airspeed window will display a magenta PITCH, as shown in the example below.



If more than 300 feet above descent path, the FMS will increase speed to ECON + 20 (not to exceed VMO - 10 knots) to recapture the path. The FMS speed should not increase if FMS EDIT speed is being used. If the return to path speed (ECON + 20) is insufficient to return to path before reaching an altitude constraint, the message ADD DRAG is displayed on the ND. Speed brakes may be needed to help regain the path. When the path can be made without speed brakes, the ADD DRAG message extinguishes. If an altitude constraint cannot be met, the MCDU message ALTITUDE ERROR AT FLCON (as one constraint waypoint example) is displayed.

If descending on the optimum PROF path and operating in FMS ECON speed airspeed may gradually increase to help maintain the path. When airspeed is 10 knots faster than the target the ADD DRAG message is displayed on the ND. The ADD DRAG message is removed when the speed is 3 knots above target airspeed. As speed decays below target -5 knots, the RMV DRAG message is displayed. If on path and speed constraint cannot be met, the message SPD ERROR AT ERLIN (as one constraint waypoint example) is shown.

Note: ADD DRAG and RMV DRAG are advisory messages. The amount of drag added or reduced is at the discretion of the pilot. The ADD DRAG message is not displayed in cases of the FMS level flight segments when airspeed is higher than required.

When the FMS uses speed to recapture the PROF path, and needs to transition through 10,000 feet, the message SPEED LIMIT EXCEEDED will appear in the scratchpad. The aircraft will slow to 245 knots at approximately 10,500 feet, and once 245 knots has been reached, the message will be cleared and the aircraft will resume the PROF descent.

**PROF Descents and VMO Overspeeds**

The FMS does not schedule airspeeds in excess of VMO-10. However, fast descent speeds, high cost indexes or above path descents may result in the aircraft operating at or near VMO-10. Due to limitations of the aircraft automation, differences between actual and forecast descent winds, and/or turbulence may result in temporary airspeed deviations greater than VMO. When operating at or near VMO-10 exercise caution and be prepared to intervene with speedbrakes to prevent overspeeds. Additionally, consider slowing to an airspeed of VMO-20 or less to mitigate the overspeed threat.

Note: When descending on an optimum PROF path the FMS is operating in speed on THRUST mode and will accordingly adjust throttles and airspeed to maintain path and speed. If the aircraft experiences “pressure” on the path due to less than forecast headwinds or greater than forecast tailwinds the FMS will prioritize the path and increase the airspeed to maintain the PROF path. If operating at or near VMO-10 this airspeed acceleration may result in an overspeed.

Note: Use of the shadow path (or level change) puts the airplane in a speed on PITCH descent. In this case, the FMS would not increase airspeed to maintain path. If operating at or near VMO-10 making a speed on PITCH descent will help mitigate the overspeed threat.

Note: When descending in an above PROF path condition, airspeed may increase up to 20 knots to help the aircraft regain the path. This increase in speed will not exceed VMO-10. Any light chop, or sometimes the shear momentum of the speed increase to recapture the path, will cause an overspeed. Use edit speed, speed select, speed brakes, level change or any appropriate combination of the four to mitigate this threat.

Descent Rates

The following Descent Rate table provides 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	2,200 fpm	4,000 fpm
250 knots	1,700 fpm	3,200 fpm
210 knots slats extended	1,700 fpm	2,300 fpm

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 60 seconds and 7 nm to decelerate from 320 to 250 knots in level flight without speedbrakes. It requires an additional 25 seconds and 2 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.

Note: Be aware that full speedbrake extension increases VMIN approximately 10 knots. If slats are not extended first, the ATS may increase power to keep airspeed above the foot.

While using the speedbrakes in descent, allow sufficient altitude and airspeed margin to level off smoothly. Retract the speedbrakes before adding thrust.

When descending with the autopilot engaged and the speedbrakes extended at speeds near VMO/MMO, the airspeed may momentarily increase above VMO/MMO if the speedbrakes are retracted quickly. To avoid this condition, smoothly and slowly retract the speedbrakes to allow the autopilot to adjust the pitch attitude to maintain the airspeed within limits.



717 Flight Crew Training Manual

When the speedbrakes are retracted during altitude capture near VMO/MMO, a momentary overspeed condition may occur. This is because the autopilot captures the selected altitude smoothly by maintaining a fixed path while the thrust is at or near idle. To avoid this condition, it may be necessary to reduce the selected speed and/or descent rate prior to altitude capture or reduce the selected speed and delay speedbrake retraction until thrust is increased to maintain level-off airspeed.

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, slats, flaps).

Note: Using the landing gear for increased drag potentially increases passenger discomfort and decreases gear door life.

Extend the flaps when in the terminal area and conditions require a reduction in airspeed below $V_{MIN} + 5$.

Engine Icing During Descent

CAUTION: Failure to follow the recommended anti-ice procedures can result in decaying airspeed, engine stall, overtemperature, engine damage, or engine failure.

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 windshield 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.

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.

Holding FMS Entries

The FMS holding function is used to insert a holding pattern with a pilot-controlled termination into the flight plan or to modify an existing holding pattern. The holding pattern may be inserted at any waypoint, to include the FROM waypoint for holding at the present position. A revision at an existing holding fix is permitted. Any inserted change becomes effective upon the next crossing of the holding fix. Changes are activated immediately if made on the active leg prior to entry of the holding pattern. A LAT REV (left LSK) provides access to the HOLD selection prompt and the holding page.

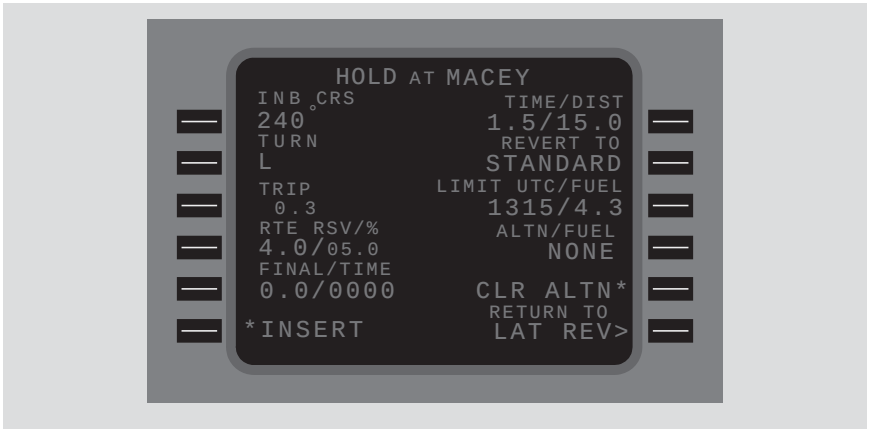
Note: When entering procedure turns or holding airspace, FMS NAV may not constrain the airplane from maneuvering beyond protected airspace. Pilots are responsible for procedural compliance, both in entry procedure and airspeed limits. The latter can be accomplished with an FMS speed constraint or FCP selected speed.

To enter a holding pattern at a specific waypoint, select the LAT REV key adjacent to the desired waypoint on the F-PLN page. On the LAT REV page select the HOLD prompt at LSK 2R. The FMS holding page is then displayed. The holding pattern may be modified. After the holding pattern is confirmed to be correct, selecting the INSERT key at LSK 6L will insert the HOLD into the F-PLN and it will be displayed on the ND.



717 Flight Crew Training Manual

If holding at the present position is desired, select the LAT REV key adjacent to the F-PLN FROM position at LSK 1L. Then select the HOLD prompt at LSK 2R. The standard holding page (which may be modified) is then displayed. Once confirmed and entered with the INSERT prompt the FMS and ND will display the HOLD and the aircraft will enter holding at the present position.



There are three types of FMS HOLDING. They are displayed in the HOLD title page. (MACEY is just one waypoint example.)

- HOLD AT MACEY - This is displayed when the holding pattern has been modified.
- DATABASE HOLD AT MACEY - This is displayed when the holding pattern is defined by the NAV database.
- STANDARD HOLD AT MACEY - This is displayed when a holding pattern is initially entered and a standard holding pattern is created by the FMS (default).

Additional HOLD page information:

- INB CRS (1L) - The holding inbound course defaults to:
 - Database or pilot-defined holding pattern inbound course, or
 - Inbound course from the flight plan, or
 - Current track (when page accessed) for PPOS holding.
- TURN option (2L) - default is right (R) but pilot may enter left (L) or (R).
- TRIP data (3L) - is the FMS calculated trip fuel from holding fix to destination.
- RTE RSV (4L) - Entered during preflight. This is FMS reserve fuel from the flight plan. May be edited.
- FINAL/TIME (5L) - Not used. Represents the fuel and time allowance for holding at an alternate.



-
- **TIME/DIST (1R)** - Is the time (in minutes) and leg distance of the holding pattern. Default time is 1.0 minute at or below 14,000 feet and 1.5 minutes above 14,000 feet. Either time or distance may be entered as the leg defining parameter but not both.
 - **REVERT TO STANDARD (2R)** - If STANDARD or DATABASE HOLD is modified, a prompt will appear at 2R that says REVERT TO STANDARD or REVERT TO DATABASE (as appropriate). Selecting this prompt will restore the original holding parameters.
 - **LIMIT UTC/FUEL (3R)** - Calculated values in LARGE font are shown and pilot entry is not allowed. Dashes displayed if value not available.
 - **LIMIT UTC** - Predicted time at which FOB is equal to LIMIT FUEL.
 - **LIMIT FUEL** - Fuel necessary to complete the flight plan with no changes to fuel reserves.
(LIMIT FUEL = TRIP + RTE RSV + ALTN + FINAL)
ALTN and FINAL not currently used, they are accounted for in FMS reserve fuel from flight plan.
 - **ALTN/FUEL (4R)** - Not normally used. This is the alternate airport and the fuel to fly from the destination airport to the alternate airport. If there is no alternate, then NONE is displayed. The fuel burn to the alternate is accounted for in the FMS reserve fuel from the flight plan, that is entered in the RTE RSV block. Normally we do not enter the alternate in the FMS during preflight.
 - **CLR ALTN (5R)** - Not normally used. This is displayed if an ALTN destination exists and it is desired to remove it. Normally we do not enter the alternate in the FMS during preflight.

Note: Holding speed edits must be entered by the pilot via the scratch pad into the appropriate LSK.

Note: Lateral revisions from holding fix on the F-PLN page must be entered at LSK 3L. Revisions from LSK 1L will result in loss of holding pattern in FLT PLN and on ND.



Holding Airspeeds

For maximum holding airspeeds, refer to the Airway Manual, Ops Specs, Maximum Holding Airspeeds.

If the FMS holding speed is greater than the ICAO or FAA maximum holding speed, holding may be conducted with reference to the foot ($V_{MIN} + 5$). Slats or flaps may be required to slow to the required holding speed. 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.

Three minutes prior to the holding fix while in FMS ECON speed, the airplane will begin a deceleration to the holding speed. The holding speed, like any other speed, is bounded by upper and lower speed envelopes ($V_{MAX} - 10$ and $V_{MIN} + 5$).

If the recommended holding speed exceeds the ICAO maximum holding speed for a given altitude, request clearance to hold at the higher speed. If using FMS ECON SPD, once flaps are extended the FMS speed target will be $V_{MIN} + 5$. If in an FMS EDIT, the speed target will remain at the EDIT speed during a hold, even when flaps are extended.

If descent in holding is required, the PROF descent rate defaults to 750 feet per min descent.

Note: If holding speed is not available from the FMS, refer to the ODM. If time does not permit immediate reference to the ODM, fly no slower than $V_{MIN} + 5$ knots. $V_{MIN} + 5$ knots provides a reasonable approximation of minimum fuel burn speed with appropriate margins to initial buffet.

Holding Pattern Exit

CAUTION: The PF must ensure that the ‘TO’ waypoint displayed on the ND is correct when leaving the holding pattern.

When exiting the holding pattern, the F-PLN page must be updated to enable proper waypoint sequencing. This can be done by:

- Selecting the EXIT AT FIX prompt (6R) on the FMS HOLD page. When executed, the aircraft will cross the holding fix and exit holding. If executed when outbound in the holding pattern the airplane will immediately turn inbound and exit holding when the fix is crossed.
- Entering a waypoint in the DIRECT TO field of the MCDU F-PLN.
- Clearing the holding fix from the MCDU F-PLN.
- Selecting a heading and then deleting the holding pattern from the F-PLN page. Ensure the next downstream waypoint is active to ensure proper waypoint sequencing.

The target airspeed will change to the speed appropriate for the phase of flight when exiting the holding pattern (e.g., from Holding 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.

Note: Pushing the EXIT AT FIX prompt displays the RESUME HOLD prompt. Pressing the RESUME HOLD prompt re-establishes holding and re-displays the EXIT AT FIX prompt.

Approach and Missed Approach

Chapter 5

Table of Contents

Section TOC

Approach	5.1
Instrument Approaches	5.1
Approach Category	5.2
Approach Clearance	5.2
Procedure Turn	5.3
Radio Altimeter	5.4
Sidestep	5.4
Runway Change	5.4
Maneuver Margin	5.5
Landing Performance Data	5.6
Quick Reference Landing Length	5.6
Flap Configurations for Approach and Landing	5.7
Flap Extension	5.7
Parallel Rudder	5.8
ILS Approach	5.9
ILS Approach Profile	5.9
ILS CAT I/II/III CAT I/II/III or LDA with GS	
Approach Guide	5.11
Approach	5.15
ILS PRM Approach	5.24
ILS Approach - Landing Geometry	5.29
Non - ILS Instrument Approaches	5.30
Non-ILS Approach Profile Using PROF	5.30
RNAV (GPS or GNSS), GPS, LOC, LDA (without GS),	
VOR, or NDB Expanded Approach Guide	5.32
Non-ILS Approach Profile Using FPA or V/S	5.36

RNAV (GPS or GNSS), GPS, ILS (G/S Out), LOC, LDA (without GS), VOR, or NDB Expanded Approach Guide NAV, LOC ONLY, or VOR ARM & FPA or V/S Modes	5.38
Non - ILS Instrument Approaches	5.42
Non - ILS Instrument Approaches - General	5.43
Non-ILS Instrument Approach Using NAV	5.46
Non-ILS Instrument Approach Using PROF	5.48
Non-ILS Instrument Approach Using FPA or V/S	5.50
Circling Maneuver	5.51
Circling Maneuver Profile	5.52
Approach Guide	5.54
Circling Maneuver - General	5.54
Obstruction Clearance	5.55
Missed Approach - Circling	5.57
Visual Approach	5.59
Visual Approach Profile	5.59
Approach Guide	5.61
Visual Approach - General	5.61
Internal Visual Cues	5.62
High Energy Approach	5.62
Engine Inoperative Approach Operations	5.63
ILS Approach Profile - One Engine Inoperative	5.64
ILS Approach - Engine Inoperative	5.66
Engine Inoperative, Rudder Trim - All Instrument Approaches	5.66
Non-ILS Instrument Approach Profile Using PROF - One Engine Inoperative	5.67
Non-ILS Instrument Approach Profile Using FPA or V/S - One Engine Inoperative	5.69
Non - ILS Approach - One Engine Inoperative	5.71

 DELTA
717 Flight Crew Training Manual

Circling Maneuver Profile - One Engine Inoperative	5.72
Circling Maneuver - One Engine Inoperative	5.74
Engine Failure On Final Approach	5.74
Go-Around and Missed Approach Profile - One Engine Inoperative	5.75
Go-Around and Missed Approach - One Engine Inoperative	5.77
Engine Failure During Go-Around and Missed Approach	5.79
Go-Around and Missed Approach - All Approaches	5.80
Go-Around and Missed Approach Profile - All Approaches	5.80
Go-Around and Missed Approach - All Engines Operating	5.82
Go-Around after Touchdown	5.86

Intentionally
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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 F-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 FCP heading, altitude, and airspeed selectors. Updating the waypoint sequence on the F-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. Verify ILS, LOC, or VOR are tuned and identified if required for the approach.

For ILS approaches, if the approach has been entered into the FMS and the aircraft is within 25 nm of the navaid, the FMS will auto tune the ILS localizer, GS and DME (if available). The appearance of the ILS frequency on the PFD indicates that the FMS has tuned the appropriate navaid. The appearance of the four letter identifier on the PFD indicates that the navaid is tuned and identified.

If cleared to intercept a localizer outside of 25 nm, the final approach course may be intercepted by using NAV until within 25 nm or by entering the localizer frequency (or four letter identifier) and inbound course on the NAV RAD page and selecting LOC ONLY.

CAUTION: When hard tuning an ILS, if the inbound localizer course is not entered on the NAV RAD page, localizer and GS raw data will still be displayed on the PFD, however the FCCs will not capture and track the data.

CAUTION: If a previous ILS frequency is hard tuned on the NAV RAD page, it will prevent the FMS from auto tuning the ILS frequency for the approach loaded in the FMS.

Note: If the aircraft is within 20 nm of the destination and invalid data is continually received for three seconds, the MCDU scratchpad message ILS UNTUNABLE is displayed. The frequency should be confirmed by the crew and, if necessary, manually tuned and identified.

For ILS (GS out) and LOC only approaches, the Localizer will auto tune as described above.

For VOR approaches, the use of NAV is recommended. The appropriate VOR frequency (or identifier) and final approach course may be hard tuned on the NAV RAD page at 1L (or 1R). Selecting 2L (or 2R) displays a VOR ARMED prompt which arms the FCCs to capture the VOR course. VOR ARMED will be displayed on the FMA. When the course is captured, VOR TRACK is displayed on both the FMA and NAV RAD page.

NDB frequencies cannot be manually tuned or displayed. NDB approaches will be flown using NAV.

Note: The requirement to tune and identify nav aids can be satisfied by confirming that the correct approach is loaded in the FMS, or has been manually entered on the NAV RAD page.

Check that the marker beacon is selected on the audio panel, if needed. The course and glideslope signals are reliable only when their warning flags are not displayed, localizer and glideslope pointers are in view, and the ILS identifier is received. Confirm the published approach inbound course is displayed on the F-PLN or NAV RAD page.

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 Airway Manual, Ops Spec, IAP.

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 PROF prior to final approach fix, all altitude and speed constraints must be entered either manually, by selecting a published approach, or by a combination of both. When properly entered, PROF complies with all altitude and airspeed constraints. Crossing altitudes may be higher than the minimum altitudes for that segment because PROF is designed to optimize descent profiles.

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-depicted procedure turn, or holding pattern in lieu of procedure turn, complies with airspace limits. The published procedure turn altitudes are normally minimum altitudes.

The procedure turn size is determined by the ground speed at the IAF.

Verify on the ND that the procedure turn direction and entry are correct.

Some procedure turns for approaches are contained in FMS data base and may be entered into the FMS as an approach transition. Once the procedure turn has been entered in the FMS, a line will appear as a waypoint on the F-PLN page with the words PROCT INTCPT. The procedure turn will be depicted on the ND in reduced size until the procedure turn waypoint is the TO point. At that point, the procedure turn ND depiction will increase to actual size.

It is possible to manually enter a procedure turn by making a lateral revision at the desired waypoint and selecting the procedure turn prompt (3R). Three entries are required to create a manual procedure turn:

- OUTB CRS - This is the outbound offset course. The FMS calculates the reciprocal inbound course.
- INB DIST - This is the distance to be flown on the final approach course prior to the final approach fix.
- INB CRS - This is the desired course to the procedure fix on the inbound leg (usually the final approach course).

After these three entries are made, the FMS checks the integrity of the entries and, if satisfactory, displays the insert prompt.

Note: If the FMS and aircraft are not capable of making the FMS programmed turn, the track line on the ND will be broken or inappropriate for proper entry procedures. It is preferable to align the aircraft for procedure turn entry to best fly the procedure turn track.

WARNING: When utilizing FMS flight guidance, it remains pilot responsibility to ensure the aircraft flight profiles and path conform to the issued clearance. In some cases, FMS NAV may not constrain the aircraft to safe maneuvering airspace.

Refer to Airway Manual, Ops Specs, IAP.

Radio Altimeter

A Radio Altimeter (RA) is normally used to determine DH when a DA(H) is specified for Category II or 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. The radio altimeter is not used for determining CAT I DA/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 the Airway Manual, Ops Specs, IAP.

Sidestep Procedure

Pilot Flying	Pilot Monitoring
A/P - Disengage	NAV RAD key - Push Hard tune the new ILS frequency and course. Push APPR/LAND
Maneuver as required to intercept the new localizer course and glide slope. Note: The FMA will display heading and vertical speed until the localizer and glide slope are captured.	Notify the PF when the autopilot is available.

Runway Change

Time permitting, the runway change should be made in the FMS. Depending on the phase of flight, this may include updating the STAR, TRANS and APPR through the LAT REV page. Refer to Vol. 1, SP.11, for the Arrival Change procedure.

An alternate method of changing the runway, (and if necessary the STAR, TRANS and APPR) in the FMS is through SEC F-PLN. Refer to SEC F-PLN procedures in Vol. 1, SP.11.

If a runway change is assigned while flying a runway dependent STAR, lateral revisions should normally be made at or after any manually entered crossing restriction waypoint and at or before the last common waypoint on the arrival.



717 Flight Crew Training Manual

When assigned a runway change while conducting a runway dependent STAR, choosing to LAT REV from a waypoint prior to the manually entered waypoint crossing restriction will delete the crossing restriction. This may result in failure to meet an ATC assigned crossing restriction.

When assigned a runway change while conducting a runway dependent STAR, choosing to LAT REV from a waypoint after the last common point will cause the FMS to create a DISCON after the selected waypoint, and then insert the entire TRANS, STAR and APPR to the new runway. This can be corrected by selecting the last common point and performing a new LAT REV.

If the runway change is given after passing the last common waypoint on a runway dependent arrival, ATC must assign vectors to the final approach course. The new runway may be entered in the FMS by making a lateral revision at the FMS TO waypoint, selecting the new APPR, and clearing the STAR and TRANS (as necessary).

If the arrival is not runway dependent, lateral revisions should be made at the last waypoint prior to the F-PLN discontinuity between the arrival and approach segments.

Maneuver Margin

Flight profiles should be flown at VMIN + 5 for the existing flap configuration. These speeds approximate maximum fuel economy and allow full maneuvering capability (25° bank with a 15° overshoot).

Note: Extending speedbrakes will increase VMIN up to 10 knots. If operating at or near VMIN and increased drag is required, extend slats or flaps as necessary, or increase speed to a minimum of VMIN + 10 prior to extending speedbrakes. If speedbrakes are extended and the current airspeed is below the new VMIN, the ATS will advance the throttles to the new VMIN + 5.

Full maneuver margin exists for all normal landing procedures whenever speed is at or above VMIN. Observe the bank angle limit on the top of PFD attitude sphere.

Adequate maneuver margin exists with flaps 13 at VMIN + 5 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. If it is necessary to apply wind additives to the VREF speeds, refer to Chapter 1, Command Speeds, for an explanation of wind additives.

Landing Performance Data

The ODM FAR Dry Landing Field Length chart shows distances for flaps 40, 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 VREF.
- Maximum braking, speed brakes extended, and no reverse thrust.

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 40 approaches and landings may be conducted normally without reference to the ODM Landing Distances table according to the following guidance.

Quick Reference Landing Length	
Includes a 15% Safety Margin	
Refer to the ODM for landings with abnormal configurations, MCOs affecting landing distance, or if above the maximum landing weight (MLW).	
Quick Reference Minimum Runway Length	717
	7,000 feet

Assumptions:

- Airport elevation 4,000 feet or less (including KSLC and KDEN)
- Touchdown no later than 1,500 feet from threshold
- Up to Max Landing Weight
- Max manual braking
- Wet or Dry runway
- Zero wind and runway slope
- Two engines at full reverse thrust

Additional stopping performance is available by:

- 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 13 or 18 with the gear up is acceptable.

FLAPS 40 Landing

Flaps 40 is the normal landing configuration.

Flap Extension

During flap extension, selection of the next flap setting should be made when approaching, and before decelerating below, the minimums speed displayed on the PFD speed tape as the top of the amber band, or the foot (VMIN). These minimum speeds are also listed on the FMS TO/APPR page. The foot varies with aircraft weight and provides full maneuver capability or at least 40° of bank (25° angle of bank and 15° overshoot) to stick shaker at all weights.

The most efficient method for decelerating is to “lead with speed.” When setting a slower speed which will require a configuration change, set the lower airspeed value first, then follow the power reduction with the desired configuration change. This prevents a burst of power by the autothrottles.

Stick shaker activation may occur while operating near the flap minimum maneuvering speed due to:

- Operating with the speed brakes extended
- Maneuvering at or below the minimum speed for the selected flap setting
- Maneuvering or encountering turbulence at high gross weights.

Parallel Rudder

The Flight Control Computer operation of the rudder can be in either Series or Parallel mode.

In Series, the rudder acts as a yaw damper and turn coordinator with the autopilot engaged or disengaged. Motion of the rudder is not fed back to the rudder pedals and rudder authority is limited to 2°.

Parallel rudder is an engaged autopilot mode in which the autopilot is given full authority to control the rudder. During parallel rudder operation, rudder motion is fed back to the rudder pedals and rudder authority is limited to 27°.

The purpose of parallel rudder is to give the FCC the ability to manage greater asymmetry including full thrust on one engine and no thrust on the other. Parallel rudder is also used to ALIGN the aircraft at 150 feet AGL during an autoland.

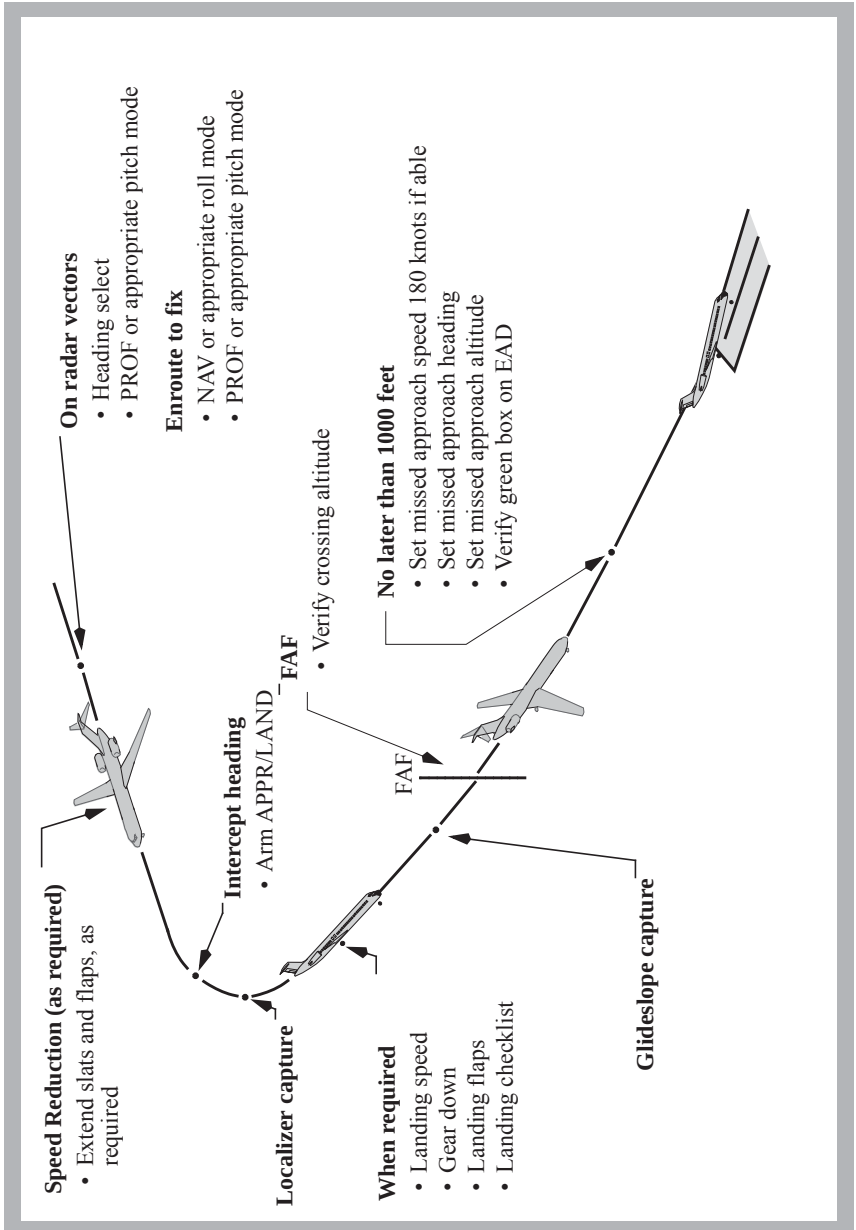
Parallel rudder is automatically commanded when the autopilot is engaged during takeoff, go-around and anytime the FMA indicates AUTOLAND.

When Parallel mode is engaged, the bank angle limiter on the PFD will indicate 10° or less.

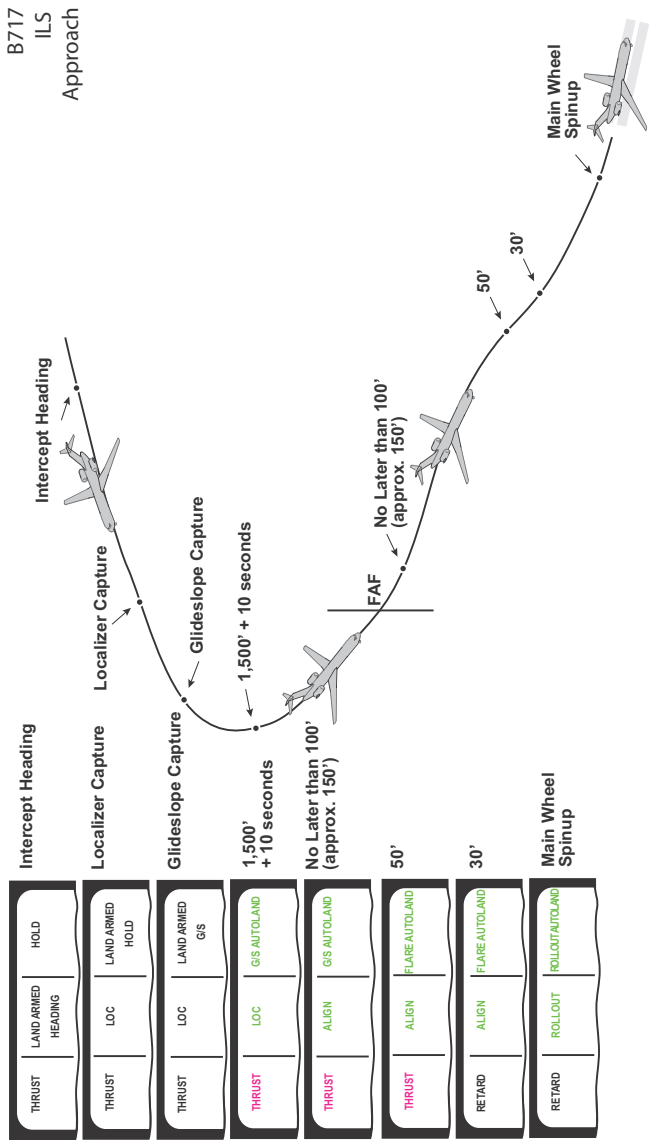
Parallel mode will terminate during takeoff or GA when a new lateral mode is selected (heading select, heading hold, or NAV) or when the flaps and slats are retracted (clean configuration). The bank angle limiter will then return to normal and the rudder pedals will rapidly return to their non-corrected position. Pilots should be prepared to make proper rudder inputs when parallel rudder is terminated.

ILS Approach

ILS Approach Profile



FMA Progression





ILS CAT I/II/III CAT I/II/III or LDA with GS Approach Guide

APPR/LAND Mode

For inoperative equipment, refer to the QRH, Non-Normal Ops Info tab, ILS Approach Equipment Requirements.

For any inoperative ground based equipment, refer to the Airway Manual, Ops Specs, IAP.

For approaches not in the FMS database, refer to Vol. 1, SP.11.

Note: For CAT I and CAT II approaches, the aircraft may continue to DA(H) if established on the final segment and the controlling RVR goes below minimums. Specific foreign country exceptions may apply.

Note: For CAT III approaches, if the aircraft is established on the final approach segment and the controlling RVR decreases below the authorized minima, the approach shall not continue to DA(H) and a go-around must be performed.

Note: Approaches may be flown using autoland procedures for CAT I approaches. The approach information contained in this guide assumes the autopilot will be used to touchdown. If the autopilot will not be used to touchdown or APPR ONLY appears in the FMA altitude window, disconnect the autopilot no later than 50 feet below minimums.

Note: CAT II and CAT III approaches must be flown using autoland procedures.

Note: For LDA with GS, the autopilot must be disconnected no later than 50 feet below minimums.

Note: If operable, both the autopilot and flight director will be utilized for all ILS approaches when the reported weather is below 4000 feet RVR or 3/4 mile.

Note: When using PROF on an ILS approach to meet altitude crossing restrictions prior to the FAF, set the FAF altitude in the FCP altitude window. After glideslope capture and no later than 1000 feet, set the missed approach altitude.

Maximum reported wind component to initiate approach and land using autoland:

25 knots headwind, 15 knots crosswind, 10 knots tailwind.

Airport diagram and SMGCS chart.....Review

Both pilots should have the applicable chart out and available for taxi assistance.

FMS approach procedure Select and verify

Select the correct approach in the FMS. Verify the F-PLN waypoints and altitudes match the Jeppesen chart waypoints and altitudes.

For LDA with GS approaches that have a MIN PROF box, hard tune the localizer frequency and course. Enter ILS/CRS in 4L on the NAV RAD page. This will allow APPR/LAND to be armed, and the AFS and FD to track the localizer and glideslope.

Flight and nav instruments Set

Verify the correct localizer identifier is displayed on the PFD. This will not appear on the PFD until the aircraft is approximately 25NM or less from the destination airport.

Minimums Set

CAT I:

Set the MINIMUMS inner collar to BARO and rotate the outer knob to set published DA on the PFD.

CAT II:

RA authorized - Set the MINIMUMS inner collar to RA and rotate the outer knob to set published RA on the PFD.

RA not authorized - Set the MINIMUMS inner collar to BARO and rotate the outer knob to set published DA on the PFD.

Note: For RA not authorized, the inner marker is required. The decision altitude is determined by the inner marker or the first officer's BARO altimeter, whichever occurs first. The inner marker audio can be heard by selecting MKR on the audio control panel.

CAT III:

Set the MINIMUMS inner collar to BARO and rotate the outer knob to set published DA on the PFD.

LDA with GS:

Set the MINIMUMS inner collar to BARO and rotate the outer knob to set published MDA or DA, as required.

Callouts Review

Call "ALIGN" when ALIGN appears in the FMA roll window.

717 Flight Crew Training Manual

FMA Review

Refer to FCTM, Chapter 5, ILS Approach Profile, for FMA progression.

When cleared for the approach:

APPR/LAND Select

Select when established on a published inbound segment of the approach or when on a final approach course intercept heading. Adhere to all published step down fix altitudes located outside the final approach segment.

The expanded localizer on the PFD is used to confirm localizer capture.

After “AUTOLAND G/S” is displayed in the FMA altitude window (approximately 1500 feet AGL), the autoland approach mode is locked in and the flight path cannot be changed by the FCP or MCDU. Autoland can only be disengaged by doing one of the following:

- Pushing either GA switch
- Disconnect the autopilot, maneuver outside the LOC capture zone (1/2 dot), and select APPR/LAND. This breaks the autoland lock and restores normal FCP operation.

When cleared to intercept the localizer but not yet cleared for the ILS approach:

- Inside of 25 nm - select the LOC ONLY prompt
- Outside of 25 nm - select NAV or hard tune the localizer frequency and course and select the LOC ONLY prompt.

Once cleared for the ILS approach, select APPR/LAND.

No later than 1000 feet AGL:

Missed approach altitude Set

Set lowest initial level off altitude on missed approach procedure.

Note: When approaching the DA(H) on a CAT II or CAT III approach, the captain (PF) will primarily be scanning outside for visual cues and the FO (PM) will primarily be scanning the flight instruments.

Execute a Missed Approach for any of the following:

- Criteria listed in the Airway Manual, Ops Specs, IAP
- Navigation radio or flight instrument failure occurs which affects the ability to safely complete the approach
- Full scale deflection of the localizer or glide slope
- For CAT II/III only, APPR ONLY appears in the FMA altitude window
- For CAT III only, any controlling RVR goes below minimums.

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 avionic 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

CAUTION: The FMS will not capture a NAV final approach course or programmed missed approach NAV track if the approach is not cleaned up.

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 plan view of the area.

The arrival and approach transition may be flown using heading select or NAV for lateral tracking and PROF, level change, or V/S for altitude changes. PROF is recommended when flying arrivals, transitions and approaches with mandatory crossing restrictions. However, level change is the preferred descent mode for approach while on radar vectors.

When being vectored off a STAR or transition to the final approach course, the approach should be cleaned up. The intent of this is to move the FMS active waypoint from the arrival and onto the approach.

The approach can be cleaned up in a number of ways, to include:

- Select DIR INTC to an appropriate fix on the final approach course and clear the T-P.
- Select DIR INTC to a Place-Bearing-Distance (PBD) waypoint along the extended final approach course and clear the T-P.
- When on an intercept heading for the final approach course, select an appropriate fix on the final approach course and use the DIR INTC page FIX/CRS prompt (1R) to create a waypoint along the extended final approach course and clear the T-P.

Clearing the T-P is recommended when being radar vectored to the final approach course. This enables the FMS to:

- Auto sequence the waypoints on the approach
- Display cross track error from the final approach course below the airplane symbol on the ND
- Display distance remaining to the FAF or appropriate fix on the approach.

Clearing the T-P also makes the selected waypoint the FMS FROM point. When clearing the T-P, the airplane's current altitude will appear in large font as the FROM Point altitude on the F-PLN page. If subsequently cleared to the FROM point to commence the approach, that waypoint must be re-entered on the DIR-INTC page and any appropriate altitude restriction entered as well.

When operating in FMS SPD edit or FCP speed select mode, timely speed selections minimize throttle movement during the approach. This reduces cabin noise levels and increases fuel efficiency.

Select APPR/LAND when:

- The ILS is tuned and identified
- The aircraft is on an inbound intercept heading or a published inbound segment
- Both localizer and glideslope pointers appear on the attitude display in the proper position
- Clearance for the approach has been received.

After selecting, observe LAND ARMED is displayed in white in the roll control window of the FMA.

If needed, use heading select to establish an intercept heading to the final approach course.

CAUTION: After LOC and/or G/S have been captured but prior to AUTOLAND being displayed in green (approximately 1500 feet AGL), any lateral or vertical changes made on the FCP will disarm that captured mode. The desired mode must be reselected.

To avoid unwanted glideslope capture, LOC ONLY mode may be selected initially, followed by the APPR/LAND mode. The glideslope may be captured from either above or below, as long as LOC is active.



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 Final Approach Fix (FAF), Glideslope Intercept Point or “Feather” when temperatures are higher than standard can place the aircraft below minimum crossing altitudes for fixes prior to the FAF.

The use of PROF prior to the FAF when cleared for the approach protects against violating an altitude constraint. Once all altitude constraints prior to the FAF have been met, intercept the ILS glideslope for the remainder of the approach. For significant hot or cold temperature deviations, selecting level change and adjusting the descent rate may be needed to assist with glideslope capture prior to the FAF, depending on the amount of deviation.

Final Approach

At localizer capture, select the heading to match the inbound course. For normal localizer intercept angles, very little overshoot occurs. For large intercept angles or intercept speeds greater than 180 KIAS, some overshoot can be expected.

Use the map display to maintain awareness of distance to go to the final approach fix. When required select landing speed, extend flaps as required, extend landing gear, select landing flaps and perform landing checklist. If not using FMS speeds, speed select VREF + 5 knots or VREF + wind additives, as required. When established on glide slope, set the missed approach altitude in the FCP no later than 1000 feet AGL.

Note: When using FMS SPD to set VAPP, ensure the FMS target speed (magenta donut) is visible and appropriate for configuration (slightly above VMIN). When FMS SPD is selected, the FMS will fly that target speed. If the magenta donut is not visible and appropriate, clear the existing FMS Speed edit or select FMS SPD twice on the FCP to set the appropriate FMS target speed.

When using the autothrottles to touchdown, no additional wind additive is required. Sufficient wind and gust protection is available with the autothrottles engaged as the autothrottles are designed to adjust thrust rapidly when the airspeed drops below command speed while reducing thrust slowly when the airspeed exceeds command speed. In turbulence, the result is that average thrust is higher than necessary to maintain command speed. This results in an average speed exceeding command speed.

The pilot monitoring should continue standard callouts during final approach and the pilot flying should acknowledge those callouts.

Check for correct crossing altitude when crossing the final approach fix (FAF or OM).

With AUTO FLIGHT engaged and after passing 1,500 feet AGL + 10 seconds, the altitude window will display AUTOLAND in addition to G/S. The roll window will display LOC. FMA displays will be green.

Note: If APPR ONLY displays, the autopilot will automatically disconnect at 100 feet AGL.

Note: It is normal for MCDU 1 to blink whenever the aircraft transitions to AUTOLAND when descending through 1,500 feet AGL.

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 PROF 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 HAT 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 spoiler deployment.

At 150 feet AGL (but no later than 100 feet AGL) in AUTOLAND, verify ALIGN (green) annunciates in the FMA roll window, and a runway alignment maneuver occurs to remove existing crab angle.

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 in the touchdown zone. Guard the controls on approach through landing and be prepared to take over manually, if required.

717 Flight Crew Training Manual

Decision Altitude or Height - DA(H)

A Decision Altitude or Height is a specified altitude or height in an ILS/LDA (with GS) 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. 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 and all Category III 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.

Descent Below Decision Altitude or Height - DA(H)

Refer to Airway Manual, Ops Specs, IAP.

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 Airway Manual, Ops Specs, IAP.

Visual References

Refer to Airway Manual, Ops Specs, IAP.

Category III operations apply a DH of 50 feet and requires that the runway touchdown zone be clearly visible. If not, execute an immediate missed approach.

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 Airway Manual, Ops Specs, IAP; QRH, NNOI.1; or MDM for specific systems and equipment needed for Category II and Category III operations.

Category II and III Operations

Category II and III operations are based on an approach to touchdown using the automatic landing system.

The aircraft has been demonstrated to meet Category II and III criteria with two engines operating or with one engine operating for flaps 25 landing.

Autoland Capabilities

Refer to the applicable Vol. 1 limitations for AFS limitations and a description of demonstrated autoland capabilities.

Note: For autoland use flaps 40 unless an NNC requires the use of flaps 25.

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

The 717 is not a fail operational aircraft.

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. A DA(H) is used as approach minimums.

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 2 miles (3200m) or less.

**717 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.

ILS critical areas are usually not protected when the weather is above 800 foot ceiling and/or 2 statute miles visibility. As a result, ILS beam bends may occur because of vehicle or aircraft interference. Sudden and unexpected flight control movements may occur at a very low altitude or during the landing and rollout when the autopilot attempts to follow the beam bends. At ILS facilities where critical areas are not protected, be alert for this possibility and guard the flight controls (control wheel, rudder pedals, and throttles) throughout automatic approaches and landings. Be prepared to disengage the autopilot and manually land or go-around.

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 Volume 1, SP.16, Guidelines for Takeoff on Contaminated Runways or Landing with Braking Action Less than Good, Crosswind Guidance.

If an autoland is accomplished on a contaminated runway, the pilot must be prepared to disengage the autopilot and take over manually should ROLLOUT directional control become inadequate.

Transition to Manual Approach or Landing

A transition from an autopilot coupled CAT I ILS approach to a manual approach can be accomplished anytime during the ILS approach (refer to Vol. 1, NOI for autopilot use during approach and landing). 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. Considerations should be given to not interrupting the autoland after DH. Consideration should be given to using autoland during low visibility approaches above CAT II/III minimums.

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:

- Ensure APPR/LAND is selected, and both LOC and LAND ARMED are displayed.
- As soon as the aircraft is established on the localizer:
 - Select no lower than 1,000 feet AFE on the FCP
 - Initiate descent and re-select APPR/LAND (this rearms the LOC and G/S)
 - Establish final landing configuration and set the missed approach altitude no lower than 1,000 feet AFE.

Note: When using V/S to help capture the glideslope, changing the V/S wheel at glideslope capture will cause LOC to revert to HDG and G/S to revert to V/S.

Monitor the rate of descent and airspeed to avoid exceeding flap speed tape values. At G/S capture observe the flight mode annunciations for correct modes and monitor G/S deviation. After G/S capture, continue with normal procedures. Comply with the recommendations on the use of speedbrakes found in chapter 4 of this manual.

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. 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, and then adjust thrust to maintain it. Complete the Landing checklist.

At all times comply with stabilized approach criteria.

Faults

Autoland must be used for all CAT II/III approaches. All CAT II/III approaches must end in an automatic landing in the touchdown zone or a go-around. Due to the close proximity with the ground when minimums and the Autoland flare and landing functions are occurring, the F/O must be familiar with the Autoland sequence and possible malfunctions. This will allow for quick recognition of a problem and the timely execution of a go-around. Some possible faults are:

- Flashing APPR ONLY
- No ALIGN by 100 feet AFE
- No FLARE at 50 feet AFE
- No RETARD at 30 feet AFE
- No ROLLOUT after touchdown
- Improper runway line up (Offset rising RWY symbol).

Raw Data - (No Flight Director)

ILS deviation is displayed on the PFD. ILS deviation may also be displayed on the ND by selecting APPR on the ECP. The localizer course deviation scale on the attitude indicator remains normal scale during the approach. Continue to crosscheck the map display against the attitude indicator raw data.

The magnetic course/bearing information from the VOR pointers on the navigation display may be used to supplement the attitude display localizer deviation indication during initial course interception. Begin the turn to the inbound localizer heading at the first movement of the localizer pointer.

After course intercept, the track line and read-out on the navigation display may be used to assist in applying proper drift correction and maintaining desired course. Bank as needed to keep the localizer pointer centered and the track line over the course line. 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 pointer begins to move (glideslope alive) and further configuration is desired, select FMS speed (or VAPP speed), extend flaps as required, and extend the landing gear. When established on the glideslope, preset the missed approach altitude in the altitude window. On final approach, maintain VREF + 5 knots or appropriate wind corrections. Check altitude crossing the FAF. To stabilize on the final approach speed as early as possible, it is necessary to exercise precise speed control during the glideslope intercept phase of the approach. The rate of descent varies with the glideslope angle and ground speed. Expeditious and smooth corrections should be made based on the ILS course and glideslope indications. Apply corrections at approximately the same rate and amount as the flight path deviations.

Selecting FPA display is a useful tool while flying a raw data approach to assist in tracking the G/S. The top of the Flight Path Vector “tail” touching the horizon equals a three degree descent angle.

The missed approach procedure is the same as a normal missed approach. Flight Director guidance appears if GA is selected. Refer to Go-Around and Missed Approach - All Approaches, this chapter.

ILS PRM Approach

PRM Procedures

Refer to Vol. 1, NOI, ILS Precision Runway Monitor (PRM) Considerations.

Refer to Airport Specific Attention All Users Page.

- Use automatic ILS approach procedures. Select APPR/LAND 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.

LDA PRM Procedures

Although the LDA with GS is considered to be a non-ILS approach complete with a Missed Approach Point (MAP) as opposed to a DA, procedurally it is flown like an ILS approach. Automatic approach procedures are required until reaching VMC.

ATC is required to stagger the aircraft on the straight-in ILS PRM approach so it is slightly ahead of the LDA PRM aircraft. This will permit the LDA PRM aircraft to be in position to visually acquire the ILS PRM aircraft prior to the MAP. ATC may issue speed assignments to either aircraft to ensure this slight stagger is maintained.

717 Flight Crew Training Manual

A visual segment of the LDA PRM approach is established prior to the LDA MAP. The visibility requirement for the LDA PRM will allow the flight crew to see the runway at the MAP. Certain ceiling requirements are established before ATC can initiate SOIA (Simultaneous Offset Instrument Approaches) operations. These ceiling requirements allow flight crews approximately 30 seconds to acquire the ILS PRM aircraft before the MAP is reached. During this visual segment and prior to the MAP, the crew must comply with the following or a missed approach must be executed:

- Sight the ILS PRM aircraft
- Report the ILS PRM aircraft in-sight to ATC (ATC will not acknowledge)
- Sight the runway environment
- Maintain LDA centerline until reaching the MAP.

Upon sighting the ILS PRM aircraft, the LDA PRM aircraft is expected to report to ATC, aircraft in-sight. This report is made regardless of where on the approach the ILS PRM aircraft is sighted. There is no requirement for ATC to acknowledge this transmission. Failure to make this report by the MAP may result in a missed approach or breakout instruction from ATC.

Regardless of when the ILS PRM aircraft is sighted, the LDA PRM aircraft is to maintain the LDA centerline until the MAP.

CAUTION: Performing the runway alignment maneuver before reaching the MAP will result in the aircraft entering the No Transgression Zone and will cause ATC to issue a breakout instruction to one or both aircraft.

After passing the MAP, visually align the aircraft with the runway centerline using care not to overshoot. The MAP is established at an altitude that will allow sufficient time to perform this alignment maneuver so as to align with the runway centerline by 500 feet HAA. This portion of the approach is known as the visual segment and is shown on the chart as a dashed line marked “Fly Visual”.

Although the runway touchdown zones are situated so that the LDA PRM aircraft is always above the ILS PRM aircraft’s wingtip vortices, use caution for wake turbulence during the final stage of the approach.

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 off and hand flying the turn. The bank angle should not exceed bank angle limiter.

Transition to a smooth climb or descent as instructed. Descents need not exceed 1,000 fpm. Recognize if the aircraft is already tracking the glideslope (at approximately 800 fpm) that little or no change of pitch or rate of descent may be required.

Phraseology

TRAFFIC ALERT: If an aircraft enters the NO TRANSGRESSION ZONE (NTZ), the controller will breakout the threatened aircraft on the adjacent approach. The phraseology for the breakout will be:

TRAFFIC ALERT (aircraft callsign), **TURN** (left/right) **IMMEDIATELY HEADING** (degrees). **CLIMB/DESCEND AND MAINTAIN** (altitude).

Note: If ATC Breakout instructions coincide with TCAS RA, follow the vertical guidance of the RA and the lateral guide directed by ATC.



717 Flight Crew Training Manual

PRM Breakout Maneuver

Pilot Flying	Pilot Monitoring
A/P - Disengage	Set the ATC directed heading and altitude in the FCP. Push APPR/LAND when outside 1/2 dot deviation to break the localizer and glideslope lock. Set the ATC assigned heading in the heading window and pull the heading select knob. Set the ATC assigned altitude in the altitude select window. Rotate the pitch wheel to approximately 500fpm climb or descent.
Maneuver as directed by ATC. Disregard flight director guidance. Little to no change in pitch is required on a descending breakout. For a climbing breakout, set approximately 7.5° nose up. Use approximately 10° of bank to comply with the ATC directed heading. Note: If ATC “breakout” instructions coincide with a TCAS RA, follow the vertical guidance of the RA and the lateral guidance directed by ATC. Note: If descending, vertical speed should not exceed 1,000 fpm.	Communicate with ATC as required.

Pilot Flying	Pilot Monitoring
Follow flight director guidance.	Notify the PF when flight director guidance can be followed. Notify the PF when the autopilot is available.
When “breakout” is complete, reset automation to appropriate level. Note: In order to clear LAND ARMED from the FMA altitude window, push heading hold when established on the ATC assigned heading.	

DELTA
717 Flight Crew Training Manual

PRM Breakout Recovery Technique

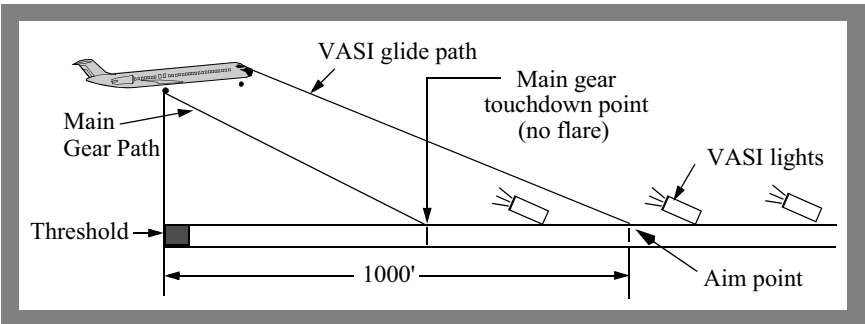
When the aircraft is established on the breakout heading:

- Autopilot as desired
- Set Speed Select to 180 knots
- Set flaps 13
- Raise the landing gear
- Complete After Takeoff Checklist.

ILS Approach - Landing Geometry

The following diagrams use these conditions:

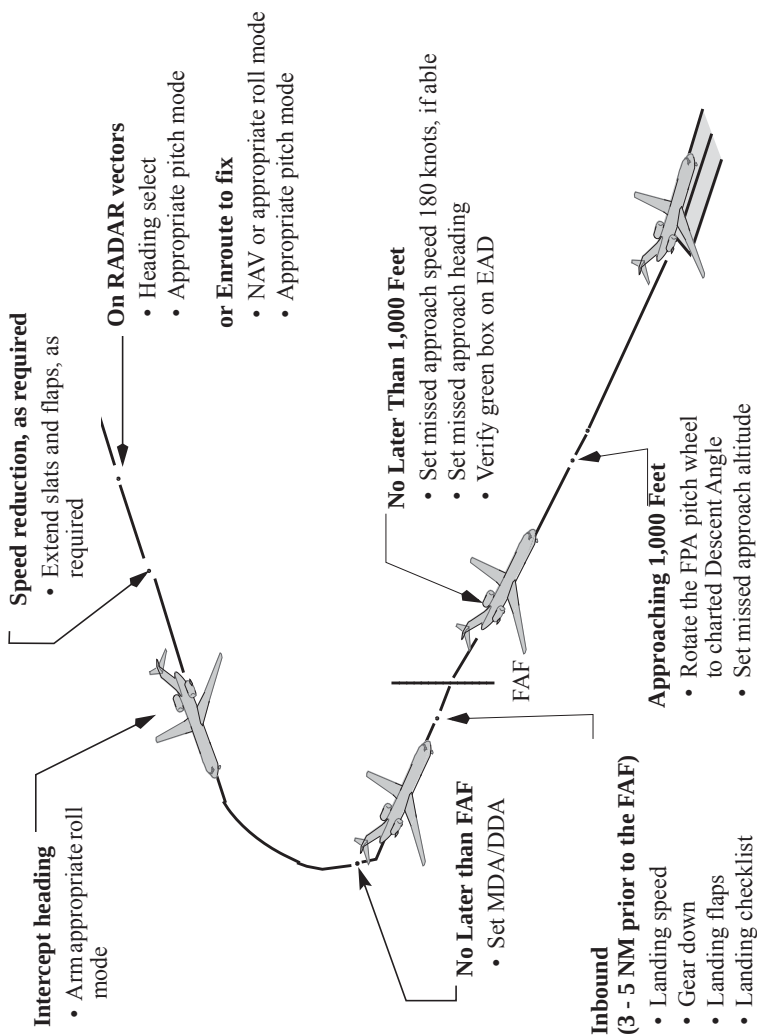
- Data is based on typical landing weight.
- Aircraft body attitudes are based on flaps 40, VREF 40 + 5, and should be reduced by 1° for each 5 knots above this speed.
- Pilot eye height is measured when the main gear is over the threshold.
- Aircraft ILS antenna crosses threshold at 50 feet.



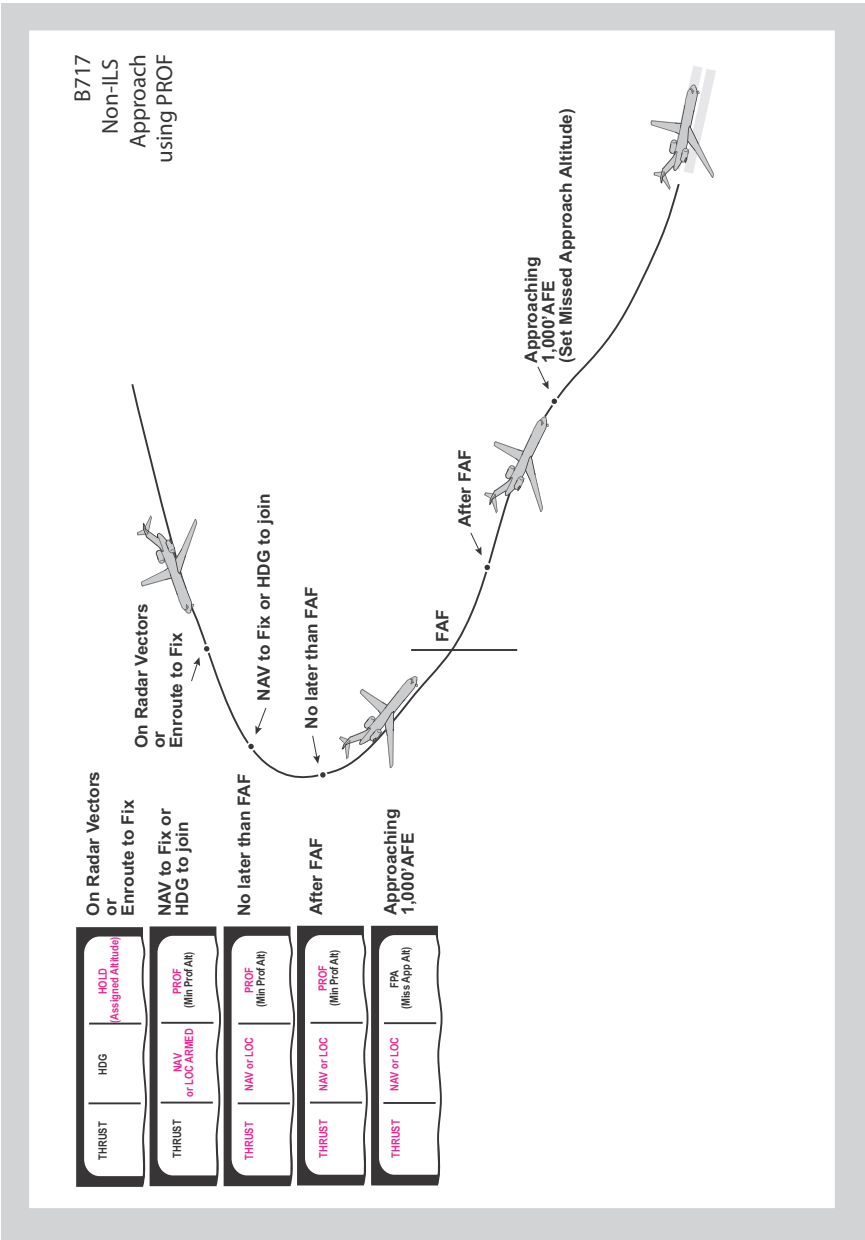
717 Model	Flaps 40		Main Gear over Threshold		Threshold to Main Gear Touchdown Point - No Flare (feet)
	Glide Path (degrees)	Aircraft Body Attitude (degrees)	Pilot Eye Height (feet)	Main Gear Height (feet)	
- 200	2.5	5.7	50	31	707
	3.0	5.2	58	40	766

Non - ILS Instrument Approaches

Non-ILS Approach Profile Using PROF



FMA Progression



RNAV (GPS or GNSS), GPS, LOC, LDA (without GS), VOR, or NDB Expanded Approach Guide

NAV or LOC ONLY & PROF Modes

Approach Considerations

If the ground based navaid is out of service or compatible avionics is either not installed or not operational, the approach may be flown using RNAV procedures as long as one GPS is operational and the approach is authorized on the Company page or flight plan remark.

For RNAV approaches with inoperative equipment, refer to QRH, Non-Normal Ops Info tab, RNAV Approach Equipment Requirements.

Use of the autopilot is required in IMC until visual contact with the runway can be maintained or upon reaching the MDA, whichever comes first.

The planned approach must be contained in the FMS database.

Note: RNAV (GNSS) approaches are the ICAO designated equivalent of RNAV (GPS) approaches in the U.S.

Approach Preparations

Autopilot Required in IMC
Disconnect the autopilot no later than 50 feet below the MDA.

FMS approach procedure Select and verify
Select the appropriate approach procedure in the FMS. When the approach is selected, the MIN PROF box will appear. Enter 200 feet above charted Apt Elev rounded up to the nearest 10 feet in the MIN PROF box.

INSERT and select an appropriate approach transition if desired.
Verify FMS F-PLN page waypoints and altitude constraints match the charted approach.

Do not manually build the approach.

No waypoints may be added or deleted in the flight plan between the FAF and the MAP.



Flight and nav instruments Set

Ensure correct arrival and approach procedures are entered.

For RNAV approaches, confirm G/I or GNS is displayed on the ND.

For a localizer or LDA approach, confirm the correct localizer identification is displayed on the PFD.

For a VOR approach, the correct VOR information is displayed on the ND by selecting ECP RANGE VOR 1 or 2.

VOR approaches may be flown by selecting the VOR ARM prompt, but NAV is the preferred method. NDB receivers are not installed, but NDB approaches contained in the database can be flown using NAV.

Minimums Set DA

Set LNAV (MDA) using the ECP BAROSET knob and use as a DA.

Set DDA (MDA + 50 feet) when flying an approach outside the United States and its associated territories.

Note: DDA must be used for approaches that do not have PROF path guidance inside the FAF or for non-ILS approaches outside the U.S. and its associated territories.

Note: LPV and LNAV/VNAV minimums are not authorized.

Raw data and PATH ERROR Monitor

Raw data must be monitored throughout the approach on the PFD when conducting any localizer based approach.

For VOR approaches, monitor raw data, if available, on the ND.

For approaches using NAV, select ECP DATA mode to observe crosstrack deviation value on the ND.

Monitor path error on the ND vertical deviation indicator.

Note: The VDI is more accurate than the PERF DES page. Deviations will not show on the PERF DES page until they are 100 feet or greater.

RNP Set 0.3 by FAF

Set RNP of 0.3 on the POS REF page prior to final approach.

Approach Procedure

When cleared for the approach:

NAV or LOC ONLY Select

For RNAV, GPS, VOR or NDB approaches, select NAV on the FCP.

For LOC or LDA approaches, select the LOC ONLY prompt on the NAV RAD page.

PROF Select or verify

Verify the mode in the FMA altitude window is magenta.

Active/TO waypoint altitude Verify

Verify the active waypoint altitude is in large font.

When:

- Established on a published segment of the approach, or
- Cleared direct to an approach waypoint:

On course Verify

Verify the aircraft is on course by confirming the aircraft symbol on the MAP display is on the magenta line.

FCP Altitude Set

Set MDA in the FCP altitude window.

CAUTION: If the airplane is NOT on the magenta line and a lower altitude is set in the FCP, the airplane will NOT honor the hard altitudes in the FMS and will begin an immediate descent. Be prepared to intervene with altitude HOLD.

No later than 1,000 feet AGL:

FPA Select

Rotate the pitch wheel to charted Descent Angle. This will allow the missed approach altitude to be set.

Note: Ensure the FMS computed descent profile is established prior to rotating the pitch wheel. This may mean the aircraft descends below 1,000 feet before the pitch wheel can be rotated to the charted value. This is acceptable as long as the missed approach altitude is set prior to reaching minimums.

Note: For approaches with minimums higher than 1,000 feet, ensure FPA and the missed approach altitude are set prior to capturing the FCP altitude.

Missed approach altitude Set

Set lowest initial level off altitude on missed approach procedure.

Note: Immediately after rotating the pitch wheel spin the altitude select knob quickly so the autopilot does not capture the FCP altitude.

No later than 50 feet below MDA or 100 feet below DDA:

Autopilot Disconnect

Execute a Missed Approach for any of the following:

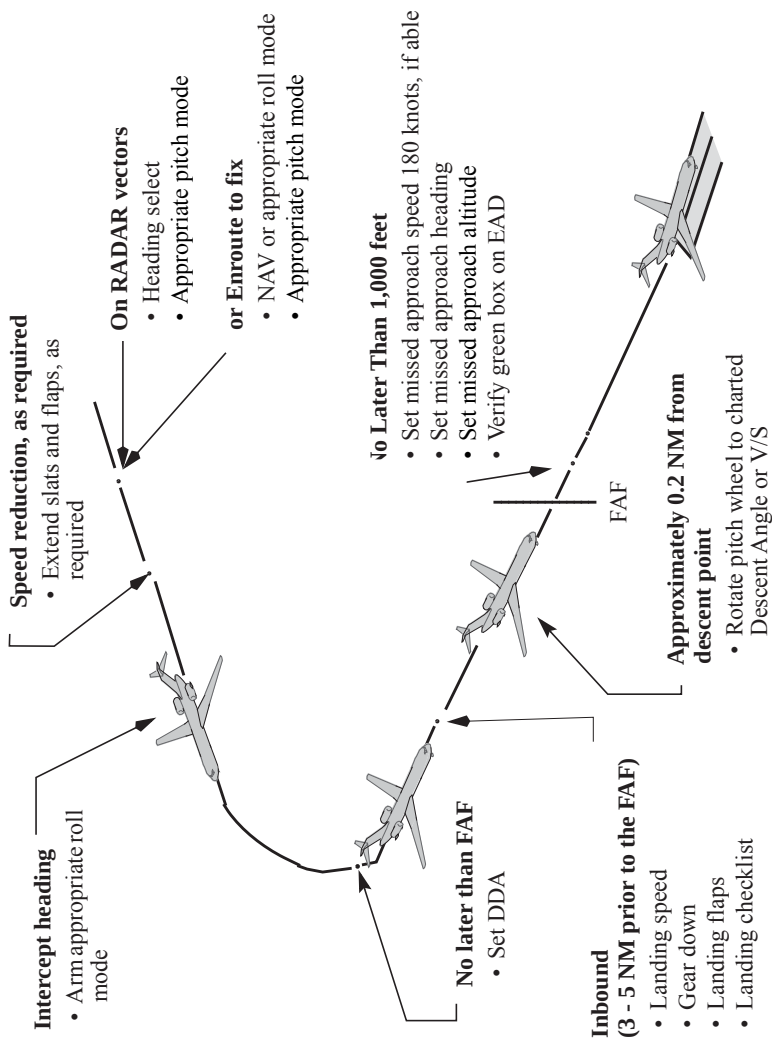
- Criteria listed in Airway Manual, Ops Spec, IAP or
- In IMC, a navigation radio or flight instrument failure occurs which affects the ability to safely complete the approach, or
- In IMC, full scale deflection of the localizer, or
- In IMC, actual course deviates from published inbound course by more than 10 degrees during a VOR approach.

Additional Considerations:

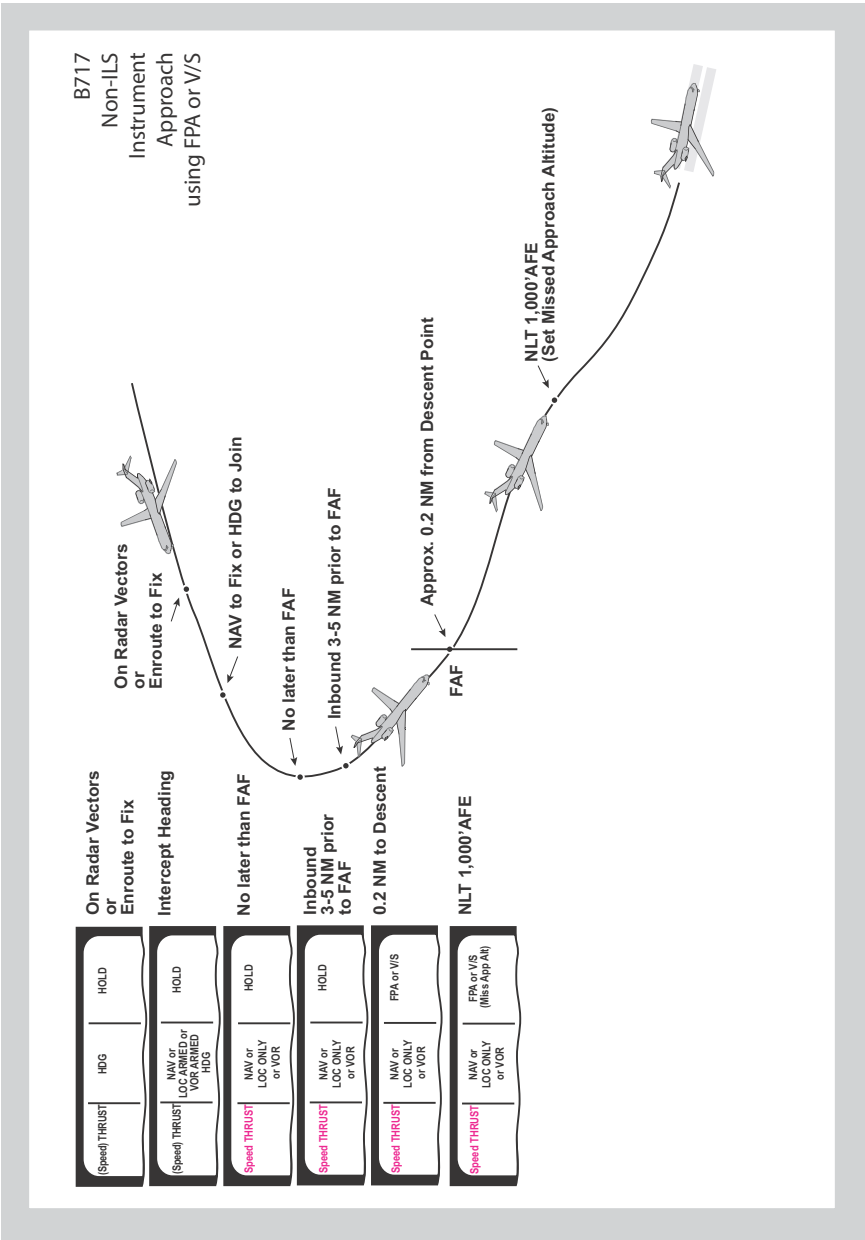
Non-localizer based approaches with raw data unavailable, execute a missed approach if any of the following occur:

- ADIRU FAULT alert message
- FMS FAIL alert message
- GPS FAIL alert message
- UNABLE RNP alert message
- XTK error greater than 0.3.

Non-ILS Approach Profile Using FPA or V/S



FMA Progression



RNAV (GPS or GNSS), GPS, ILS (G/S Out), LOC, LDA (without GS), VOR, or NDB Expanded Approach Guide NAV, LOC ONLY, or VOR ARM & FPA or V/S Modes

Approach Considerations

Use this procedure for:

- Approaches without a MIN PROF box
- Approaches without a published Descent Angle
- Approaches not in the FMS database
- PROF unavailable or unreliable.

If the ground based navaid is out of service or compatible avionics is either not installed or not operational, the NDB, NDB/DME, VOR, or VOR/DME approach may be flown using RNAV procedures as long as one GPS is operational and the approach is authorized on the Company page or flight plan remark.

For RNAV approaches with inoperative equipment, refer to QRH, Non-Normal Ops Info tab, RNAV Approach Equipment Requirements.

Use of the autopilot is required in IMC until visual contact with the runway can be maintained or upon reaching the DDA, whichever comes first.

Approach Preparations

Autopilot Required in IMC

Disconnect the autopilot no later than 50 feet below the MDA.

Approach procedure Select and verify

For Approaches in FMS Database:

Select the appropriate approach procedure in the FMS. INSERT, and select an appropriate approach transition, if necessary.

Note: A MIN PROF value may need to be entered in order to INSERT the approach. Enter 200 feet above Apt Elev rounded up to the nearest 10 feet.

Note: VOR approaches contained in the FMS database should be flown using NAV. NDB receivers are not installed, but NDB approaches contained in the database can be flown using NAV, when authorized.

Verify FMS F-PLN page waypoints and altitude constraints match the charted approach.

No waypoints may be added or deleted in the flight plan between the FAF and the MAP.

For Approaches Not in FMS Database:

Localizer based approaches (ILS G/S Out, LOC, or LDA without GS)
- Hard tune the approach on the NAV RAD page.

Enter ILS/CRS in 4L. The ILS frequency or the ILS identifier must be entered in the ILS value. The inbound course must be entered in the CRS value.

Note: Both the frequency (or identifier) and course must be entered in order to intercept and track the localizer.

VOR - Hard tune the approach on the NAV RAD page.

Enter VOR identifier/CRS in 1L or 1R. The VOR frequency or the VOR identifier must be entered in the first value. The inbound course is entered in the CRS value.

Note: After the values are entered, VOR ARMED will be displayed in 2L and on the FMA. When the course is captured, VOR TRACK will be displayed in 2L and VOR 1 (or 2) on the FMA.

Note: NDB approaches that are not in the database cannot be flown. NDB receivers are not installed.

Flight and nav instruments Set

For Approaches in FMS Database:

Ensure correct arrival and approach procedures are entered.

For RNAV approaches, confirm G/I or GNS on the ND.

For a localizer based approach, confirm that the correct localizer identifier is displayed on the PFD.

For a VOR approach, select ECP RANGE VOR 1 or 2 and confirm correct VOR information on ND.

For Approaches Not in FMS Database:

Localizer based approaches - Select APPR on ECP.

VOR approaches - Select VOR on ECP.

Minimums Set DDA

Enter DDA using the ECP BAROSET knob.

Note: DDA must be used for approaches that do not have PROF path guidance inside the FAF or for non-ILS approaches outside the U.S. and its associated territories.

For RNAV approaches, add 50 feet to the charted LNAV (MDA) value to determine the DDA.

Note: LPV and LNAV/VNAV minimums are not authorized.

For all other approaches add 50 feet to the charted MDA.

Raw data Monitor

For approaches using NAV, raw data must be monitored by selecting ECP DATA to observe crosstrack error on the ND.

For localizer based approaches, raw data must be monitored continuously on the PFD expanded localizer display.

For VOR approaches, raw data must be monitored by selecting ECP RANGE VOR 1 (or 2) and observing the correct VOR information on the ND.

RNP Set 0.3 by FAF

For approaches in the FMS database, set RNP of 0.3 on the POS REF page prior to final approach.

Approach Procedure

When cleared for the approach:

NAV or LOC ONLY prompt or VOR ARMED prompt..... Select

For Approaches in FMS Database:

For RNAV, GPS, VOR or NDB approaches, select NAV on the FCP.

For an ILS G/S Out, LOC, or LDA without GS approach, select the LOC ONLY prompt on the NAV RAD page.

For Approaches Not in FMS Database:

For an ILS G/S Out, LOC, or LDA without GS approach, select the LOC ONLY prompt on the NAV RAD page.

717 Flight Crew Training Manual

For a VOR approach, select VOR ARMED prompt on the NAV RAD page.

When:

- Established on a published segment of the approach
- Level at FAF altitude:

On course Verify

For an approach using NAV to track the lateral path, verify on the magenta line.

For a localizer based approach, verify by confirming less than one dot on the expanded localizer.

For a VOR approach not in the database, verify by 5 degrees or less on the ND VOR display.

FCP Altitude Set

Set DDA in the FCP altitude window after the FMA altitude window displays “HOLD” in white.

When approximately 0.2 nm from the descent point:

FPA or V/S..... Select

Rotate the pitch wheel to charted Descent Angle or V/S.

V/S may be used, but FPA is the preferred method.

Use FPA 3.0 or V/S 800 if no descent angle is published.

No later than 1,000 feet AGL:

Missed approach altitude Set

Set lowest initial level off altitude on missed approach procedure.

Note: Immediately after rotating the pitch wheel, spin the altitude select knob quickly so the autopilot does not capture the FCP altitude.

No later than 100 feet below DDA:

Autopilot Disconnect

Execute a Missed Approach for any of the following:

- Criteria listed in Airway Manual, Ops Specs, IAP, or
- In IMC, a navigation radio or flight instrument failure occurs which affects the ability to safely complete the approach, or
- In IMC, full scale deflection of the localizer, or
- In IMC, actual course deviates from published inbound course by more than 10° during a VOR approach.

Additional Considerations:

Non-localizer based approaches with raw data unavailable, execute a missed approach if any of the following occur:

- ADIRU FAULT alert message
- FMS FAIL alert message
- GPS FAIL alert message
- UNABLE RNP alert message
- XTK error greater than 0.3.

Non - ILS Instrument Approaches

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.

Note: The 717 is authorized to conduct RNAV (GPS) and RNAV (GNSS) approaches. The 717 is not authorized to conduct RNAV (RNP) approaches.

- 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.
- RNAV (GPS or GNSS) 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.

Note: RNAV (GNSS) approaches are the ICAO designated equivalent of RNAV (GPS) approaches in the U.S.

717 Flight Crew Training Manual

- VOR approach - NAV is the recommended lateral navigation mode when flying VOR approaches. However, use of VOR mode is acceptable.
- NDB approach - NDBs are not installed in the 717. However, NAV may be used to fly NDB approaches that are contained in the FMS database.
- LOC, LDA or similar approaches.

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 PROF, as illustrated in the profile, 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. A circling maneuver may be flown following an instrument approach using FPA or V/S provided the FCP altitude is set in accordance with the circling maneuver procedure.

Types of Approaches

All non-ILS approaches have the following features in common:

- 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.

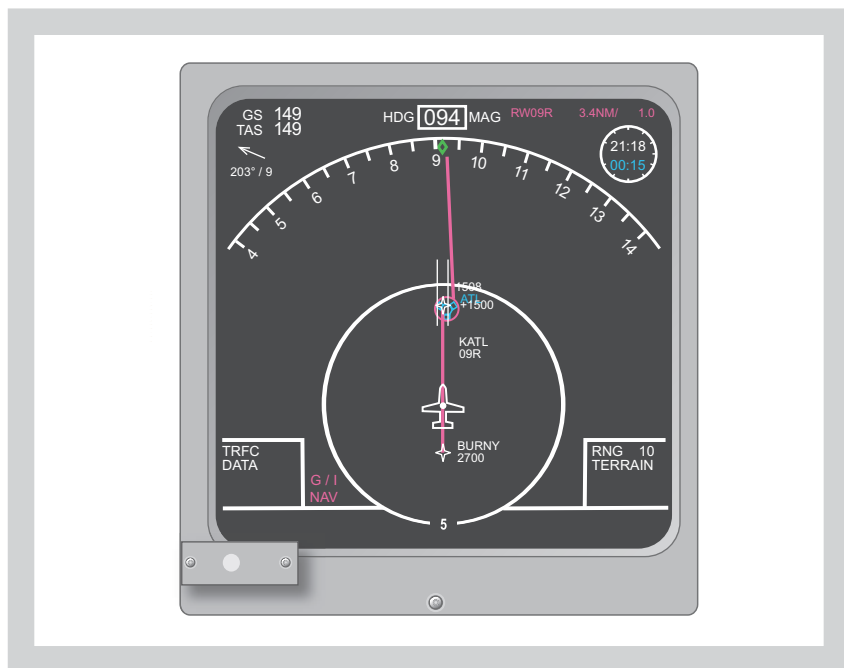
Raw Data Monitoring Requirements

For localizer based approaches, monitor raw data throughout the approach on the PFD.

Monitor vertical path deviation on the vertical deviation indicator on the ND. Vertical path deviation can also be monitored on the FMS PERF DES page. Vertical path deviations will not be displayed on the PERF DES page until they exceed 100 feet.

Note: RNAV approaches are non-precision approaches. Due to FCC and autopilot limitations, it is possible that the airplane may not be properly aligned with the runway during the final approach segment. When using NAV on final approach, monitor the crosstrack error displayed below the airplane symbol on the ND for deviations left or right of centerline. Be prepared to promptly maneuver the aircraft back to centerline once the runway is in sight. If unable to safely maneuver the aircraft back to centerline, execute a missed approach.

The following diagram represents a typical navigation display with the NAV display selected.





MAP Displays and Raw Data

The map mode should be used to the maximum extent practicable. The map display provides a plan view of the approach, including final approach and missed approach routing. The map increases crew awareness of progress and position during the approach.

The map is 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. The map 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. Use of the MAP function selectable on the ECP is the recommended method for making this comparison. The VOR pointers should be displayed on the map.

Transition to Non- ILS instrument Approaches

The arrival and approach transition may be flown using heading select or NAV for lateral tracking and PROF, level change, or V/S for altitude changes. Level change is the preferred descent mode for approach while on radar vectors as the FMS calculated PROF path may not meet the intentions of ATC clearances. However, PROF may continue to provide useful descent path information.

Database Selection

- This method is required for RNAV and GPS approaches. An approach procedure selected through the FMS STARS page provides the simplest method of selecting proper waypoints. Procedures in the database comply with obstruction clearance criteria for non-ILS approaches.
- No waypoints may be added or deleted between the FAF and the MAP. If an additional waypoint reference is desired, use the FIX page and do not modify waypoints on the F-PLN page.

Non-ILS Instrument Approach Using LOC or VOR

LOC is the recommend method for flying LOC, ILS (G/S out) or LDA (G/S out) approaches. These approaches should be selected from the FMS Database.

Note: Approaches listed in the FMS Database as LOC approaches will have a MIN PROF box and may be flown using PROF procedures.

NAV is the recommended method for flying VOR approaches. If necessary, VOR approaches may be flown using VOR data. The appropriate VOR frequency (or identifier) and final approach course should be hard tuned on the NAV RAD page at 1L (or 1R). Selecting 2L (or 2R) displays a VOR ARMED prompt, which arms the FCCs to capture the VOR course. VOR ARMED will be displayed on the FMA. When the course is captured, VOR TRACK is displayed on both the FMA and NAV RAD page.

Non-ILS Instrument Approach Using NAV

Use of NAV

To use NAV for approaches and missed approaches, a proper series of legs/waypoints that describe the approach route (and missed approach) must appear on the F-PLN page. There are two methods of loading these waypoints:

Manual Waypoint Entry

Note: These methods are only for situational awareness in VMC conditions. In order to fly a Non-ILS approach in IMC, the planned approach must be in the FMS database or manual procedures used (NAV RAD page hard tuning). Refer to Vol. 1, SP.11, Approach Not in FMS Database.

Note: Pilots should not become involved in excessive “heads down” FMS manipulation to build map displays while at low altitude. Raw data VOR and ILS displays should be used to avoid distractions during higher workload phases of flight. Map building should be avoided below 10,000 feet AGL.

If no approach procedure is available in the navigation database, select the landing runway in the FMS. Waypoints may be then added prior to the runway on the FMS F-PLN page to assist with approach guidance and situational awareness during the approach.

The waypoints may be conveniently defined by using names of waypoints or navaids in the database, bearing/distance from such fixes, or latitude/longitude information.

Note: NAV/PROF is available with manually entered waypoints.

Due to potentially inadequate terrain clearance, manual waypoint entry should not be used with RNAV or GPS approaches.

DME arcs usually cannot be manually entered (unless they can be defined by a series of waypoints). DME arcs may require use of heading select.



NAV cannot be used to track fix or radial data displayed on the map that is not part of the active route. A navaid/waypoint and the appropriate radial may be inserted on the FIX page to create a “course” line on the map that helps to improve situational awareness. Selecting the appropriate VOR on the NAV RAD page and selecting the desired course can create a similar display. These methods provide reference information on the map display only. They are not reflected on the F-PLN page and cannot be tracked with NAV. These methods should only be used when there is no opportunity to use an approach selected from the navigation database and should therefore be considered only when normal means of displaying approaches are not available. Pilots should be aware that the displayed course is an FMS-calculated course and is not raw data information.

Joining a NAV Approach

There are two methods to join a NAV approach:

- Radar Vectors to intercept the final approach course
- Using NAV to the final approach course by flying a published transition or direct to a point on the final approach course

The preferred method is using NAV. This will ensure that the airplane is on the magenta line and tracking the NAV final approach course. If joining final on radar vectors, ensure that there is no crosstrack error prior to selecting a lower altitude on the FCP.

Cleaning up a NAV Approach

CAUTION: The FMS will not capture a NAV final approach course or the published missed approach NAV track if the approach is not cleaned up.

When being vectored off a STAR or transition to the final approach course, the approach should be cleaned up. The intent of this is to move the FMS active waypoint from the arrival and onto the approach.

The approach can be cleaned up in a number of ways, including:

- Select DIR INTC to an appropriate fix on the final approach course and clear the T-P
- Select DIR INTC to a Place-Bearing-Distance (PBD) waypoint along the extended final approach course and clear the T-P
- When on an intercept heading for the final approach course, select an appropriate fix on the final approach course and use the DIR INTC page FIX/CRS prompt (1R) to create a waypoint along the extended final approach course and clear the T-P.

In addition to enabling the airplane to capture the final approach course, cleaning up the approach provides:

- A display of distance remaining to the FAF, OM, or appropriate fix
- A depiction of cross track error from the final approach course
- NAV capability during the missed approach procedure.

Note: When cleaning up an approach, clearing the T-P makes the selected waypoint the FROM point. When clearing the T-P, the airplane's current altitude will be inserted in large font as the FROM Point altitude on the F-PLN page. If subsequently cleared to the FROM point to commence the approach, that waypoint must be re-entered on the DIR-INTC page and any altitude restriction re-entered as well.

Note: If established on a heading to join an RNAV approach, consider using the DIR-INTC 1R prompt by inserting the FMS TO fix and the final approach course and selecting NAV. This creates an FMS fix at the final approach course intercept point and ensures that the aircraft will be tracking the NAV final approach course once established on final.

Non-ILS Instrument Approach Using PROF

Approach Preparations for Using PROF

Approaches using PROF include RNAV (GPS or GNSS), GPS, LOC, LDA (without GS), VOR, or NDB and have the ability to enter a MIN PROF altitude.

Select the approach from the STAR and APPR page. Boxes will be displayed in LSK 2R for entry of a MIN PROF altitude (limited from 200 feet to 5,000 feet above airport elevation). The *INSERT prompt will be available after a MIN PROF altitude has been entered.

Enter 200 feet above charted Apt Elev rounded up to the nearest 10 foot in the MIN PROF box. INSERT and select an appropriate approach transition if desired.

The FMS uses the MIN PROF value as the lower limit for descent path construction and builds a path from the FAF to that point. The FMS generates path guidance information for the autopilot and flight director down to the MIN PROF altitude, but not below. This data is displayed on the Vertical Deviation Indicator (VDI) and the FMS PERF page.

Approaches using PROF may be flown to 1,000 feet AGL.

Note: The FMS PROF mode will automatically disengage at the pilot-entered MIN PROF altitude and the aircraft will revert to the AFS basic modes of ALT HOLD or VERT SPEED depending on the FCP altitude setting and AFS pitch mode reversion criteria.



Transition to an Instrument Approach Using PROF

CAUTION: If the airplane is not on the magenta line and a lower altitude is set in the FCP, the airplane will not honor the hard altitudes in the FMS and will begin an immediate descent. Be prepared to intervene with altitude HOLD.

There are several methods which help ensure a smooth descent transition to a non-ILS final approach where PROF will be used.

- After cleaning up the approach, ensure all the altitude restrictions are in large font.
- Ensure the aircraft is on the magenta line. Although this can be interpreted to mean 0.0 crosstrack deviation on the ND when in NAV, there have been instances of aircraft tracking the magenta line with greater than 0.0 crosstrack deviation due to winds at the aircraft altitude. The important point is that after selection of PROF and once the FCP altitude window is lowered to MDA, ensure the aircraft does not begin an early descent.

Final Approach Using PROF

After crossing the FAF and allowing the PROF descent rate to stabilize, rotate the pitch wheel one click to open up the FPA window. Then, rotate the pitch wheel to the charted Descent Angle. Next, spin the altitude select knob quickly to the missed approach altitude so the autopilot does not capture the FCP altitude.

This must normally be accomplished no later than 1,000 feet AGL.

Note: Ensure the FMS computed descent profile is established prior to rotating the pitch wheel. This may mean the aircraft descends below 1,000 feet before the pitch wheel can be rotated one click. This is acceptable as long as the missed approach altitude is set prior to reaching MDA. Descend at an appropriate descent rate to arrive at the MDA at a distance from the runway to allow a normal landing profile.

Non-ILS Instrument Approach Using FPA or V/S

Approach Preparations for Using FPA or V/S

Approaches using FPA or V/S include RNAV (GPS or GNSS), GPS, ILS (G/S Out), LOC, LDA (without GS), VOR or NDB. These approaches cannot use PROF inside the FAF for one or more of the following reasons:

- The approach does not have the option to enter a MIN PROF altitude.
- The approach does not have a published descent angle.
- The approach is not in the database.
- PROF is unavailable or unreliable.

Using PROF, if available, to descend to FAF altitude on the final approach course may be desired in order to meet altitude restrictions outside the FAF. After meeting all altitude restrictions prior to the FAF, use V/S or level change to descend to the FAF altitude.

Ensure the aircraft is level at the FAF altitude, with white HOLD displayed in the FMA altitude window prior to the FAF.

Final Approach Using FPA or V/S

- Set DDA in the FCP altitude window after the FMA altitude window displays HOLD in white.

Initiate descent 0.2 nm prior to the FAF or descent point due to autoflight reaction time. Select FPA or V/S and descend at an appropriate descent rate to arrive at the DDA at a distance from the runway to allow a normal landing profile. Initial selection of an appropriate FPA or V/S should be made considering the recommended descent angle or vertical speeds published on the approach chart, if available. If no recommended descent angle or vertical speed is published, set FPA 3.0 or V/S 800 fpm.



717 Flight Crew Training Manual

When stabilized in a descent on final approach, if desired, use one of the following techniques to make small changes to the flight path angle or vertical speed to achieve a constant descent path to minimums.

Note: The vertical path deviation indication on the ND should not be used for vertical path guidance beyond the FAF as it does not represent the correct descent path for the approach.

- Use the DIST to THR or RECOMMENDED ALTITUDES block on the approach chart to verify the aircraft is on the correct descent path. The flight path angle or descent rate should be adjusted in small increments for significant deviations from the normal path.
- Using 300 feet per mile for a 3 degree path, determine the HAA which corresponds to the distance in nm from the runway end. The PM can then call out recommended altitudes as the distance to the runway changes (Example: 900 feet - 3 nm, 600 feet - 2 nm). The flight path angle or descent rate should be adjusted in small increments for significant deviations from the normal path.

Derived Decision Altitude (DDA)

The pilot monitoring should expand their instrument scan to include outside visual cues when approaching DDA. Be prepared to land or go-around at the DDA. Do not continue the approach below DDA 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 DDA or any time thereafter, if any of the above requirements are not met, immediately execute a go-around and fly the missed approach procedure.

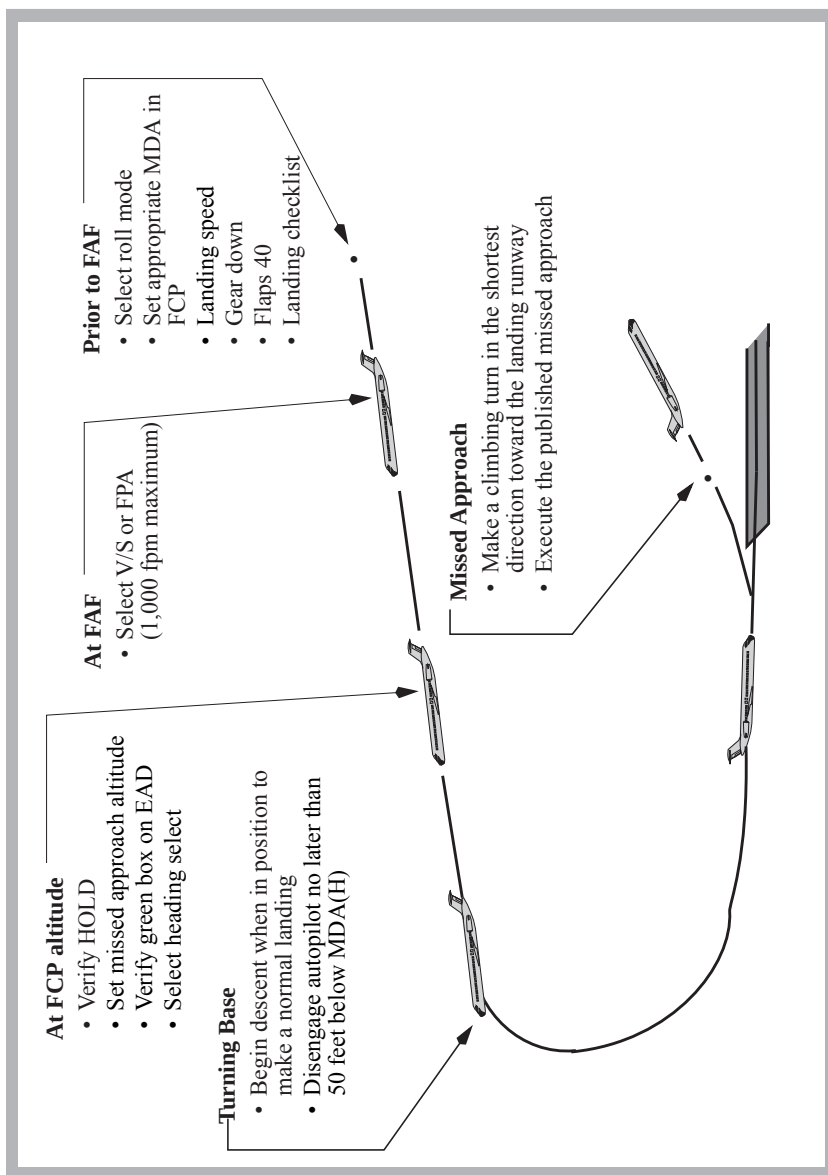
When suitable visual reference is established, maintain the descent path to the flare. Do not descend below the visual glide path.

Note that a normal landing cannot be completed from the published missed approach point on many instrument approaches.

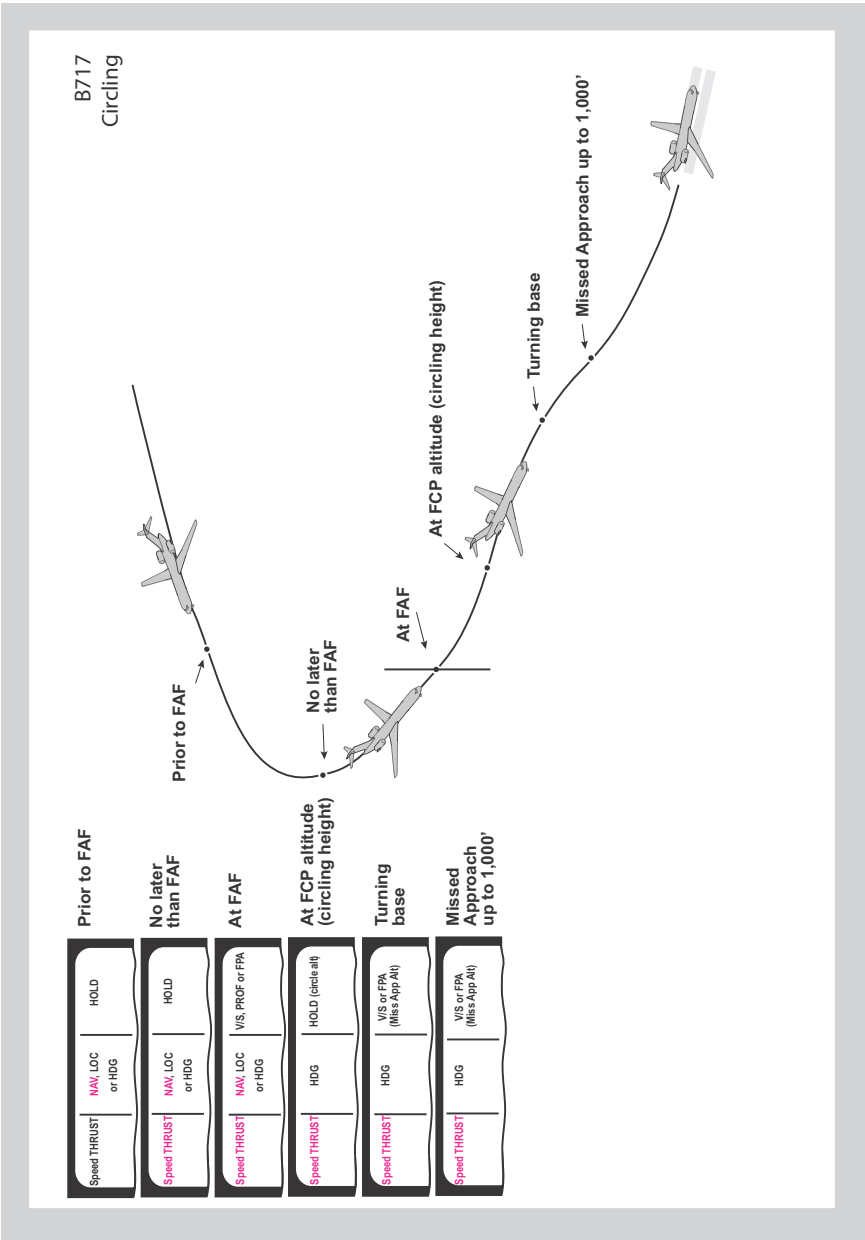
Circling Maneuver

A circling approach may be flown following an instrument approach using PROF, FPA or V/S provided the FCP altitude is set in accordance with the circling approach procedure.

Circling Maneuver Profile



FMA Progression



Approach Guide

Refer to Vol. 1, NOI.3 for Circling Maneuver guidance.

Circling Maneuver - General

The following guidance supplements normal approach preparations and procedures for the type of approach to be flown.

Several flight incidents have been attributed to the difficulties in flying cross-cockpit (i.e., first officer flying a left-hand circling maneuver or the captain flying a right-hand circling maneuver). The captain should consider the direction of the circling maneuver when determining the PF assignment.

The circling maneuver is flown fully configured 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/highest speed HAA 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. Select the ILS or non-ILS instrument approach to be flown in the MCDU in the same manner as a normal instrument approach. During the instrument approach, use FPA or V/S mode to descend to the circling MDA. Do not use APPR/LAND mode for the following reasons:

- The AFDS does not level off at FCP altitude
- Exiting the APPR/LAND Mode requires initiating a go-around or disengaging the autopilot.

Maintain MDA using ALT HOLD. Use heading select for the maneuvering portion of the circling approach.

When in ALT HOLD at FCP altitude or the MDA and before commencing the circling maneuver, set the missed approach altitude.

To avoid overshooting final approach course, adjust the turn to final to initially aim at the inside edge of the runway threshold. Do not descend below MDA until intercepting the visual profile to the landing runway.

Disengage the autopilot no later than MDA minus 50 feet. Flight director guidance using heading select and V/S or FPA may be used to maintain the descent path to the runway.

The FMS may be used to aid in situation awareness during the circling maneuver.

Enter the landing runway in the fix page and any radials to assist in situational awareness.



For example:

KMEM ILS 27 circle to land 18R

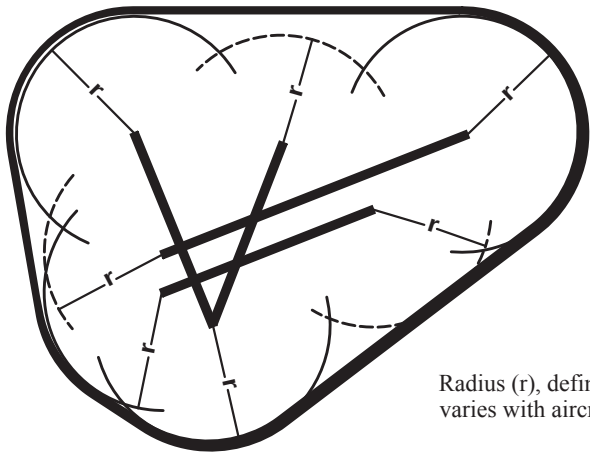
FIX key - Push.

Type KMEM18R in the scratchpad and enter in 1L.

Type 358 in scratchpad and enter in 3L. This will depict a dotted line from the end of runway 18R.

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.

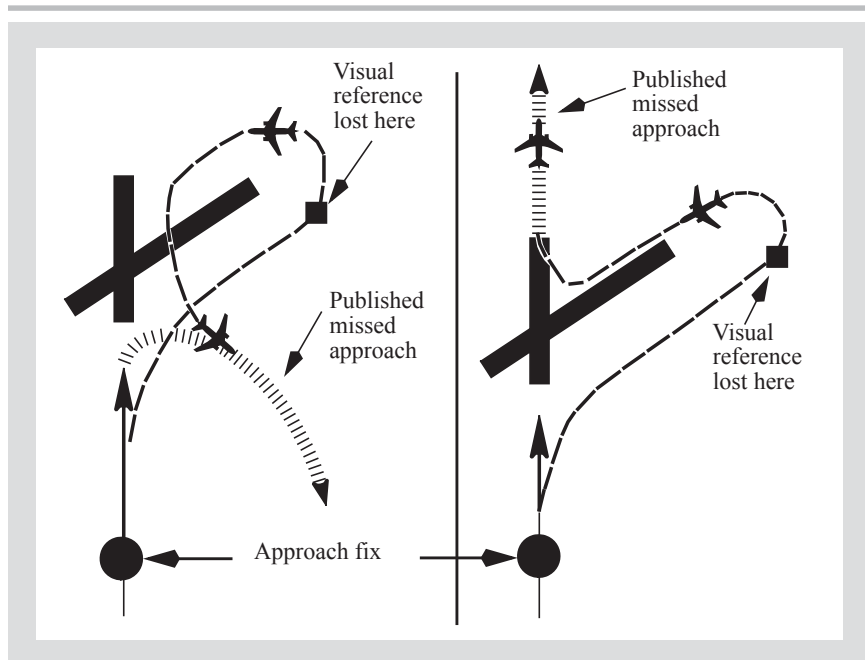
Note: Adjust aircraft heading so the aircraft ground track does not exceed the obstruction clearance distance from the runway at any time during the circling maneuver.

Note: Aircraft maneuvering outside of the 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.

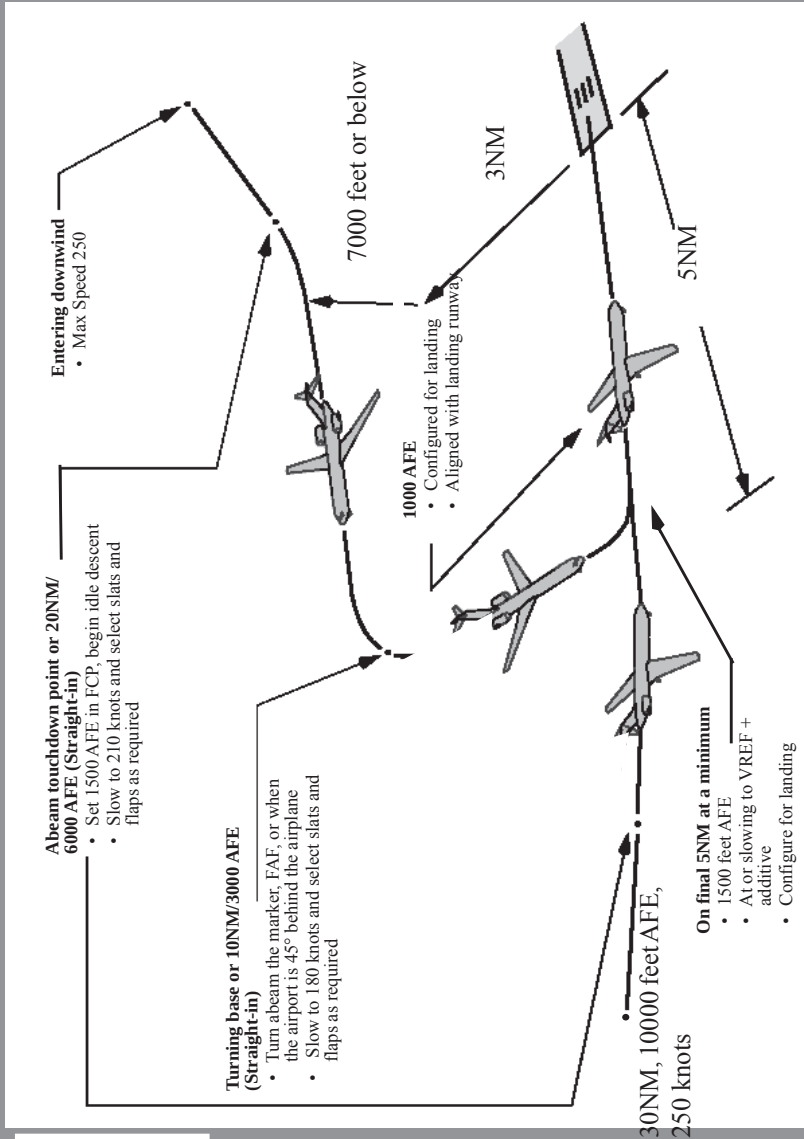


In the event that a missed approach must be accomplished from below the MDA, consideration should be given to selecting a flight path which ensures safe obstacle clearance until reaching an appropriate altitude on the specified missed approach path.

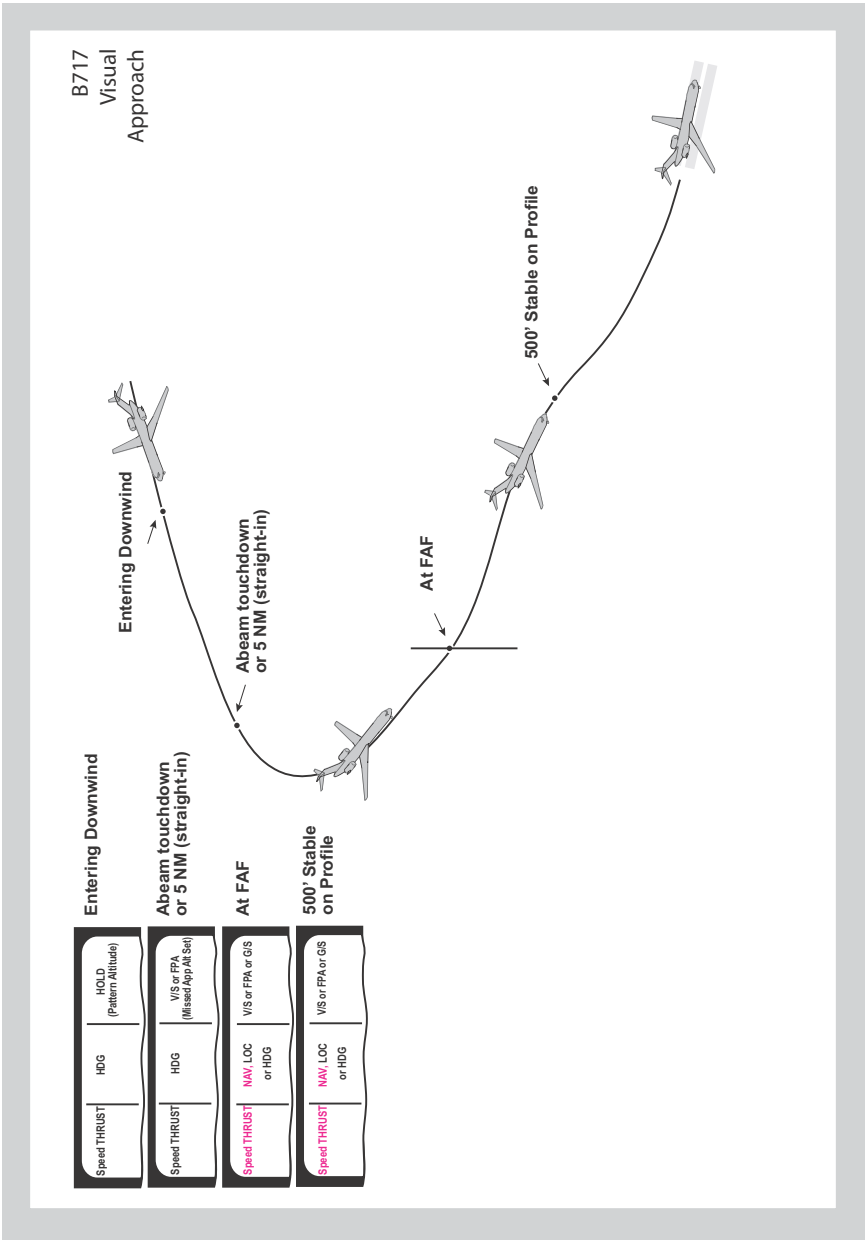
Refer to Go-Around and Missed Approach - All Approaches, this chapter.

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 $2\frac{1}{2}^{\circ}$ to 3° . Once the final approach is established, the aircraft configuration remains fixed and only small adjustments to the glide path, approach speed, and trim are necessary. This results in the same approach profile under all conditions.

Downwind and Base Leg

Fly at a minimum altitude of 1,500 feet above the runway elevation and enter downwind at 250 knots. Maintain a parallel track approximately 3 nm abeam the landing runway.

Abeam the touchdown point, descend to or maintain 1,500 feet and slow to 210 knots. Turn base leg abeam the marker or FAF, or when the runway is approximately 45° behind the aircraft. Slow to 180 knots and extend the slats and flaps as necessary.

Approaching extended centerline, configure for landing and slow to VAPP. Begin descent so as to intercept a 3° descent path to the runway.

If the downwind leg is extended and the aircraft is at an altitude higher than 1,500 AGL, descend 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 the altitude at the point in the base turn that allows the aircraft to rollout on final at 1,500 feet AGL.

Allow the speed to decrease to VAPP and trim the aircraft. Perform the Landing checklist. When established in the landing configuration, maneuvering to final approach may be accomplished at VAPP.

Vertical Guidance On a Visual Approach

Descending prematurely below the 3:1 path or the vertical guidance on a visual approach can expose the crew to threats such as obstacles and terrain. If below a 3:1 descent profile/vertical guidance, climb to reestablish the desired descent profile/vertical guidance or execute a go-around.

Final Approach

Autothrottles may be used for landing, however, if controlling thrust manually, attempt to keep thrust changes small to avoid large trim changes. Stabilize the aircraft at VAPP in trim with an approximate rate of descent of 3° or 800 fpm on the desired glide path. Maintain stabilized approach criteria throughout the approach.

Internal Visual Cues

Select an approach from the FMS that has the runway end (RWXX) as a waypoint on the procedure. In the absence of an approach to the runway, select the runway. Use the cross track indication to establish the desired downwind leg displacement. Use the PERF PATH ERROR or FMS Vertical Deviation on the Navigation Display to reference the vertical path to the runway. Reference the RWY symbol on the ND (10 mile scale) for the turn to base leg. Just prior to the RWY symbol disappearing from the bottom of the ND, begin configuring and initiate the base turn. Initiate the turn to final when the cross-track error is approximately 2 nm.

High Energy Approach

Every approach requires a loss of energy (altitude and airspeed) during arrival. Energy is lost by a combination of drag and airspeed changes. The time and distance required to lose energy using configuration and airspeed changes are described below.

High Speed Profile

The method to achieve the greatest descent gradient (feet/mile) occurs with the gear down, slats extended, full speedbrakes, idle thrust, and speed 250 KIAS. This results in a descent rate of approximately 4000 fpm with a descent gradient of approximately 750 feet/nm. The distance to slow from 250 KIAS to VAPP will require approximately 3 nm.

High Speed Descent Profile:

- Speed select 250 KIAS, extend full speedbrakes, slats extended, and the landing gear
- Set a target altitude (typically FAF altitude, but not lower than 1,500 feet HAT) in the FCP altitude window and pull level change
- Select LOC ONLY in the FMS.

Note: This airspeed/configuration combination will create significant airframe noise.

After descending below the ILS glideslope:

- Speed select VAPP
- Select APPR/LAND
- Extend the flaps on schedule as the aircraft slows
- Retract the speedbrakes prior to selecting greater than flaps 18
- Set the missed approach altitude.

The High Speed Descent profile requires approximately 10 nm in a no wind environment to lose 7,000 feet.

717 Flight Crew Training Manual

More specifically:

- The descent from 10,000 feet to 3,000 feet at 250 KIAS using level change will result in an average descent rate of 4000 fpm and take approximately 10 nm
- Slowing from 250 KIAS to VAPP will take approximately 3 nm.

Low Speed Profile

The method to achieve the greatest descent gradient (feet/mile) occurs when fully configured, idle thrust, and speed 190 KIAS. This results in a descent rate of approximately 3000 fpm with a descent gradient of approximately 800feet/NM. The distance to slow from 190 KIAS to VAPP will require approximately 1.5 nm.

Low Speed Descent Profile:

- Speed select 190, extend the landing gear, and take the flaps to 40 on schedule
- Set a target altitude (typically FAF altitude, but not lower than 1,000 feet HAT) in the FCP altitude window and pull level change
- Select LOC ONLY in the FMS.

After descending below the ILS glideslope:

- Speed select VAPP
- Select APPR/LAND.

The Low Speed Descent profile requires approximately 9 nm in a no wind environment to lose 7,000 feet.

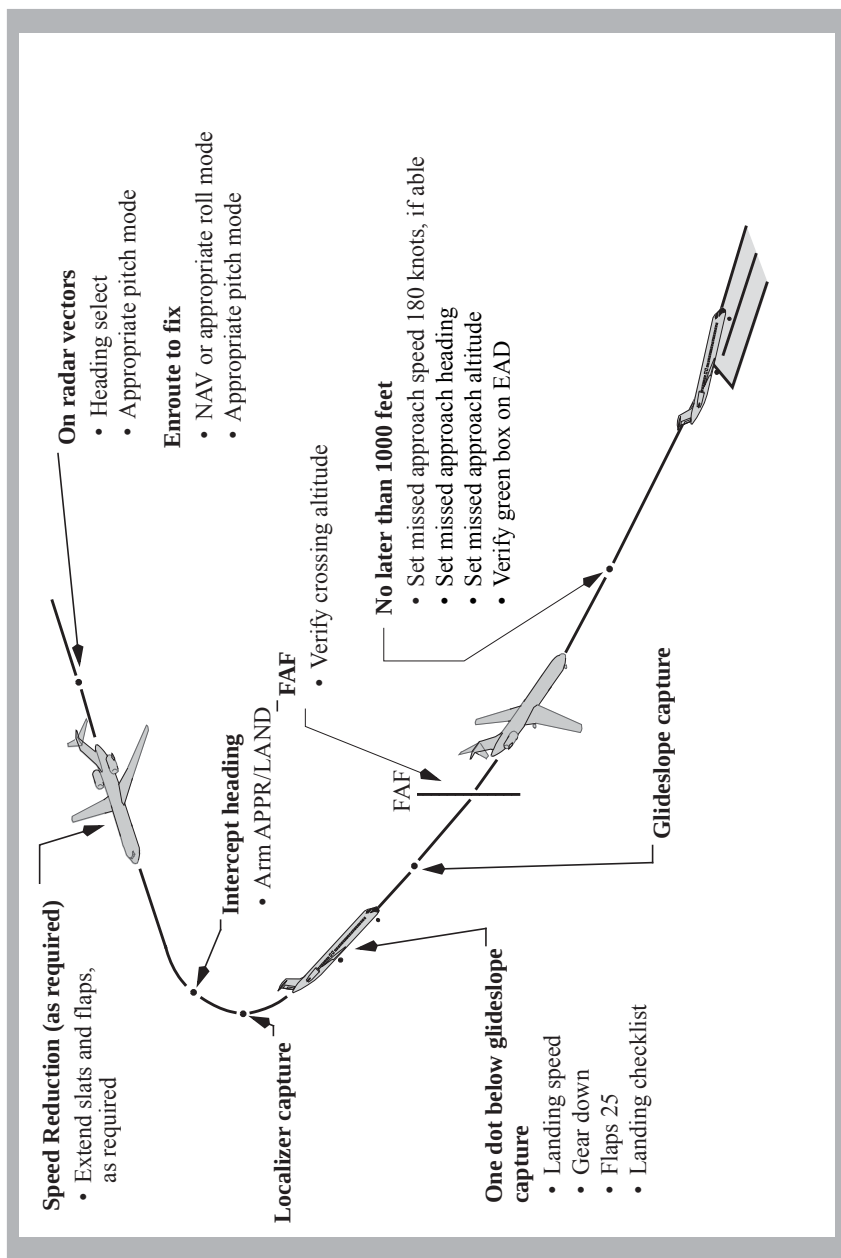
More specifically:

- Slowing from 250 KIAS to 190 KIAS in level flight at 10,000 feet with landing gear down and extending the flaps to 40 will take approximately 1.5 nm.
- The descent from 10,000 feet to 3,000 feet at 190 KIAS using level change will result in an average descent rate of 3,000 fpm and will take approximately 9 nm.
- Slowing from 190 KIAS to VAPP in level flight at 3,000 feet with gear down and flaps 40 will take approximately 1.5 nm.

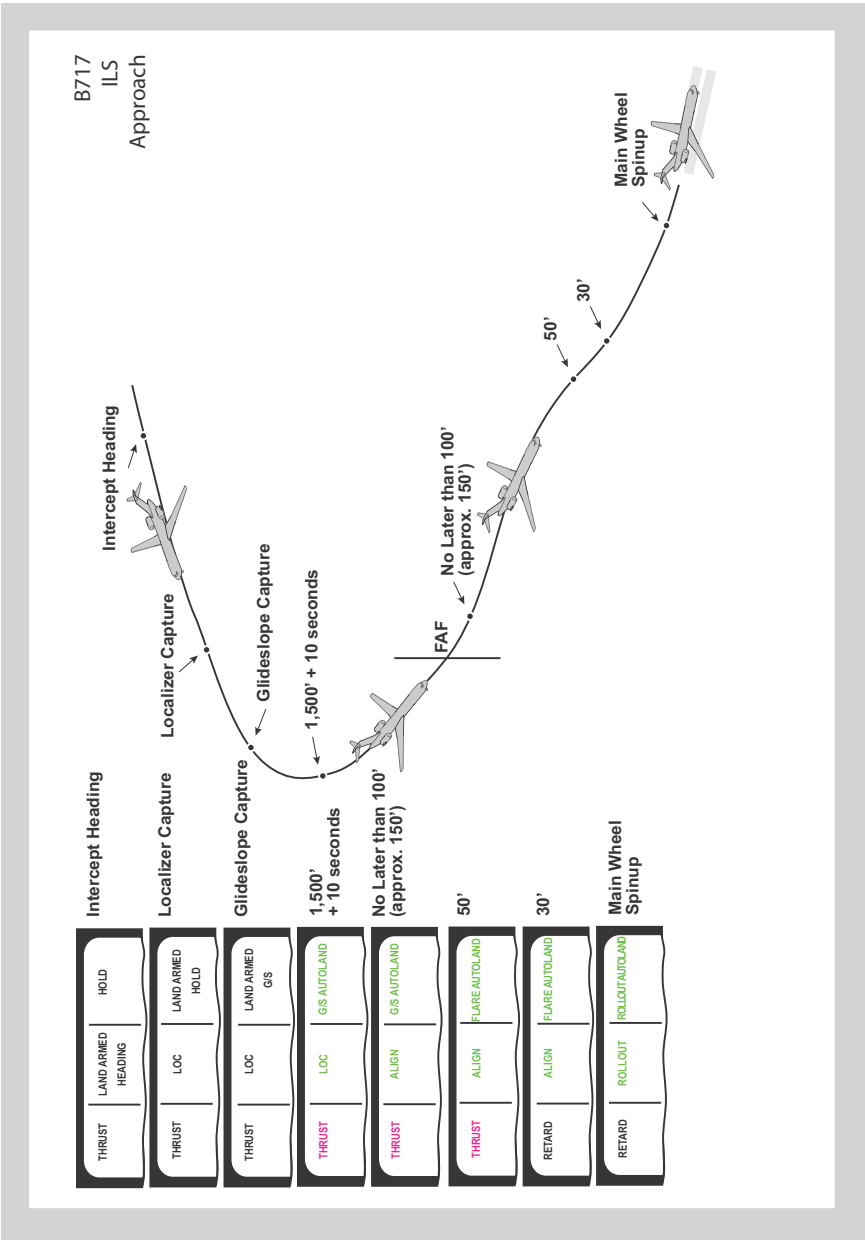
Engine Inoperative Approach Operations

This section describes pilot techniques associated with engine inoperative approaches. Techniques discussed minimize workload, improve crew coordination, and enhance flight safety. However, a thorough review of applicable non-normal checklists associated with engine inoperative flight is a prerequisite to understanding this section.

ILS Approach Profile - One Engine Inoperative



FMA Progression



ILS Approach - Engine Inoperative

AFS management and associated procedures are similar to those used during the normal ILS approach. Autoland may be used. Weather minima for an ILS approach with one engine inoperative are specified in the Vol. 1 or Airway Manual, Ops Specs, IAP.

During a single engine approach, the pilot must use rudder pedal pressure to control yaw, followed by rudder trim to maintain an in-trim condition during the entire approach unless parallel rudder is active. A centered control wheel indicates proper trim.

Minimize throttle movements to reduce both asymmetry and speed changes. Aircraft configuration changes require little thrust change until capturing the glideslope.

Intercept the localizer. At approximately one dot below glideslope set final approach speed, lower the landing gear, extend flaps to 25, and perform the landing checklist.

Be prepared to take over manually in the event system performance is not satisfactory.

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 flaps 25 is used for landing.

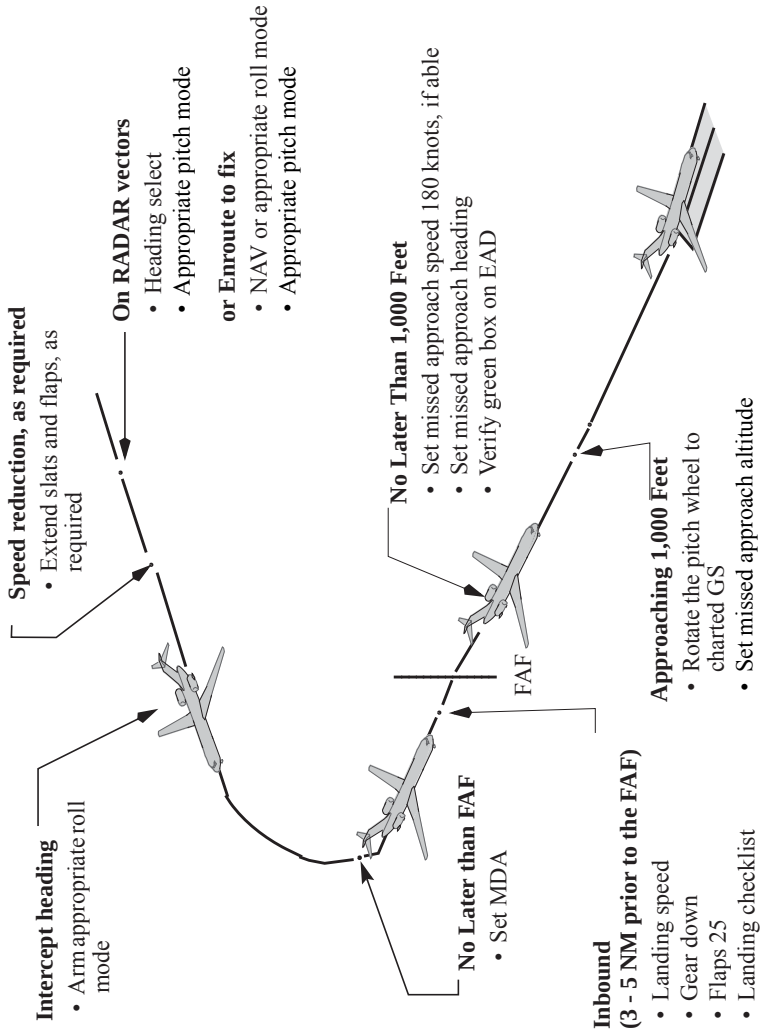
Engine Inoperative, Rudder Trim - All Instrument Approaches

The pilot must use rudder pedal pressure to control yaw, followed by rudder trim to maintain an in-trim condition during all approaches.

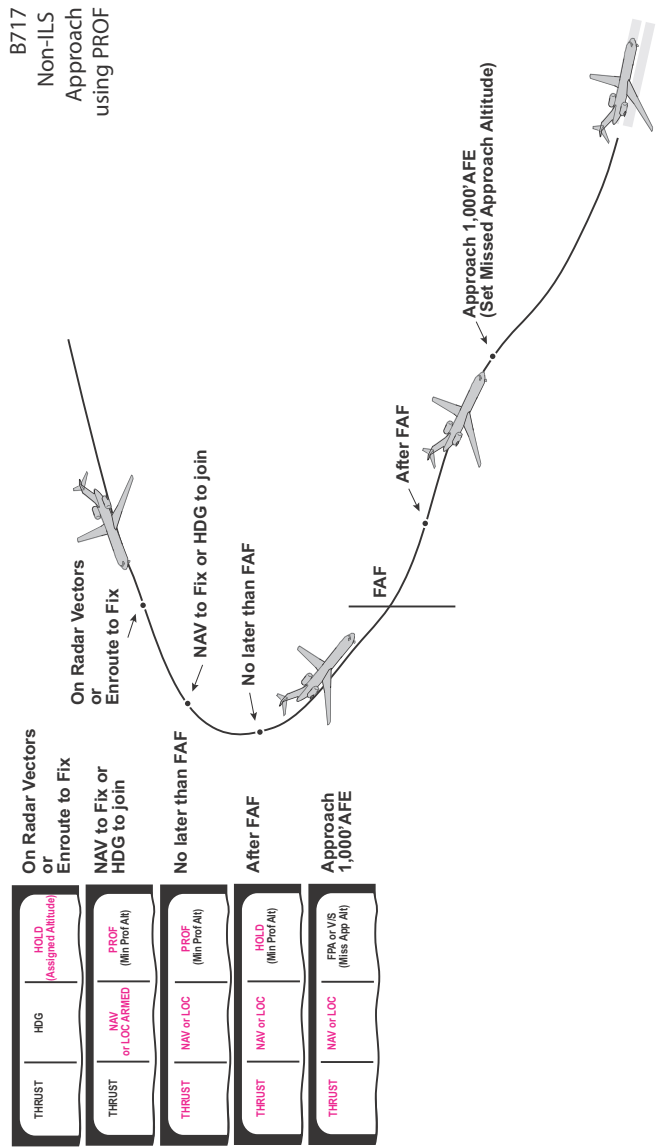
Rudder trim should be set to zero to facilitate directional control during thrust reduction. This is normally accomplished just prior to touchdown, as the power is being reduced for landing.

Centering the rudder trim before landing allows most of the rudder pedal pressure to be removed when the thrust of the operating engine is retarded to idle at touchdown. Full rudder authority and rudder pedal steering capability are not affected by rudder trim. If touchdown occurs with the rudder still trimmed for the approach, be prepared for the higher rudder pedal forces required to track the centerline on rollout.

Non-ILS Instrument Approach Profile Using PROF - One Engine Inoperative

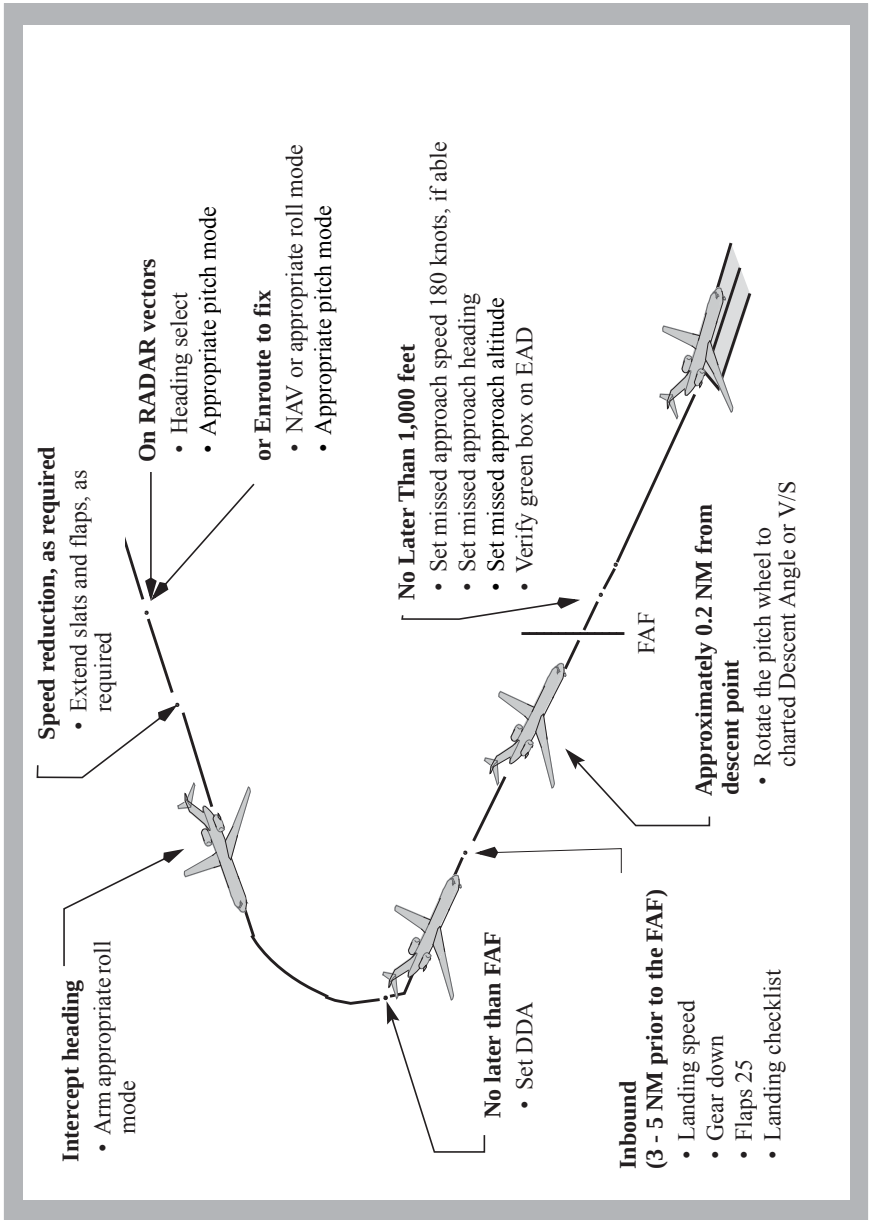


FMA Progression

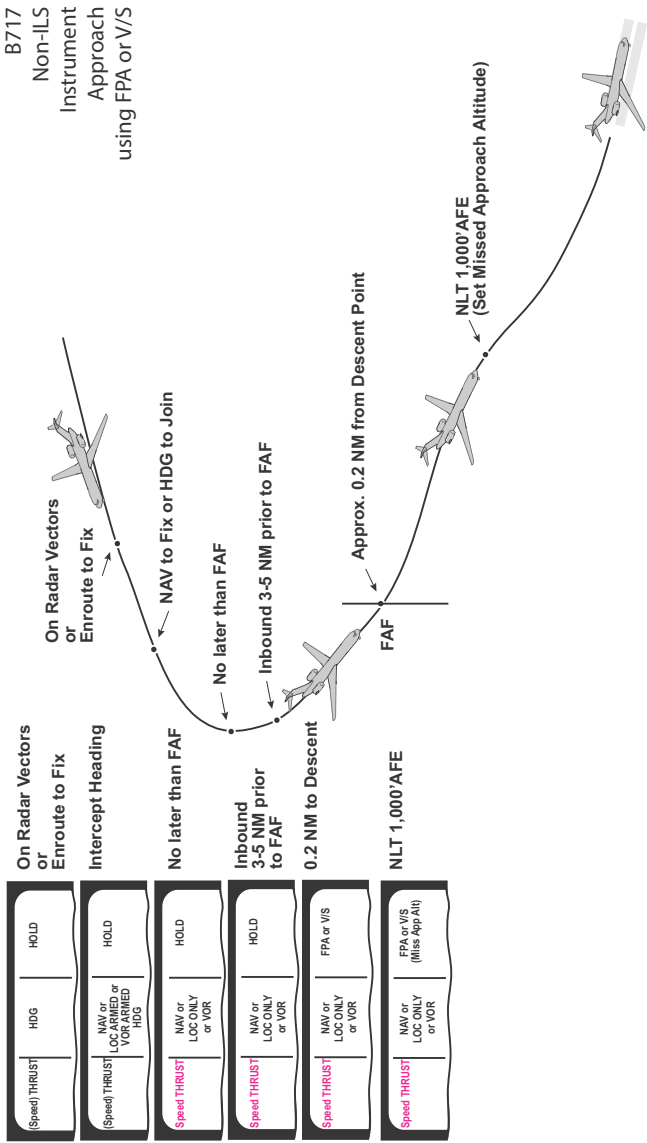




Non-ILS Instrument Approach Profile Using FPA or V/S - One Engine Inoperative



FMA Progression

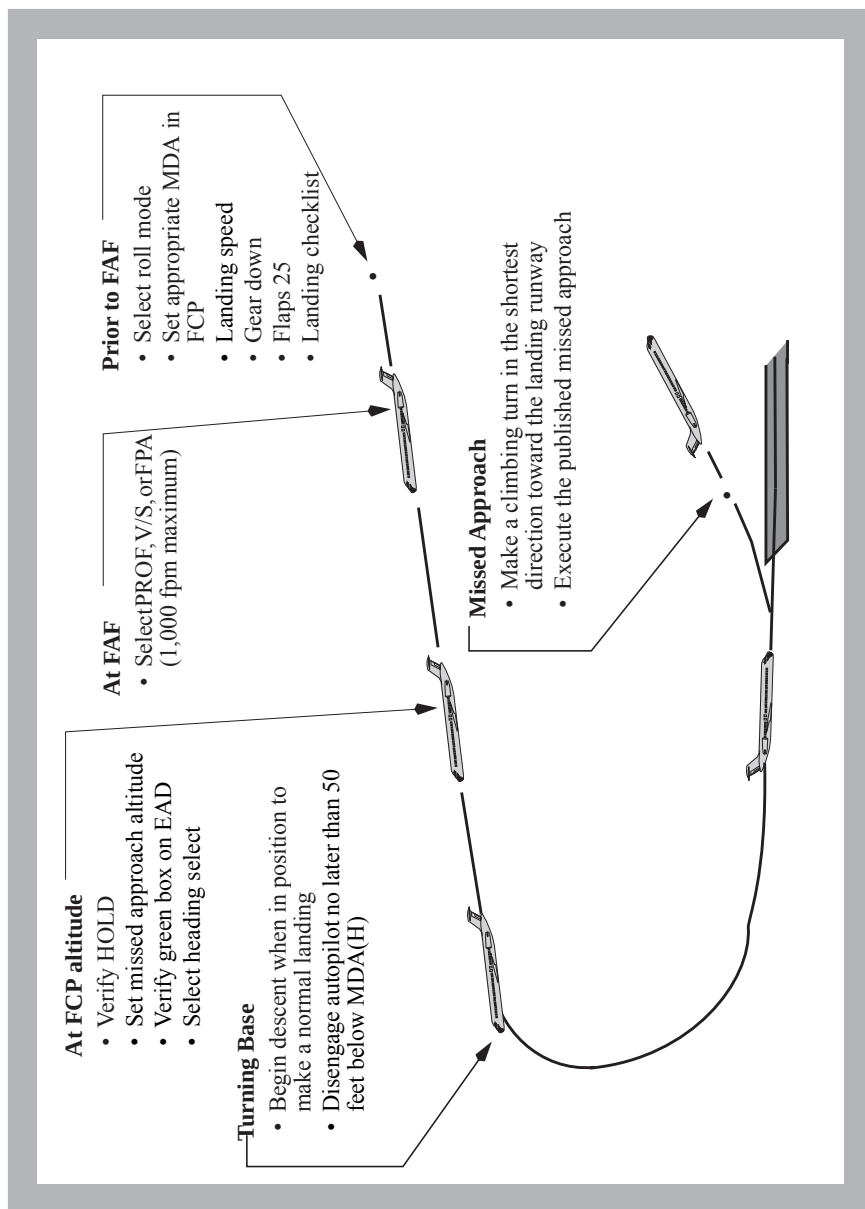




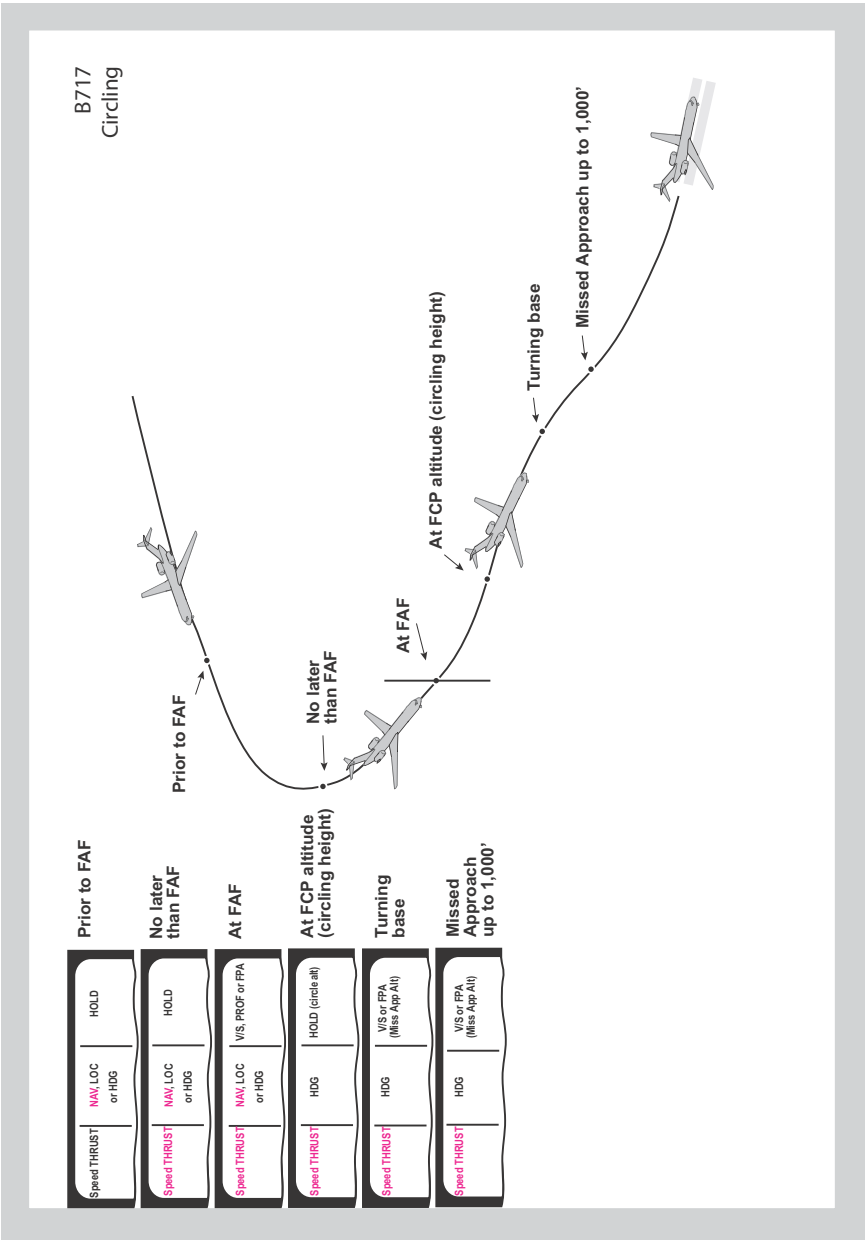
Non - ILS Approach - One Engine Inoperative

Maneuvering before and after the final approach fix with one engine inoperative is the same as for an all engine non-ILS approach with the exception that flaps 25 is used for landing. Consider delaying configuration at high gross weights and/or high temperature or pressure altitudes.

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, with the exception that flaps 25 is used for landing.

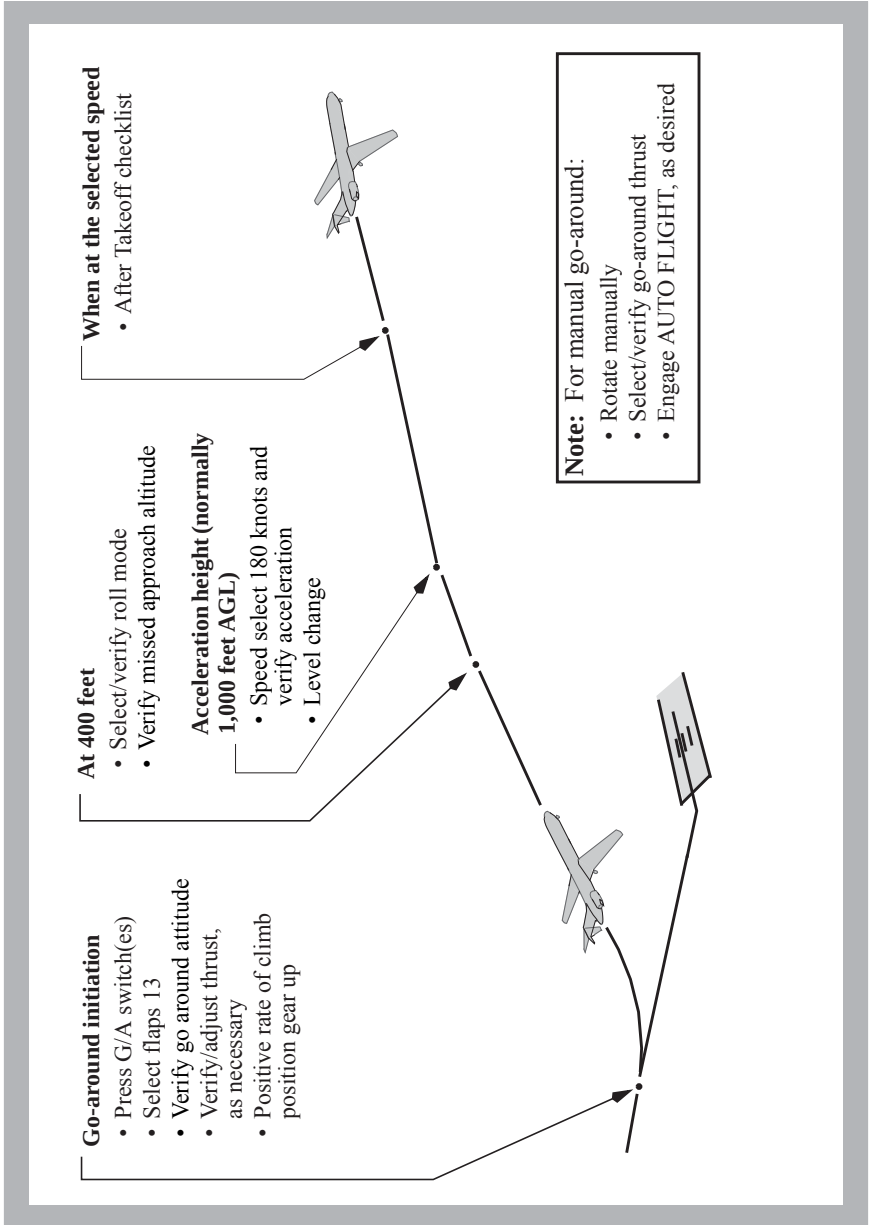
Engine Failure On Final Approach

If an engine failure should occur on final approach with flaps 40, the decision to continue the approach or execute a go around should be made immediately. If the approach is continued, change the configuration from flaps 40 to flaps 25 and adjust speed accordingly.

If a go around is required, follow the engine out go around procedures.

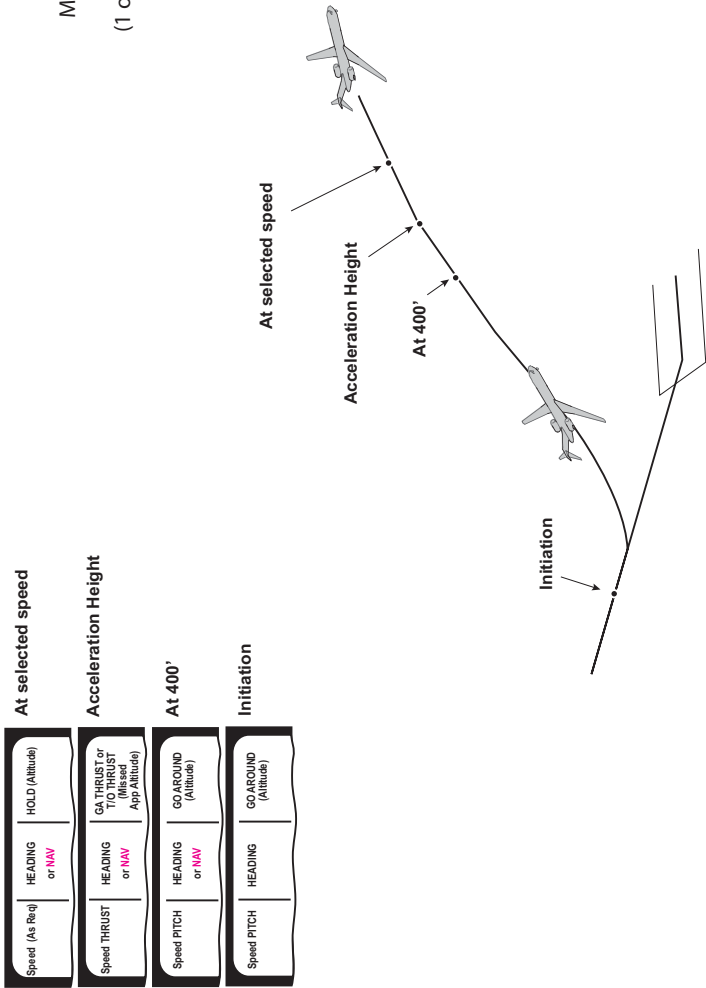
If the approach is continued at flaps 25, increase the thrust to maintain the appropriate speed or ensure autothrottle operation is satisfactory.

Go-Around and Missed Approach Profile - One Engine Inoperative



FMA Progression

B717
Go-Around and
Missed Approaches
All Approaches
(1 or 2 Engines Op)



Go-Around and Missed Approach - One Engine Inoperative

The missed approach with an engine inoperative should be accomplished in the same manner as a normal missed approach. The pilot must control yaw with rudder and trim. Some rudder pedal pressure may be required even with full rudder trim.

Pilot Flying	Pilot Monitoring
When a go-around is initiated:	
Push either GA switch and verbalize "GO AROUND." - For a manual go-around: - rotate manually; follow the flight director - engage autopilot as needed	Verify FMA displays PITCH, HEADING and GO AROUND and verbalize FMA altitude window. "GO AROUND VERIFIED" Verbalize any other FMA annunciations other than the normal go around modes. Callout any omissions.
Call "FLAPS 13."	Set FLAP/SLAT handle as directed.
Verify: - Rotation to go-around pitch attitude, - Thrust setting, - Proper FMA mode annunciation.	
	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 landing gear lever to UP
	Verify missed approach altitude is set
	Call out any trend toward terrain contact, descending flight path, or significant airspeed changes.

Pilot Flying	Pilot Monitoring
Above 400 feet RA:	
Verify or call for appropriate roll mode.*	Select or verify roll mode.
At acceleration height (normally 1,000 feet AFE):	
Call "SPEED SELECT 180" and "LEVEL CHANGE". Verify 180 knots in speed window and missed approach altitude in altitude window.	Pull speed select knob and set 180 knots in speed window. Pull level change knob and verify missed approach altitude in altitude window.
If another approach is warranted at the destination airport:	
Consider leaving flaps at 13 or establish the appropriate configuration for the desired airspeed.	Set the FLAP/SLAT handle as directed.
If a diversion is required:	
Call "FLAPS __ and/or SLATS __" Accelerate to desired airspeed and retract the flaps and slats on schedule.	Set the FLAP/SLAT handle as directed.
When at planned flap configuration:	
Call "AFTER TAKEOFF CHECKLIST."	Accomplish After Takeoff checklist.

Note: *Refer to the Airway Manual, Ops Specs, IAP, or the Company page, Critical Performance Procedures, Missed Approach/Rejected Landing table.

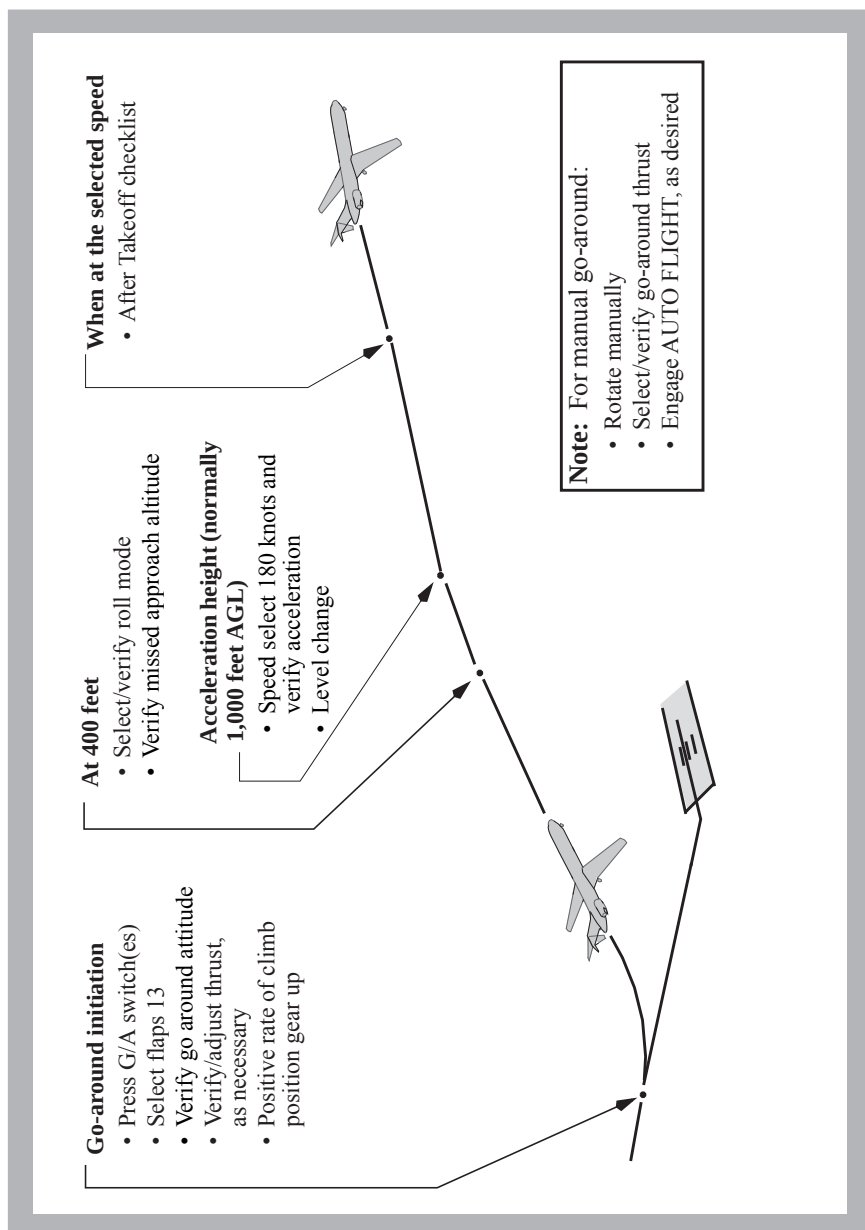


Engine Failure During Go-Around and Missed Approach

If an engine fails during go-around, perform normal go-around procedures. Engage autopilot, complete the After Takeoff checklist and NNC procedure, and adjust flaps/slats and speed as necessary for return to airport or diversion.

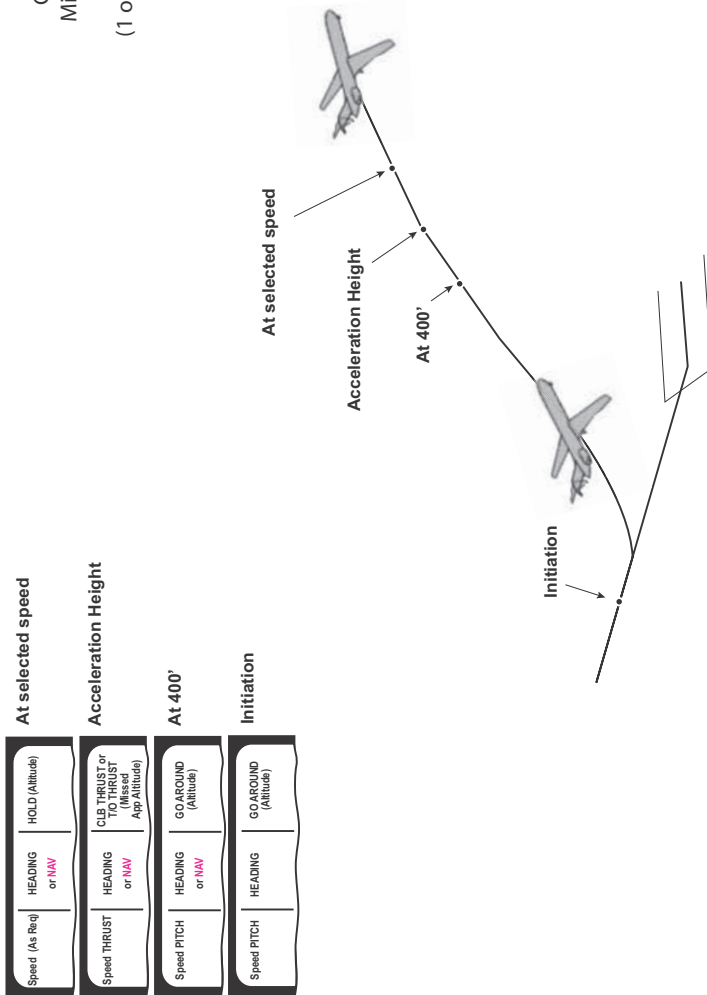
Go-Around and Missed Approach - All Approaches

Go-Around and Missed Approach Profile - All Approaches



FMA Progression

B717
Go-Around and
Missed Approach
All Approaches
(1 or 2 Engines Op)



Go-Around and Missed Approach - All Engines Operating

The go-around and missed approach is performed in the same manner whether an instrument or visual approach was flown and defines pilot flying and pilot monitoring duties. The go-around and missed approach is flown using the Go-Around procedure described in the Vol. 1, NP.20, and utilizing Standard Callouts. The discussion in this section supplements those procedures.

If a missed approach is required following an autopilot approach, leave the autopilot and autothrottles engaged. The pilot flying will push either GA switch and verbalize "GO AROUND". The pilot monitoring will verify that the FMA altitude window annunciation is GO AROUND. The level of automation should be AP1 or AP2. After FMA verification, the pilot monitoring will verbalize "GO AROUND VERIFIED" or call out any FMA omissions.

Examples of FMA omissions are:

- GO AROUND is not annunciated - Callout - "GO AROUND NOT VERIFIED, PUSH THE GO AROUND SWITCH"
- AP OFF annunciation and the level of automation is flight director - Callout - "GO AROUND VERIFIED, AUTOPILOT IS OFF"
- ATS OFF annunciation - Callout - "GO AROUND VERIFIED, NO AUTOTHROTTLES"

If the FMA mode is not GO AROUND, or if AP OFF or ATS OFF is annunciated, it must be verbalized by the pilot monitoring.

The pilot flying calls for flaps 13, ensure go-around thrust for the nominal climb rate is set and monitor autopilot performance. Retract the landing gear after a positive rate of climb is indicated on the altimeter.

717 Flight Crew Training Manual

Go-Around Maneuver - All Engines Operating

Pilot Flying	Pilot Monitoring
When a go-around is initiated:	
Push either GA switch and verbalize "GO AROUND." - For a manual go-around: - rotate manually; follow the flight director - engage autopilot as needed	Verify FMA displays PITCH, HEADING and GO AROUND and verbalize FMA altitude window. "GO AROUND VERIFIED" Verbalize any other FMA annunciations other than the normal go around modes. Callout any omissions.
Call "FLAPS 13."	Set FLAP/SLAT handle as directed.
Verify: - Rotation to go-around pitch attitude, - Thrust setting, - Proper FMA mode annunciation.	
	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 landing gear lever to UP
	Verify missed approach altitude is set
	Call out any trend toward terrain contact, descending flight path, or significant airspeed changes.
Above 400 feet RA:	
Verify or call for appropriate roll mode.*	Select or verify roll mode.
At acceleration height (normally 1,000 feet AFE):	

Pilot Flying	Pilot Monitoring
Call "SPEED SELECT 180" and "LEVEL CHANGE". Verify 180 knots in speed window and missed approach altitude in altitude window.	Pull speed select knob and set 180 knots in speed window. Pull level change knob and verify missed approach altitude in altitude window.
If another approach is warranted at the destination airport:	
Consider leaving flaps at 13 or establish the appropriate configuration for the desired airspeed.	Set the FLAP/SLAT handle as directed.
If a diversion is required:	
Call "FLAPS ___ and/or SLATS ___" Accelerate to desired airspeed and retract the flaps and slats on schedule.	Set the FLAP/SLAT handle as directed.
When at planned flap configuration:	
Call "AFTER TAKEOFF CHECKLIST."	Accomplish After Takeoff checklist.

Note: *Refer to the Airway Manual, Ops Specs, IAP, or the Company page, Critical Performance Procedures, Missed Approach/Rejected Landing table.

During an automatic go-around initiated at 50 feet, approximately 30 feet of altitude is lost. If touchdown occurs after a go-around is initiated, the go-around continues. Observe that the autothrottles apply go-around thrust or manually apply go-around thrust as the aircraft rotates to the go-around attitude.

Note: An automatic go-around cannot be initiated after touchdown.

The GA pitch mode initially commands a go-around attitude and then transitions to speed as the rate of climb increases. Commanded airspeed during climb will be VMIN + 5 for 13° flaps or indicated airspeed when GA button was pushed, whichever is higher.



717 Flight Crew Training Manual

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.

If initial maneuvering is required during the missed approach, do the missed approach procedure through gear up before initiating the turn. Delay further flap retraction until initial maneuvering is complete and a safe altitude and appropriate speed are attained.

At acceleration height (normally 1,000 feet AFE), call "speed select 180" and verify 180 knots is set in the speed window and maintain flaps 13. If flap retraction is desired, select FMS SPD and retract flaps on schedule.

Go-Around from an Altitude Below the Acceleration Height

Should a go-around be initiated below the acceleration height, use normal go-around procedures.

Go-Around from an Altitude Above the Acceleration Height

Note: Autopilot, Flight Director, and Autothrottle Go-Around are not available above 2,500 AGL or with flaps less than 5°.

Executing a go-around above the normal acceleration height (typically 1000' AFE) is often confusing. It is important that both pilots not focus entirely on the FCP. The PF should continue to "Fly the aircraft" while the PM assists as directed by the PF. Selecting TOGA provides immediate flight guidance. Immediate modifications to the flight path can be made by selecting alternate pitch and roll modes if required (e.g., Heading Select, Level Change).

**Go-Around Not Requiring a Climb
(Approach Cancellation prior to descent)**

Should an approach clearance be canceled prior to descent, make appropriate FCP inputs and fly the aircraft to comply with either ATC or specific instrument approach procedure instructions. Disarm any armed modes, use the appropriate roll and pitch modes to maneuver as required. Accelerate and retract landing gear and flaps on schedule.

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 AFS 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.

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

- Use the autothrottle.
- If full go-around thrust is used, reduce to climb thrust earlier than normal.
- Disconnect the AFS and complete the level off manually if there is a possibility of an overshoot.
- If the autothrottle is not available, be prepared to use manual thrust control as needed to manage speed and prevent flap overspeed.

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 spoilers retract as throttles are advanced. The F/D go-around mode will not be available until go-around is selected after becoming airborne.

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.

Landing

Table of Contents

Chapter 6

Section TOC

Visual Approach Slope Indicator (VASI / T-VASI)	6.1
Three Bar VASI / T-VASI	6.2
VASI Landing Geometry	6.2
Precision Approach Path Indicator	6.3
PAPI Landing Geometry	6.3
Landing Geometry	6.4
Visual Aim Point	6.4
Runway Markings (Typical)	6.5
Threshold Height	6.6
Tail Strike	6.6
Landing Risk Factors	6.6
Flare and Touchdown	6.8
Airspeed Control	6.9
Landing Flare Profile	6.10
Pitch and Roll Limit Conditions	6.10
Bounced Landing Recovery	6.10
Rejected Landing	6.11
Landing Roll	6.11
Spoilers	6.12
Directional Control and Braking during Landing Roll	6.12
Factors Affecting Landing Distance	6.13
Wheel Brakes	6.14
Reverse Thrust Operation	6.17
Crosswind Landings	6.21
Crosswind Landing Guidelines	6.21
Crosswind Landing Techniques	6.21

Overweight Landing	6.22
Overweight - General.	6.22
Overweight Autolands	6.23
Shutdown	6.24

Visual Approach Slope Indicator (VASI / 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 one red bar over two white bars. Three-bar VASI may be safely used with respect to threshold height, but may result in landing further down the runway.

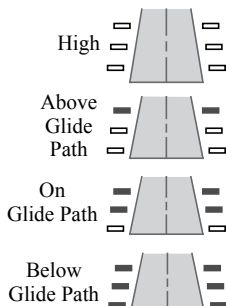
For a T-VASI, flying the approach with one additional white fly down light visible provides additional wheel clearance.

Three Bar VASI / T-VASI

Visual Approach Slope Indicator (VASI)

 Red VASI Lights
 White VASI Lights

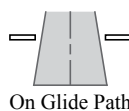
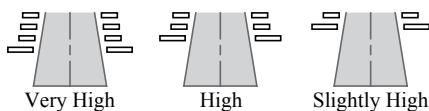
Standard (3-bar)



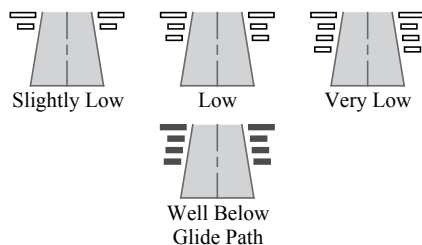
Visual Approach Slope Indicator (T-VASI)

 Red T-VASI Lights
 White T-VASI Lights

Fly Down Lights



Fly Up Lights



VASI Landing Geometry

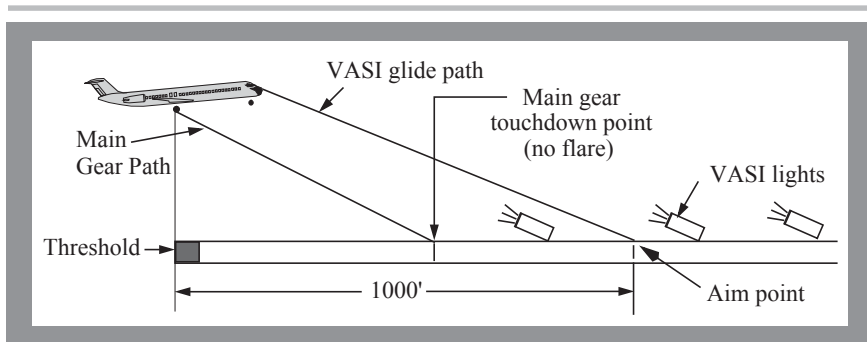
Two-bar VASI installations provide one visual glide path which is normally set at 3°. Three-bar VASI installations provide two visual glide paths. The lower glide path is provided by the near and middle bars and is normally set at 3° while the upper glide path, provided by the middle and far bars, is normally 1/4° 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
- Aircraft body attitudes are based on Flaps 40, VREF + 5 and should be reduced by 1° for each 5 knots above this speed
- Pilot eye height is measured when the main gear is over the threshold.

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717 Flight Crew Training Manual

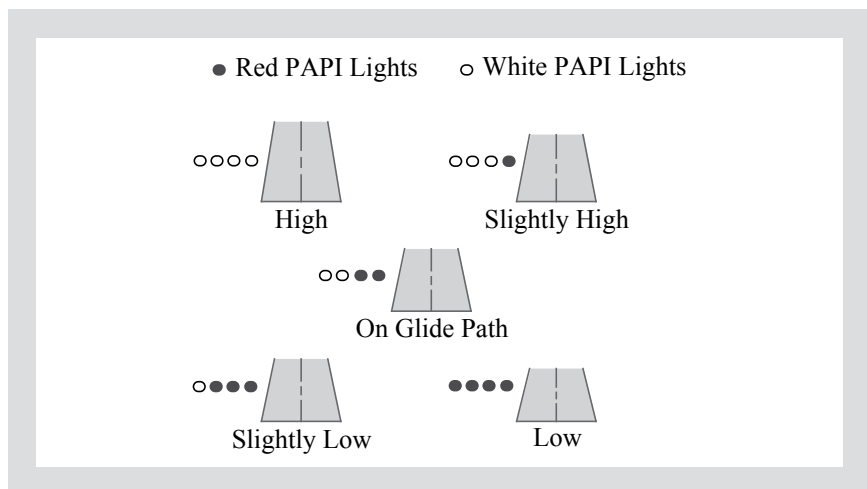


Precision Approach Path Indicator

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.

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 or tail skid (as installed) 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.

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. 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. At any altitude, if the stabilized approach criteria cannot be established and maintained, initiate a go-around.

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.

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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.

Trimming in the Flare

Trimming the stabilizer in the flare may contribute to a tail strike. The pilot flying may easily lose the feel of the elevator while the trim is running. Too much trim can raise the nose, even when this reaction is not desired. The pitch up can cause a balloon, followed either by dropping in or pitching over and landing in a three-point attitude. Flight crews should trim the airplane during the approach, but not in the flare.

Mishandling of Crosswinds

When the airplane is placed in a sideslip attitude to compensate for the wind effects, this cross-control maneuver reduces lift, increases drag, and may increase the rate of descent. If the airplane then descends into a turbulent surface layer, particularly if the wind is shifting toward the tail, the stage is set for tail strike.

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 additional thrust, if needed, and 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. When the go-around mode is initiated, the flight director immediately commands a go-around pitch attitude. If the pilot flying abruptly rotates up to the pitch command bar, a tail strike can occur before the airplane responds and begins climbing. During a go-around, an increase in thrust as well as a positive pitch attitude is needed. If the thrust increase is not adequate for the increased pitch attitude, the resulting speed decay will likely result in a tail strike. 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, in trim and 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 autothrottle 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. Initiate the flare when the main gear is approximately 20 feet above the runway by increasing pitch attitude approximately 2° - 3° . This slows the rate of descent.

 DELTA
717 Flight Crew Training Manual

After the flare is initiated, smoothly retard the throttles to idle, and make small pitch attitude adjustments to maintain the desired descent rate to the runway. A smooth thrust reduction to idle also assists in controlling the natural nose-down pitch change associated with thrust reduction. Ideally, main gear touchdown should occur simultaneously with throttles reaching idle. Hold sufficient back pressure on the control column to keep the pitch attitude constant. A touchdown attitude as depicted in the Landing Flare Profile section is normal with an airspeed of approximately VREF plus any gust correction.

Avoid rapid control column movements during the flare. If the flare is too abrupt and thrust is excessive near touchdown, the aircraft tends to float in ground effect. Do not allow the aircraft to float or attempt to hold it off. Fly the aircraft onto the runway at the desired touchdown point and at the desired airspeed.

Note: Do not trim during the flare or after touchdown. Trimming in the flare increases the possibility of a tail strike.

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.

Typically, the pitch attitude increases slightly during the actual landing, but avoid over-rotating. Do not increase the pitch attitude, trim, or hold the nose wheel off the runway after landing. This could lead to a tail strike.

Airspeed Control

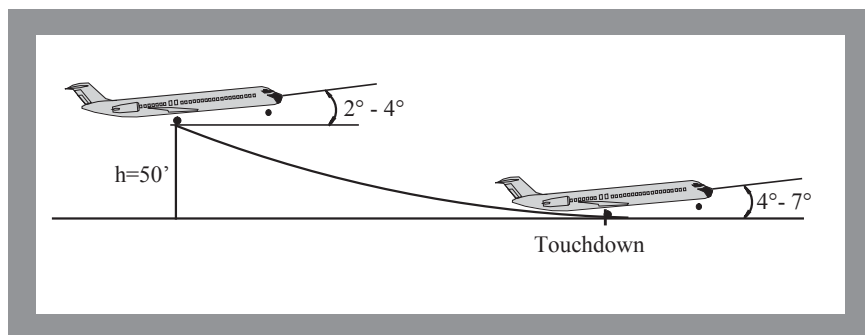
If engaged, the autothrottle retards the thrust so as to reach idle at touchdown. The 5 knot additive is bled off during the flare.

If the autothrottle is or will be disconnected prior to landing, maintain VREF plus the wind additive until approaching the flare. The steady headwind additive is bled off before touchdown while the gust correction is maintained to touchdown. Plan to touchdown at VREF plus the gust correction. With proper airspeed control and thrust management, touchdown should occur at no less than VREF - 5 knots.

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
- Aircraft body attitudes are based upon typical landing weights, flaps 40, VREF 40 + 5 knots (approach) and VREF 40 + 0 (touchdown), and should be reduced by 1° for each 5 knots above this speed.



Pitch and Roll Limit Conditions

Prolonged flare increases the body pitch attitude 2° to 3° . When prolonged flare is coupled with a misjudged height above the runway aft body contact is possible.

Fly the airplane onto the runway at the desired touchdown point and at the desired airspeed. Do not hold it off and risk the possibility of a tailstrike.

Note: A smooth touchdown is not the criterion for a safe landing.

Bounced Landing Recovery

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 go-around thrust and use normal go-around procedures. Do not retract the landing gear until a positive rate of climb is established because a second touchdown may occur during the go-around.

If higher than idle thrust is maintained through initial touchdown, the automatic spoiler deployment may be disabled even when the ground spoilers are armed. This can result in a bounced landing.

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.

Landing Roll

Avoid touching down with thrust above idle since this may establish an aircraft nose up pitch tendency and increases landing roll.

After main gear touchdown, initiate the landing roll procedure. If the spoilers do not extend automatically move the spoiler lever to the UP position without delay.

Fly the nose wheels smoothly onto the runway without delay. Control column movement forward of neutral should not be required. 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.

Note: Reversers will not deploy until the nose wheel is on the ground.

To avoid possible aircraft structural damage, do not make large nose down control column movements before the nose wheels are lowered to the runway.

To avoid the risk of a tail strike, do not allow the pitch attitude to increase after touchdown. However, applying excessive nose down elevator during landing can result in substantial forward fuselage damage. Do not use full down elevator. After touchdown, 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.

Spoilers

CAUTION: If throttles are forward of the idle position during main wheel spin-up, the auto spoilers may not function. In this case the spoilers must be extended manually.

The spoilers can be fully raised after touchdown while the nose wheels are lowered to the runway, with no adverse pitch effects. The spoilers spoil the lift from the wings, which places the aircraft weight on the main landing gear, providing excellent brake effectiveness.

Unless spoilers are raised after touchdown, braking effectiveness may be reduced initially as much as 60%, since very little weight is on the wheels, and brake application may cause rapid antiskid modulation.

Normally, spoilers are armed to extend automatically. Both pilots should monitor spoiler extension after touchdown. In the event auto extension fails, the spoilers should be manually extended immediately.

Pilot awareness of the position of the spoiler lever during the landing phase is important in the prevention of over-run. The position of the spoilers 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. In a crosswind, displace the control wheel into the wind to maintain wings level which aids directional control. 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, spoilers, wheel brakes, and surface conditions of the runway.

Note: Reverse thrust and spoiler drag are most effective during the high-speed portion of the landing. Deploy the spoiler lever and activate reverse thrust with as little time delay as possible.

Note: 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 and Approach Speeds tables in the ODM show landing distance and VREF for various non-normal landing configurations and runway conditions.

Slippery Runway Landing Performance

CAUTION: On extremely slippery runways at high speeds, deceleration may be slower than normal which could be interpreted as a total anti-skid failure. Do not pump the brakes since this action will degrade braking effectiveness.

When landing on slippery runways contaminated with ice, snow, slush, or standing water, the reported braking action must be considered. Performance data for reported braking actions of good, medium and poor is contained in the ODM. The performance level associated with GOOD is representative of a wet grooved runway. The performance level associated with POOR is representative of a wet ice covered runway. Also provided in the ODM are stopping distances for non-normal configurations. 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.

I Refer to the Vol. 1, SP.16 and the Airway Manual, Weather, Braking Action.

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 spoilers.

The coefficient of friction depends on the tire condition and runway surface, (e.g. concrete, asphalt, dry, wet, or icy).

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.

Normally brakes are not required until approximately 80 knots. Thrust reversers do an excellent job stopping the aircraft. When applying brakes, 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.

Manual braking techniques normally involve a four-to five-second delay between main gear touchdown and brake pedal application even when actual conditions reflect the need for a more rapid initiation of braking. This delayed braking can result in the loss of 800 to 1,000 feet of runway. Directional control requirements for crosswind conditions and low visibility may further increase the delays. Distractions arising from a malfunctioning reverser system can also result in delayed manual braking application.

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.

The brake temperature monitoring system may be used for additional flight crew guidance in assessing brake energy absorption. This system indicates a stabilized value approximately fifteen minutes after brake energy absorption. Therefore, an immediate or reliable indication of tire or hydraulic fluid fire, wheel bearing problems, or wheel fracture is not available. The brake temperature monitor readings may vary between brakes during normal braking operations.

Note: Brake energy data provided in the ODM should be used to identify potential overheat situations.

Close adherence to recommended landing roll procedures ensures minimum brake temperature buildup.

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.

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 the largest available landing flap setting.
- Ensure all of the headwind additive is bled off before touchdown 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.
- After main gear touchdown and once nose lowering has commenced, normal reverse should be used. The intention is to use reverse thrust as the major force that stops the aircraft.
- 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.

CAUTION: In order to minimize the possibility of FOD, do not use reverse thrust at speeds below 40 knots.

CAUTION: Emergency reverse thrust can damage an engine and requires a maintenance inspection.

Note: Pulling the reverser levers past the second detent through a mechanical gate activates emergency reverse thrust.

Awareness of the position of the forward and reverse throttles must be maintained during the landing phase. Improper seat position as well as long sleeved apparel may cause inadvertent advancement of the forward throttles, preventing movement of the reverse throttles.

The position of the hand should be comfortable, permit easy access to the autothrottle disconnect switch, and allow control of all throttles, forward and reverse, through full range of motion.

Note: Reverse thrust is most effective at high speeds.

Note: Thrust reverser deployment is not available until the nose gear strut is compressed. It is recommended that the PF hold forward pressure on the control column to ensure nose strut compression.

Note: If nose strut compression is not maintained after reverser deployment, the REV indications will change to red, although reverser operation will be normal.

After touchdown with the throttles at idle, palm of the hand or wrist on the throttles, and once nose lowering commences, raise the reverse levers up and aft through the reverse idle position (first detent) to the normal reverse position (second detent). 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, until 80 knots. At this point start reducing the reverse thrust so that the reverse throttles are moving down at a rate commensurate with the deceleration rate of the aircraft. The reversers should be positioned to the reverse idle detent by 60 Knots. Reverse thrust is reduced to idle between 80 knots and 60 knots, 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 throttles 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.

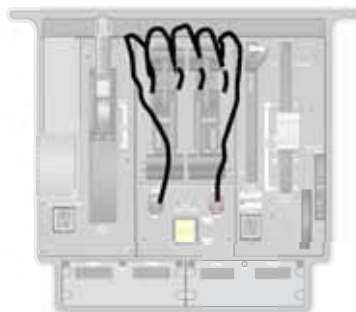
The PM should call out 80 knots to assist the PF in scheduling the reverse thrust. The PM should also call out any inadvertent selection of forward thrust as reverse thrust is canceled.

 DELTA
717 Flight Crew Training Manual

Reverse Thrust Operations



After main gear touchdown and once nose lowering has commenced, raise reversers up and aft to second detent.



Gripping Pattern

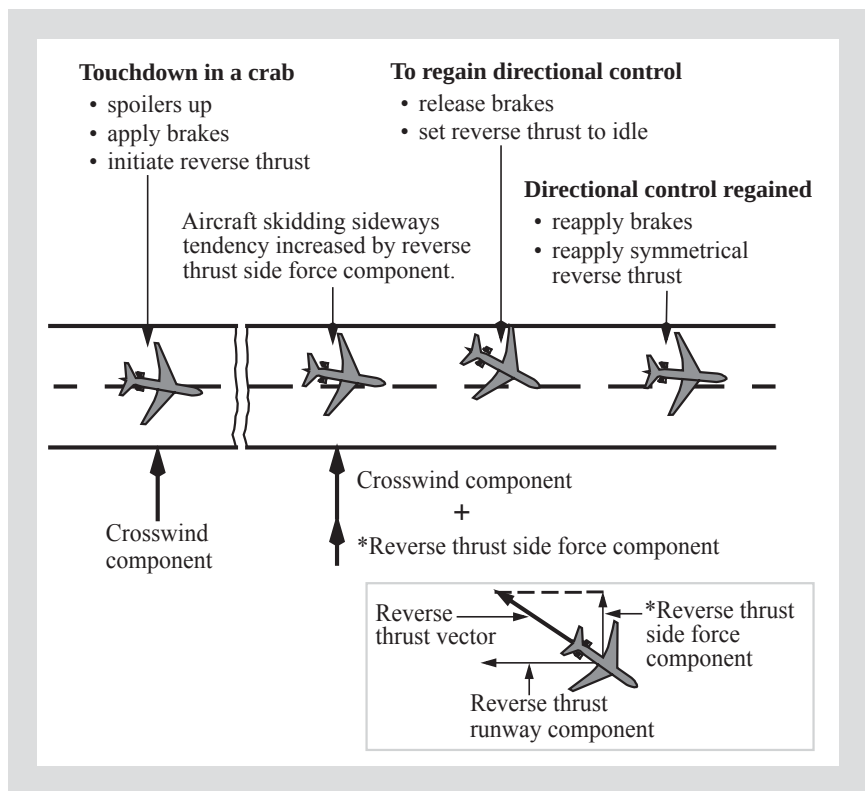


Use normal reverse until 80 KIAS.



By 80 KIAS initiate movement of reverse thrust levers to reach the reverse idle detent by 60 KIAS.

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.

 DELTA
717 Flight Crew Training Manual

Reverse Thrust - Engine Inoperative

Asymmetrical reverse thrust may be used with one engine inoperative. Use normal reverse thrust procedures and techniques with the operating engine. If directional control becomes a problem during deceleration, return the throttle to the reverse idle detent.

Crosswind Landings

Note: For additional information on crosswind guidelines, refer to Vol. 1, SP.16, Guidelines for Takeoff on Contaminated Runways or Landing with Braking Action Less than Good.

Crosswind Landing 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

Two methods of performing crosswind landings are presented. They are the de-crab technique (with removal of crab in flare), and the sideslip technique. Whenever a crab is maintained during a crosswind approach, offset the flight deck on the upwind side of centerline so that the main gear touches down in the center of the runway.

De-Crab During Flare

The objective of this technique is to maintain wings level throughout the approach, flare, and touchdown. On final approach, a crab angle is established with wings level to maintain the desired track. Just prior to touchdown while flaring the aircraft, downwind rudder is applied to eliminate the crab and align the aircraft with the runway centerline.

As rudder is applied, the upwind wing sweeps forward, developing roll. Hold wings level with simultaneous application of aileron control into the wind. The touchdown is made with cross controls and both gear touching down simultaneously. Throughout the touchdown phase upwind aileron application is utilized to keep the wings level.

Sideslip (Wing Low)

The sideslip crosswind technique aligns the aircraft with the extended runway centerline so that main gear touchdown occurs on the runway centerline.

The initial phase of the approach to landing is flown using the crab method to correct for drift. Prior to the flare the aircraft centerline is aligned on or parallel to the runway centerline. Downwind rudder is used to align the longitudinal axis to the desired track as aileron is used to lower the wing into the wind to prevent drift. A steady sideslip is established with opposite rudder and low wing into the wind to hold the desired course.

Touchdown is accomplished with the upwind wheels touching just before the downwind wheels. Overcontrolling the roll axis must be avoided because overbanking could cause the wing tip to contact the runway.

Properly coordinated, this maneuver results in nearly fixed rudder and aileron control positions during the final phase of the approach, touchdown, and beginning of the landing roll. However, since turbulence is often associated with crosswinds, it is often difficult to maintain the cross control coordination through the final phase of the approach to touchdown.

If the crew elects to fly the sideslip to touchdown, it may be necessary to add a crab during strong crosswinds. Main gear touchdown is made with the upwind wing low and crab angle applied. As the upwind gear touches first, a slight increase in downwind rudder is applied to align the aircraft with the runway centerline. At touchdown, increased application of upwind aileron should be applied to maintain wings level.

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. Landing distance is normally less than takeoff distance for flaps 25 or 40 landings at all gross weights. However, wet or slippery runway field length requirements should be verified from the landing distance charts in the ODM. Brake energy limits will not be exceeded for flaps 25 or 40 landings at all gross weights.

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 18 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.

 DELTA
717 Flight Crew Training Manual

Observe flap placard speeds during flap extension and on final approach. In the holding and approach patterns, maneuvers should be flown at the normal maneuver speeds.

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.

Overweight Autolands

Overweight autolands are not recommended. Autopilots are not certified for automatic landings above maximum landing weight. At higher than normal speeds and weights, the performance of these systems may not be satisfactory and has not been thoroughly tested. An automatic approach may be attempted, however the pilot should disengage the autopilot prior to flare height and accomplish a manual landing.

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.
- 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.

Shutdown

The engine may be shutdown after 3 minutes at idle or when the ENGINE COOL alert message is displayed. Normal use of power during ground operations, including break-away power, does not require restarting the cool down period. The use of break-away power (approximately 1.2 EPR) may reset the timer for the ENGINE COOL alert. In this case, ensure the 3 minute requirement is observed.

During single engine taxi in, the pneumatic isolation valve is opened so that both packs can be supplied by one engine. When the APU is subsequently started to supplement the cooling air do not open the APU air switch until the two minute warm up is complete (as indicated by the presence of the APU icon on the AIR SD), or after shutting down the second engine. Opening the APU air switch prior to completion of the warm up will shut off the bleed valve for the operating engine and there will be no conditioned air on the airplane until the APU warm-up is complete.

Note: If ground crews open the aft cargo door, the right engine should be shut down.

When parking, it is recommended that the nosewheel be in approximately center position before forward motion is stopped.

After landing, brake temperature differential up to 60°C on the same gear is considered normal.

Note: During the secure checklist, if external power is not available, confirm that the APU information block on the SD ENG display is removed prior to selecting emergency power and battery switch off. This will ensure that the APU doors are closed.

Maneuvers

Table of Contents

Chapter 7

Section TOC

Acceleration to and Deceleration from VMO	7.1
Engine Out Familiarization	7.2
Rudder and Lateral Control	7.2
Thrust and Airspeed	7.3
High Altitude Maneuvering, “G” Buffet	7.4
Mach Buffet	7.4
Mach Tuck	7.5
Dutch Roll	7.5
Rapid 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	7.9
Flight Control Effectiveness	7.9
Ailerons	7.9
Horizontal Stabilizer and Elevators	7.9
Rudder	7.9
Vortilons	7.10
Flight Control Effectiveness Maneuvers	7.10
Stall or Approach to Stall	7.12
Stall or Approach to Stall Recovery Maneuver	7.12
Stall or Approach to Stall Characteristics	7.14
Stall or Approach to Stall Recovery	7.16
Steep Turns	7.17
Entry	7.17
During Turn	7.17

Attitude Indicator	7.17
Vertical Speed Indicator	7.17
Altimeter	7.18
Airspeed	7.18
Rollout	7.18
Terrain Avoidance	7.18
Terrain Avoidance Maneuver	7.19
Traffic Alert and Collision Avoidance System	7.21
Traffic Advisory	7.21
Resolution Advisory	7.21
The RA Maneuver	7.21
Parallel Approach Exception to Resolution Advisory Compliance	7.23
Interaction with ATC	7.23
Mode of Operation	7.23
Other Considerations	7.24
Upset Recovery	7.25
Nose High Recovery	7.26
Nose Low Recovery	7.26
General	7.27
Upset Recovery Techniques	7.30
Windshear	7.31
General	7.31
Avoidance	7.31
Precautions	7.32
Aircraft Performance in Windshear	7.33
Windshear Encounter Recognition	7.34
Windshear Escape Maneuver	7.35
Windshear During Takeoff Roll	7.36
Windshear In Flight	7.36

 DELTA
717 Flight Crew Training Manual

Windshear Alert and Guidance System (WAGS).....	7.37
Post Windshear Considerations.....	7.38

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Acceleration to and Deceleration from VMO

Acceleration to and deceleration from VMO demonstrates performance capabilities and response to speed, thrust, and configuration changes throughout the medium altitude speed range of the aircraft. This maneuver is performed in the full flight simulator/flight training device and is for demonstration purposes only. It is normally performed at 10,000 to 15,000 feet, simulating slowdown to 250 knots due to speed restrictions.

VMO is a structural limitation and is the maximum operating indicated airspeed. It is a constant airspeed from sea level to the altitude where VMO and MMO coincide. MMO is the structural limitation above this altitude. Sufficient thrust is available to exceed VMO in level flight at lower altitudes. Failure to reduce to cruise thrust in level flight can result in excessive airspeed.

Begin the maneuver at existing cruise speed with the autothrottle connected and the autopilot disengaged. Set command speed to VMO. As speed increases observe:

- Nose down trim required to keep aircraft in trim and maintain level flight
- Handling qualities during acceleration
- Autothrottle protection at VMO.

At a stabilized speed just below VMO execute turns at high speed while maintaining altitude. Next, accelerate above VMO by disconnecting the autothrottle and increasing thrust.

When the overspeed warning occurs reduce throttles to idle, set command speed to 250 knots, and decelerate to command speed. Since the aircraft is aerodynamically clean, any residual thrust results in a longer deceleration time. As airspeed decreases observe that nose up trim is required to keep aircraft in trim and maintain level flight. During deceleration note the distance traveled from the time the overspeed warning stops until reaching 250 knots.

Once stabilized at 250 knots, set command speed to flaps up maneuver speed and decelerate to command speed, again noting the distance traveled during deceleration. Observe the handling qualities of the aircraft during deceleration.

This maneuver may be repeated using speedbrakes to compare deceleration times and distances.

Engine Out Familiarization

The exercises shown in the following table are performed to develop proficiency in handling the aircraft with one engine inoperative and gain familiarization with rudder control requirements.

	Condition One	Condition Two
Airspeed	Flaps up maneuver speed	V2
Landing Gear	Up	Down
Flaps	Up	13
Thrust	As Required	MCT
When In Trim - Retard one throttle to idle Controls - Apply to maintain heading, wings level Rudder - Apply to center control wheel Airspeed - Maintain with thrust (Condition One) Pitch (Condition Two) Trim - As required to relieve control forces		

One engine out controllability is excellent during takeoff roll and after lift-off. Minimum control speed in the air is below VR and VREF.

Rudder and Lateral Control

This familiarization is performed to develop proficiency in handling the aircraft with an engine inoperative. It also helps to gain insight into rudder control requirements.

Under instrument conditions the instrument scan is centered around the attitude indicator. Roll is usually the first indication of an asymmetric condition. Roll control (ailerons) should be used to hold the wings level or maintain the desired bank angle. Stop the yaw by smoothly applying rudder at the same rate that thrust changes. When the rudder input is correct, very little control wheel displacement is necessary. Refine the rudder input as required and trim the rudder so the control wheel remains approximately level.

When the rudder is trimmed to level the control wheel, the aircraft maintains heading. A small amount of bank toward the operating engine may be noticeable on the bank indicator. The slip/skid indicator is displaced slightly toward the operating engine.

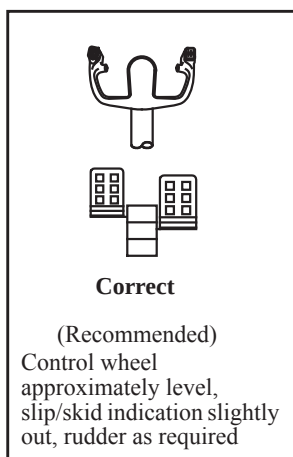
If the aircraft is trimmed with too much control wheel displacement, full lateral control is not available and spoilers on one wing may be raised, increasing drag.

DELTA
717 Flight Crew Training Manual

Make turns at a constant airspeed and hold the rudder displacement constant. Do not attempt to coordinate rudder and lateral control in turns. Rudder pedal inputs produce roll due to yaw and induce the pilot to counter rudder oscillations with opposite control wheel.

The following figure shows correct and incorrect use of the rudder.

If an engine failure occurs with the autopilot engaged, manually position the rudder to approximately center the control wheel and add thrust. Trim the rudder to relieve rudder pedal pressure.



Condition: Engine out right side.

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: Autothrottles 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 and greater than VMAX. In training, buffet is induced to demonstrate the aircraft's response to control inputs during flight in buffet.

Note: Stick shaker is close to initial buffet for all weights and altitudes. Stick shaker activation may occur if the airplane is maneuvered beyond buffet.

Establish an airspeed of 0.80M. 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 45° of bank. If buffet does not occur by 45° of bank, increase control column 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.

Mach Buffet

As altitude and airspeed increase, a flight condition will eventually be reached where the localized airflow becomes supersonic (Mach 1.0) on top of the wing and weak shock waves begin to form. This condition occurs well below an actual aircraft Mach number of 1.0 and varies with flight level and aircraft weight. Although small, weak shock waves form on the wing at Mach 0.75, noticeable buffeting does not occur on the 717 until approaching MMO. At this Mach number, shock waves become quite large and strong, and move rapidly fore and aft on the wing, causing a gentle, high-frequency buffet. Buffet intensity will be significantly increased by making a turn, or by applying a slight back pressure to the control column. If the aircraft is accelerated beyond MMO, or if excessive g loading is applied, buffet intensity can increase enough to pose structural integrity problems.



Mach Tuck

In normal subsonic flight, the center of pressure (lift) on the wing is near the 1/4 chord point of the wing (approximately 25% of the way back on the wing from the leading edge). Although the airfoil center of pressure moves aft in the subsonic speed range as speed is increased, other factors, primarily the pitching moment created by the horizontal stabilizer, create a net pitch up tendency. This tendency is desirable, since any increase in speed will be naturally opposed by the aircraft. In the transonic range, however, due to shock wave formation and the associated loss of downwash on the horizontal stabilizer, and the rapidly increased aft movement of the wing center of pressure, a new pitch-down moment results. Mach tuck will become noticeable at Mach 0.80; and the pull force required to maintain level flight increases linearly up to Mach 0.85, then remains constant. The tuck effect is automatically zeroed by Mach trim compensation.

Dutch Roll

Dihedral is considered to be positive when the wing tips are higher than the roots. The effect of dihedral is to produce a rolling moment tending to return the airplane to a balanced flight condition if sideslip occurs. Sweepback increases the dihedral stability of an aircraft, which to the pilot means the ability to pick up a wing by using opposite rudder. The dihedral stability is low for a sweptback-wing aircraft in the approach/landing configuration and also at very high Mach numbers.

An increase in wing sweepback normally degrades lateral-directional dynamic stability, better known as “Dutch Roll”. Dutch Roll is a combination of roll and yaw oscillations that are coupled together. As with most large, high-speed aircraft, there is a lateral directional oscillation present that may be excited by turbulence or rough use of the controls. With the yaw damper operative, all Dutch Roll oscillations are promptly dampened. If the yaw damper should become inoperative, Dutch Roll may be easily dampened with the primary flight controls. Recommended procedure is to use aileron to stop the roll. The oscillations have a relatively long period and the pilot should experience no difficulty in timing control inputs to dampen the oscillation.

Rapid Descent

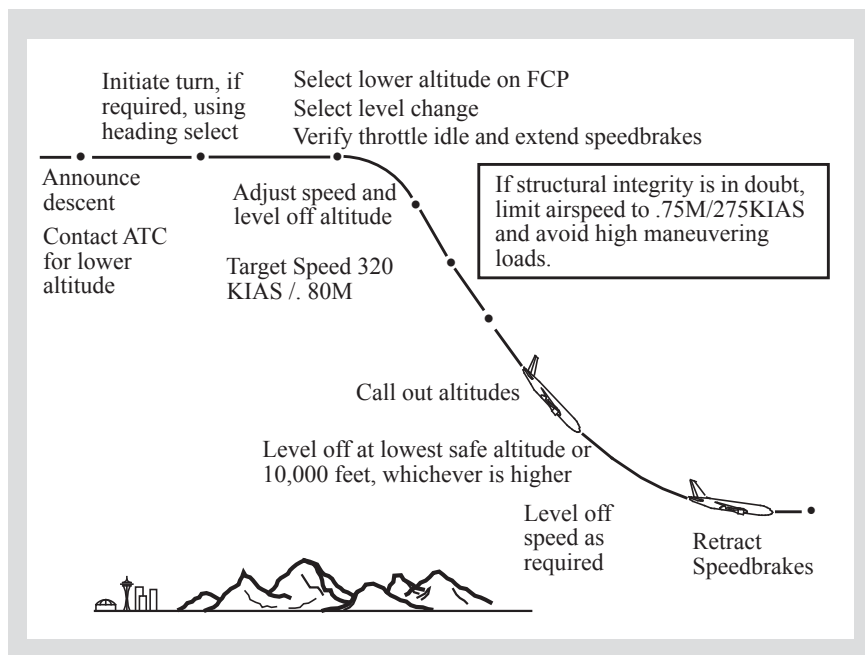
CAUTION: Descent not to exceed 10° pitch or 30° bank.

This section addresses basic techniques and procedures for a rapid 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 and thrust as required.

717 Flight Crew Training Manual

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: Rapid descents are normally made with the landing gear up.

The PM checks the lowest safe altitude, notifies ATC, and obtains an altimeter setting (QNH). Both pilots should verify that all memory items have been accomplished and call out any items not completed. 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

Level Change

Because of airspeed and altitude protection and reduced crew workload, use of the autopilot with level change mode is the recommended technique for rapid descents. Use of the V/S mode is not recommended.

Initiate a turn, if required, using heading select. Set a lower altitude in the altitude window. Select level change. Select speed with FCP speed select knob (select IAS or MACH as needed), verify speed in IAS/MACH window, close the throttles and smoothly extend the speedbrakes. If turn radius is a factor, the pilot should manually select the desired bank angle required to complete the maneuver in a safe manner. Autothrottles should be left engaged. The aircraft pitches down smoothly while the throttles retard to idle. Adjust the speed as needed and ensure the altitude window is correctly set for the level off. Manually reset to VMO as needed.

Note: When descending in PROF or level change and a speed greater than VMO is selected on the FCP a white bug will remain at VMO-5 and the selected speed bug will turn red. The ATS will maintain VMO-5. If the ATS is off it will automatically reengage to maintain VMO-5. During descent with the throttles at idle the ATS will adjust pitch to maintain VMO-5. There is no overspeed protection when descending in V/S mode.

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 FCP 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 (increases VMIN), 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 autopilot and autothrottles. smoothly lower the nose to initial descent attitude of approximately 10° nose down. Retard the throttles to idle and smoothly extend the speedbrakes.

About 10 knots before reaching target speed, slowly raise the pitch attitude to maintain target speed. Keep the aircraft in trim at all times. If MMO/VMO is inadvertently exceeded, change pitch smoothly to decrease speed.

Approaching level-off altitude, smoothly adjust pitch attitude to reduce rate of descent. The speedbrake lever should be retracted when approaching the desired level-off altitude. After reaching level flight add thrust to maintain long range cruise or 300 knots.

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, 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.

Flight Control Effectiveness

Primary flight controls consist of aileron, rudder, and elevator control systems. Secondary flight controls consist of leading edge slats, flight and ground spoilers, inboard and outboard flaps, and horizontal stabilizer. The ailerons and elevators are normally operated mechanically. The ailerons have hydraulically assisted flight spoilers for roll control. The rudder is normally hydraulically powered. In the event of a total hydraulic power loss, the primary flight controls are fully operational.

Ailerons

The ailerons are bussed together by cables and driven aerodynamically by control tabs. The control tabs are connected by cable to the control wheel. The ailerons are not powered in any way. However, rolling forces induced by aileron inputs are supplemented by hydraulically actuated spoilers on each wing surface. Movement of the control wheel beyond approximately 5° will cause the spoilers to extend.

Horizontal Stabilizer and Elevators

Longitudinal trim is accomplished by changing the angle of incidence of the horizontal stabilizer. It is effective throughout the entire center of gravity range and speed envelope of the aircraft. As the stabilizer is moved, the elevator forces must be relaxed to maintain the same attitude. Aerodynamic response induced by movement of the horizontal stabilizer is about 2½ times greater than that induced by elevator movement through the same angular deflection. Primary pitch control is obtained by movement of the elevators.

Rudder

Normally the rudder will be operated at all times in the power mode. Rudder effectiveness is more than adequate under all flight conditions including single-engine operation and autoland operation with rudder power on.

Vortilons

The vortilons (Vortex-Generating Pylons) serve a dual purpose. First, because of their size, shape, and location, there is a significant effect on the tail surfaces at high angles of attack. This action enhances aerodynamic response from the tail surfaces below the stalling speed of the aircraft (the tail is still flying after the aircraft initially stalls). The secondary purpose is to act as an aerodynamic fence, which contributes to a positive and stable restoring moment in stall recovery. During development of the original DC-9, wind tunnel tests indicated that spanwise flow on the wing caused the outboard portion of the wing to begin stalling early resulting in some minor pitch up at stall. The solution was the vortilon. The device is shaped such that the wing stagnation point in the normal flight envelope is ahead of the vortilon leading edge and no vortex drag penalty is induced at these conditions. At angles of attack approaching stall, the stagnation point moves aft of the intersection and a strong vortex is created over the top of the wing. This energizes the outer panel boundary layer and delays outer panel stall. The vortex then continues aft, rotating in a manner that creates an upwash field at the tail that adds to the pitch down forces at, and substantially beyond stall.

Flight Control Effectiveness Maneuvers

These maneuvers are performed in the full flight simulator and are for demonstration purposes only.

Proper aircraft flight dynamics and handling qualities are a function of timely, appropriate, and coordinated flight control inputs. Whether teaching recoveries from stall, CFIT, windshear or upsets, the expected norm is coordinated flight to the maximum extent possible. In order to establish a baseline for coordinated flight, Delta Air Lines presents three demonstrations to the initial qualification pilot. These are one-time demonstration/practice and intended to show the power of the flight controls (i.e. handling quality) and aerodynamic response (i.e. flight dynamic) of the aircraft. These demonstrations are accomplished at approach airspeeds representative of typical maneuver energy states and intermediate wing angle of attack. These maneuvers are:

- Rudder effectiveness demonstration
- Aileron effectiveness demonstration
- Loaded/unloaded roll demonstration.



Rudder Effectiveness

This maneuver is accomplished with hands off (hands placed behind the control column, allowing pitch inputs only) the control yoke using rudder inputs only to induce a roll to 45° of bank and return to wings level. The emphasis is on smooth, incremental application of rudder. Focus should be on rate of application and magnitude of rudder input. Properly done (slow, incremental) the aircraft will roll to dihedral effect with minimal adverse yaw. Improperly done (fast, large amplitude) the aircraft will display adverse yaw and roll coupling. Only a small amount of rudder input is needed (to induce a roll). Too much rudder applied too quickly or held too long may result in loss of lateral and directional control. Rudder is never the preferred initial response to induce a roll in a transport category aircraft.

Aileron Effectiveness

In like manner, the aileron effectiveness demonstration is accomplished in one axis (aileron roll only with feet off rudder pedals) at approach energy states and angle of attack. The pilot will smoothly roll to 60° bank and then roll back to wings level using full throw aileron authority. The instructional intent is to allow the pilot to observe full throw aileron position, authority, and the generated roll rate and roll overshoots (roll out lead points change) as the wings approach level. Additionally, any asymmetric tendencies caused by differential aileron and/or spoiler deployment will be evident.

This demonstration accomplishes three objectives. First, it demonstrates the aircraft will not depart controlled flight from full throw aileron applications. Second, it establishes a baseline in the student's mind for roll rate capability at an approach energy state. Third, it demonstrates roll overshoot tendencies inherent with large aileron deflection rolls. This level of roll demand would only be required when responding to an unanticipated departure of the aircraft in roll (e.g. wake turbulence, partial flap failure, asymmetric loss of flap structure, etc.).

Loaded/Unloaded Roll

The previous maneuvers are tied together in a coordinated training event utilizing all three axes. This exercise will also demonstrate the effectiveness of a slight release of backpressure to activate the roll mode using aileron. The pilot will smoothly roll to 60° (approximately) of bank, then pull (smoothly) to stick shaker. Recover in the following three manners:

- Roll with ailerons only without the use of rudder and no release of backpressure. The result will be a slow roll to wings level.
- Roll with ailerons only and small release of backpressure. No use of rudder. The result will be improved roll rate to wings level.
- Roll using aileron and small release of backpressure and coordinated input of rudder. The result will be improved roll rate to wings level with yaw coordination.

By the conclusion of this exercise the pilot should be proficient with:

- Recognition
- Protect the aircraft from the stall
- Maneuver to orient the lift vector
- Stabilize post recovery.

Stall or Approach to Stall

Stall or Approach to Stall Recovery Maneuver

WARNING: During takeoff, a stick shaker, STALL warning light, horn, or “STALL” aural warning at rotation may indicate an improper FLAP/SLAT configuration. PF immediately call out “SLATS EXTEND,” PM confirm “SLATS EXTENDED.”

If conditions permit accept an altitude loss while accelerating to minimum VMIN or greater for existing configuration.

Note: Do not use flight director commands during the recovery.

Note: Premature recovery may result in a secondary stall or inability to accelerate, with thrust available, to VMIN or greater for existing configuration.

 DELTA
717 Flight Crew Training Manual

Immediately do the following at the first indication of stall (buffet or stick shaker).

Pilot Flying	Pilot Monitoring
Initiate the recovery: • Hold the control column firmly. Simultaneously: • Disconnect autopilot and autothrottle. Aggressively apply maximum thrust.* • Reduce angle of attack by applying nose down elevator until buffet and stick shaker stop.**	• Monitor altitude and airspeed. • Verify all required actions have been done and call out any omissions. • Call out any trend toward terrain contact.
Continue the recovery: • If in a turn, call “HEADING HOLD” and roll in shortest direction to and maintain wings level.*** • Confirm speed brakes stowed. • If conditions permit, accept an altitude loss while accelerating to VMIN or greater for existing configuration. • If flaps/slats or landing gear are extended, do not change the configuration during stall recovery.	• Monitor altitude and airspeed. • Push HDG control knob. • Verify all required actions have been done and call out any omissions. • Call out any trend toward terrain contact.
Complete the recovery: • Accelerate to VMIN or greater for existing configuration, then adjust configuration as desired. Return to appropriate altitude and airspeed. • Re-engage autopilot and autothrottle if desired.	• Monitor altitude and airspeed. • Verify all required actions have been done and call out any omissions. • Call out any trend toward terrain contact.

Note: *If ground contact is imminent, select emergency thrust by advancing the throttles through the maximum forward throttle (N1 mode) gate to the mechanical stop.

WARNING: **In some cases, the control column may not immediately provide the needed pitch response. In such cases it may be necessary to apply full forward control input, enhancing that input with pitch trim if necessary.

WARNING: *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.**

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. However, the recovery maneuver is the same for either an approach to a stall or a fully developed stall.

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 indication (stick shaker). During the initial stages of a stall, local airflow separation results in buffeting (initial buffet), giving a natural warning of an approach to stall. At cruise Mach speed, stick shaker activation occurs just after reaching initial buffet. Recovery from an approach to stall should be initiated at the earliest recognizable stall warning, either initial buffet or stick shaker.

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.

In common with most other T-tail aircraft, the airplane is subject to a characteristic known as the “deep stall”. This term refers to an angle-of-attack range beyond the normal stall region in which the tail enters the turbulent wakes of the wing and nacelles. This causes a loss in tail effectiveness and a tendency to pitch up until the aircraft stabilizes at some very high angle-of-attack. Entry into the deep stall may not be readily apparent to the pilot since the increase in angle-of-attack may be accompanied by increasing sink rate and flight path angle so that pitch attitudes remain low.

 DELTA
717 Flight Crew Training Manual

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
- Inability to arrest descent rate.

Stall Warnings

Stall warnings alert the pilots of an approach-to-stall condition. Stick Shakers activate as the aircraft attitude approaches stall. The Pitch Limit Indicator on the PFD gives a visual representation of the angle of attack at which Stick Shaker occurs. The top of the red band on the PFD speed tape represents the speed at which Stick Shaker will occur. Following stick shaker activation, flashing red STALL annunciations appear on the captain's and first officer's PFD, an aural warning (klaxon) sounds, and a vocal warning ("stall") is activated.

The stall warnings are generated by angle-of-attack, horizontal stabilizer position, and flap/slat position inputs to the Flight Control Computers (FCCs).

A caution alert is displayed on the EAD to indicate a system failure.

Stick Pusher

During detection of an imminent stall condition, the glareshield STICK PUSHER PUSH TO INHIBIT switchlights illuminate and the autopilot, if in use, disconnects. Abrupt forward movement of both control columns occurs, followed by stick shaker deactivation.

Forward pressure on the control columns continues until either the angle-of-attack is reduced below stick shaker onset, the gravity force is sufficiently reduced, or a STICK PUSHER PUSH TO INHIBIT switchlight is pushed. The flight crew has the ability to override the stick pusher system by pushing either switchlight.

The stick pusher system is inhibited anytime a decreasing performance windshear is detected by either windshear computer.

Stall or Approach to Stall Recovery

To initiate the recovery, the angle of attack must be reduced below the wing stalling angle. Smoothly apply nose down elevator to reduce the angle of attack until the wings are unstalled (buffet or stick shaker stops). Nose down stabilizer trim may be needed if the control column does not provide the needed response.

Application of forward control column (as much as full forward may be required) and the use of some nose-down stabilizer trim should provide sufficient elevator control to produce a nose-down pitch rate. It may be difficult to know how much stabilizer trim to use, and care must be taken to avoid using too much. Pilots should not fly the aircraft using stabilizer trim, and should stop trimming nose down when they feel the g force on the aircraft lessen or the required elevator force lessen. The use of too much trim may result in the loss of control or high structural loads.

Continue the recovery by rolling in the shortest direction to wings level, as needed. If an attempt is made to roll to wings level before the wings are unstalled, the ailerons and spoilers are ineffective. Unloading the wing by maintaining continuous nose-down elevator pressure keeps the wing angle of attack low making the normal roll controls more effective. After the stall is broken, normal roll controls, up to full deflection of ailerons and spoilers, may be used to roll in the shortest direction to wings level, if needed. The use of rudder is normally not needed.

The Stall or Approach to Stall Recovery maneuver calls for the crew to advance the throttles in accordance with the maneuver.

Note: Use care during recovery from a nose low attitude after the buffet and/or stick shaker have stopped. If the pull up is too aggressive, a “secondary” stall or sustained stick shaker may result.

In extreme cases where the application of forward control column coupled with some nose-down stabilizer trim and a thrust reduction do not stop an increasing pitch rate in a nose-high situation, rolling the aircraft to a bank angle that starts the nose down may be effective. If normal roll control is ineffective, careful rudder input in the direction of the desired roll may be required. Bank angles of about 45°, up to a maximum of 60°, could be needed. Too much rudder applied too quickly or held too long may result in loss of lateral and directional control.

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 slats as directed in the Stall or Approach to Stall Recovery maneuver. Extending or retracting the flaps during the recovery at other times results in an increased altitude loss.

717 Flight Crew Training Manual

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, nose-down elevator and stabilizer trim is required to initiate a descent. 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.

Steep Turns

The objective of the steep turn maneuver is to familiarize the pilot with aircraft handling characteristics beyond 35° 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.

Note: Stabilizer trim is not recommended during the steep turn maneuver because of increased workload during roll out.

Entry

Stabilize airspeed at 250 knots on heading and altitude. Use a normal turn entry. An increase in pitch is required as the bank angle is increased to maintain constant altitude. An increase in thrust is required to maintain constant airspeed.

During Turn

Pitch and thrust control are the same as for a normal turn; however, larger pitch adjustments are required for a given altitude deviation. Varying the angle of bank while turning makes pitch control more difficult. If altitude loss becomes excessive, reduce the angle of bank as needed to regain positive pitch control.

Smooth and positive control is required. A rapid instrument scan is required to detect deviations early enough to be corrected by small adjustments.

Attitude Indicator

The attitude indicator is reliable for accurate pitch and bank information throughout the turn. Precession error does not exist because the IRS is the source of attitude information. If desired, the flight path vector (FPV), or bird, 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

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 or speed tape (as installed). 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. A decrease in thrust is required to maintain constant airspeed.

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 (as installed) 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 autothrottle until terrain clearance is assured.

 DELTA
717 Flight Crew Training Manual

Terrain Avoidance Maneuver

Ground Proximity Caution

Accomplish the following maneuver for any of these aural alerts:

- CAUTION TERRAIN
- SINK RATE
- TERRAIN
- DON'T SINK
- TOO LOW FLAPS
- TOO LOW GEAR
- TOO LOW TERRAIN
- GLIDESLOPE

Pilot Flying	Pilot Monitoring
Immediately adjust the flight path or initiate a go-around.	

The below glideslope deviation alert may be canceled or inhibited for:

- Localizer
- Circling approach from an ILS
- When conditions require a deliberate approach below glideslope
- Unreliable glideslope signal.

Note: Some aural alerts repeat.

Ground Proximity Warning

Accomplish the following maneuver for any of these conditions:

- Activation of “PULL UP” or “TERRAIN TERRAIN PULL UP” warning.
- Other situations resulting in unacceptable flight toward terrain.

 DELTA
717 Flight Crew Training Manual

Pilot Flying	Pilot Monitoring
Disconnect autopilot. Disconnect autothrottle(s). Aggressively apply emergency* thrust. Simultaneously roll wings level and rotate to an initial pitch attitude of 20°. Retract speedbrakes. If terrain remains a threat, continue rotation up to the pitch limit indicator (if available) or stick shaker or initial buffet.	Assure emergency* thrust. Verify all required actions have been completed and call out any omissions.
Do not change gear or flap configuration until terrain separation is assured. Monitor radio altimeter for sustained or increasing terrain separation. When clear of terrain, slowly decrease pitch attitude and accelerate.	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.

Note: The suggested rate or pitch increase in this maneuver is 3-4° per second. A rate significantly greater than this will produce stick shaker due to acceleration, particularly at high gross weights.

Note: Aft control column force increases as the airspeed decreases. In all cases, the pitch attitude that results in intermittent stick shaker or initial buffet is the upper pitch attitude limit. Flight at intermittent stick shaker may be required to obtain a positive terrain separation. Smooth, steady control will avoid a pitch attitude overshoot and stall.

Note: Do not use flight director commands.

Note: *Emergency thrust can be obtained by advancing the throttles through the maximum forward throttle (N1 mode) gate to the mechanical stop.

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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 to support visual collision avoidance, application of right-of-way rules, and ATC separation.

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 look for traffic using the traffic display as a guide, call out any conflicting traffic and if traffic is sighted, maneuver if needed. Maneuvers based solely on a TA may result in reduced separation and are not normally recommended.

Resolution Advisory

When TCAS determines that there is a risk for collision, a Resolution Advisory (RA) aural warning and a pitch command is generated. With the exception noted below, compliance with an RA is required even if the subject aircraft appears to be in sight and is deemed to be of no threat. There could be multiple threats and the aircraft observed may not actually be the offending traffic. Compliance with a Resolution Advisory (RA) is mandatory unless doing so imposes a greater risk.

WARNING: A DESCEND (fly down) RA issued below 1,000 feet AGL should not be followed.

The RA Maneuver

Maneuvering is required if any portion of the aircraft symbol is within the red region on the attitude indicator (as installed) or if the existing vertical speed is in the red band (RA VSI) (as installed).

The RA maneuver is a pitch-only maneuver. Continue to follow the planned lateral flight path unless visual contact with the conflicting traffic requires other action. Properly executed, the RA maneuver is mild and should not require large or abrupt control movements.

Note: The flight director is not designed to provide RA guidance.

717 Flight Crew Training Manual

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.

Note: The RA command “ADJUST VERTICAL SPEED ADJUST” always requires a reduction in vertical speed. Do not inappropriately increase vertical speed in response to this command. On later versions of TCAS, the verbal annunciation “ADJUST VERTICAL SPEED ADJUST” RA has been changed to “LEVEL OFF”.

Pilot Flying	Pilot Monitoring
Both pilots visually clear the airspace in the direction of the maneuver.	
If maneuvering is required: • Disconnect the autopilot and autothrottle. • Smoothly adjust pitch (and thrust, if necessary) to satisfy the RA command. 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 and auto-thrust, as desired.	Notify ATC (“TCAS RA”). If necessary, coordinate with ATC for further clearance. Notify ATC “CLEAR OF CONFLICT”
Attempt visual contact. Call out any conflicting traffic. Visual acquisition of traffic may be misleading and does not guarantee separation. Comply with RA guidance until clear of conflict unless doing so imposes a greater risk.	
For a TCAS climb RA in the landing configuration and when clear of conflict, reset automation to appropriate level.	
• Autopilot as desired • Speed Command Bug set to desired speed for planned flap setting • Call for "FLAPS 13" • Call for "GEAR UP" • Accelerate, call for flap retraction on schedule • After Takeoff checklist	• Make MCP and configuration changes as requested by the PF

Parallel Approach Exception to Resolution Advisory Compliance

Many airports operate simultaneous visual approaches to closely-spaced parallel runways. Occasionally, an RA is generated due to the close proximity of aircraft even though the aircraft are tracking to separate runways. A pilot may disregard RA guidance during an approach when all of the following conditions exist:

- Daytime
- VMC conditions
- Radar contact
- Parallel approach operations
- Cleared for the approach
- The traffic can be immediately and positively identified and separation can be maintained.

Note: After receiving an RA, selection of “TA Only” is not recommended. Maintaining TCAS RA guidance is desirable in the event of a go-around and/or secondary “intruder” aircraft.

Interaction with ATC

Pilots are authorized to deviate from their current ATC clearance to the extent necessary to comply with a TCAS RA. Except as specifically noted above, pilots are required to immediately comply with an RA, even if the RA is contrary to an ATC clearance or instruction issued prior to or during an active RA.

When an RA occurs, inform ATC “TCAS RA” as soon as practicable after responding to the RA.

When the RA is clear and “Clear of Conflict” is heard, inform ATC “Clear of conflict, returning to (assigned clearance)” or “Clear of conflict, reestablished (assigned clearance).”

Mode of Operation

The combined Resolution Advisory (RA) and Traffic Advisory (TA) switch position (RA/TA or TA/RA, depending on installation) should be initiated just before takeoff and continued until just after landing.

The Traffic Advisory (TA) Only mode inhibits the RA function and should be selected only when directed by:

- A Company Page, or
- An Non-Normal Checklist, or
- A flight plan remark.

Other Considerations

During the RA maneuver, the aircrew should attempt 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.

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. If stick shaker or initial buffet occurs during the maneuver, immediately accomplish the Approach to Stall Recovery procedure, this chapter. If high speed buffet occurs during the maneuver, relax pitch force as necessary to reduce buffet, but continue the maneuver.

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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. If needed, use pitch trim sparingly. 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 continuous stick shaker activation accompanied by one or more of the following:

- Buffeting which could be heavy at times
- Lack of pitch authority and/or roll control
- 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 and stick shaker activation ceases.

WARNING: * Excessive use of pitch trim or rudder may aggravate an upset situation or may result in loss of control and/or high structural loads.

Nose High Recovery

Pilot Flying	Pilot Monitoring
Recognize and confirm the situation - announce "Recover".	
- Disconnect autopilot and autothrottle - Apply as much as full nose-down elevator * Apply appropriate nose down stabilizer trim - Adjust thrust as appropriate * 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 - announce "Recover".	
- Disconnect autopilot and autothrottle - Recover from stall, if required * Roll in shortest direction to wings level (unload and roll if bank angle is more than 90°) - Recover to level flight: - Apply nose up elevator - *Apply nose up trim, if required - 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 pitch trim or rudder may aggravate an upset situation or may result in loss of control and/or high structural loads.

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717 Flight Crew Training Manual

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. 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
- 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 control column and control wheel to complete the recovery.

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. If the stabilizer trim setting is nose up, as for slow-speed flight, it partially reduces the nose-down authority of the elevator. 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 nose-down elevator and the use of some nose-down stabilizer trim. These actions should provide sufficient elevator control power to produce a nose-down pitch rate. It may be difficult to know how much stabilizer trim to use, and care must be taken to avoid using too much trim. Pilots should not fly the aircraft using stabilizer trim, and should stop trimming nose down when they feel the g force on the aircraft lessen or the required elevator force lessen. This use of stabilizer trim may correct an out-of-trim aircraft and solve a less-critical problem before the pilot must apply further recovery measures. 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 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. With airspeed as low as stick shaker onset, normal roll controls - up to full deflection of ailerons and spoilers - may be used. 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 nose-up elevator, reducing thrust, and extending speedbrakes, if necessary, changes the pitch attitude to a desired range. At extremely low pitch attitudes and high airspeeds (well above VMO/MMO), nose-up elevator and nose-up trim may be required to establish a nose-up pitch rate.



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 highest WDR-depicted takeoff thrust and flap settings.
- 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.
- Know the all-engine initial climb pitch attitude. Rotate at the normal rate to this attitude for all non-engine failure takeoffs. Minimize reductions from the initial climb pitch attitude until terrain and obstruction clearance is assured, unless stick shaker activates. 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.
- Should airspeed fall below the trim airspeed, unusual control column forces may be required to maintain the desired pitch attitude. Stick shaker must be respected at all times.

Approach and 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, FPA, PROF, or VASI/PAPI indications to detect flight path deviations and help with timely detection of windshear.
- If the autothrottle is disengaged, or is planned to be disengaged prior to landing, use the recommended method for approach speed correction as described in chapter 1.
- Avoid large thrust reductions or trim changes 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 autothrottle 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.

The crew must be aware of the normal values of airspeed, altitude, rate of climb, pitch attitude, and control column forces. Unusual control column force may be required to maintain or increase pitch attitude when airspeed is below the in-trim speed. If significant changes in airspeed occur and unusual control forces are required, the crew should be alerted to a possible windshear encounter and be prepared to take action.

Windshear Encounter Recognition

Note: The following are indications the airplane is encountering a windshear:

- Windshear Warning (two-tone siren followed by the aural message “TAILWIND SHEAR” or “HEADWIND SHEAR” announced three times)
- 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 throttle position for a significant period of time.

 DELTA
717 Flight Crew Training Manual

Windshear Escape Maneuver

Pilot Flying	Pilot Monitoring
• Disconnect autopilot and autothrottle. • Press either GA switch. • Aggressively apply maximum* thrust. • Simultaneously roll wings level and rotate toward an initial pitch attitude of 15 °. • Follow flight director GA guidance (if available) • Retract speedbrakes.	• Assure maximum* thrust. • Verify all required actions have been completed and call out any omissions. • Advise when windshear guidance is activated.
• 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.

Note: Aft control column force increases as the airspeed decreases. In all cases, the pitch attitude that results in intermittent stick shaker or initial buffet is the upper pitch attitude limit. Flight at intermittent stick shaker may be required to obtain a positive terrain separation. Smooth, steady control will avoid a pitch attitude overshoot and stall.

Note: *If ground contact is imminent, select emergency thrust by advancing the throttles through the maximum forward throttle (N1 mode) gate to the mechanical stop.

Windshear During Takeoff Roll

Prior to V1

Note: Predictive windshear is inhibited at 100 knots, reactive windshear is inhibited during takeoff until 50 feet. The primary indication of windshear between 100 knots and V1 is stagnation of airspeed.

Predictive windshear caution alert (“MONITOR RADAR DISPLAY” aural)

- Reject takeoff.

Predictive windshear warning alert (“WINDSHEAR AHEAD, WINDSHEAR AHEAD” aural)

- Reject takeoff.

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 emergency thrust. At VR, rotate at a normal rate toward a 15° pitch attitude. 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 emergency thrust, initiate a normal rotation towards 15° 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. Ensure emergency thrust is set.

Windshear In Flight

After Takeoff

Note: Reactive windshear is inhibited until liftoff and then is armed until 1500 feet. Predictive windshear is active below 2300 feet but will not give a caution or warning until below 1200 feet. Predictive windshear is inhibited after 100 knots until 50 feet.

Reactive windshear warning is an AURAL WARNING tone followed by voice: “HEADWIND SHEAR” or “TAILWIND SHEAR.” The aural warnings will be accompanied by a visual WINDSHEAR message on the PFD. The message will be amber for a head windshear and red for a tail windshear.

Predictive windshear warning is an AURAL WARNING tone followed by voice: “WINDSHEAR AHEAD, WINDSHEAR AHEAD” during takeoff/go-around. “GO AROUND WINDSHEAR AHEAD: during landing/go-around. Caution alert tone followed by voice “MONITOR RADAR DISPLAY.” The aural warnings will be accompanied by VISUAL icon on ND and either a red (warning) or amber (caution) “WINDSHEAR AHEAD” on PFD.

717 Flight Crew Training Manual

Windshear encounter

- Perform the Windshear Escape Maneuver.

On Approach

Windshear encounter

- Perform the Windshear Escape Maneuver.

Windshear Alert and Guidance System (WAGS)

If windshear indications are observed do not wait for PWS or WAGS warnings to initiate the Windshear Escape Maneuver.

During Takeoff WAGS is enabled from nose strut extension to 1,500 feet AGL.

During Approach WAGS is enabled from 1,500 feet AGL to 50 feet AGL.

When windshear is detected, WAGS provides visual alert on the EIS and aural alerts through the CAWS. Visual WINDSHEAR alerts are displayed on each PFD. A red WINDSHEAR alert is displayed for a decreasing performance windshear and an amber WINDSHEAR alert is displayed for an increasing performance windshear. On detection of windshear, CAWS generates an alert tone followed by the aural message “TAILWIND SHEAR” or “HEADWIND SHEAR” announced three times.

When decreasing performance windshear is detected and guidance is activated, WAGS provides FD pitch guidance to achieve a near optimum energy conserving flight path.

When an increasing performance windshear is detected and guidance is activated, WAGS provides energy gaining flight director guidance during takeoff and go-around.

If WAGS detects windshear during takeoff, flight director guidance is provided after nose strut extension.

If WAGS detects windshear during approach flight director guidance is provided when GA is selected or throttles are advanced to 95% of go around thrust.

Maximum takeoff thrust should be sufficient for windshear encounters. However if ground contact is imminent, the throttles should be advanced through the maximum forward throttle gate to emergency thrust.

When windshear is detected during approach selection of GA or advancing the throttles to 95% of go around thrust will cause the throttles to advance to Go-around thrust and CLAMP.

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
- Complete the normal checklist (After Takeoff).

Non-Normal Operations

Chapter 8

Table of Contents

Section TOC

Non-Normal Situation Guidelines	8.1
Troubleshooting	8.2
Approach and Landing	8.2
Landing at the Nearest Suitable Airport	8.3
Ditching	8.4
Send Distress Signals	8.4
Coast Guard Ditching Recommendations	8.4
Advise Crew and Passengers	8.4
Fuel Burn-Off	8.4
Passenger Cabin Preparation	8.5
Ditching Final	8.5
Initiate Evacuation	8.5
Electrical	8.5
Approach and Landing on Emergency Power	8.5
Engines, APU	8.7
Engine Failure versus Engine Fire After Takeoff	8.7
Engine Tailpipe Fire	8.7
Loss of Engine Thrust Control	8.8
Two Engine Flameout	8.9
High Engine Vibration	8.10
Recommended Technique for an In-Flight Engine Shutdown ...	8.11
Bird Strikes	8.11
TGT 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	8.14
Flight Controls.	8.16
Leading Edge or Trailing Edge Device Malfunctions	8.16
Jammed or Restricted Flight Controls	8.17
Stabilizer Inoperative	8.19
Runaway Stabilizer	8.19
Flight Instruments, Displays	8.20
Airspeed Unreliable	8.20
Fuel	8.21
Fuel Balance	8.21
Fuel Leak	8.22
Low Fuel	8.22
Hydraulics	8.23
Hydraulic System(s) Inoperative - Landing.	8.23
Landing Gear.	8.24
Braking with Antiskid Inoperative	8.24
Tire Failure during or after Takeoff.	8.24
Landing on a Flat Tire	8.25
Landing with Abnormal Landing Gear	8.25
Overspeed	8.28
Smoke/Fumes Principles.	8.30
Known Source	8.30
Unknown Source	8.30
Smoke/Fumes Priorities	8.30
General	8.30
Priorities	8.31

 DELTA
717 Flight Crew Training Manual

Warning Systems	8.32
Windows	8.32
Window Damage	8.32
Flight with the Side Window(s) Open.	8.32
Situations Beyond the Scope of Non-Normal Checklists	8.33
Basic Aerodynamics and Systems Knowledge	8.33
Flight Path Control	8.34
Checklists with Memory Steps	8.35
Communications	8.35
Damage Assessment and Aircraft Handling Evaluation	8.35
Landing Airport.	8.37

Intentionally
Blank

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 NNC. Maximum use of the autoflight system is recommended to reduce crew workload.
- **ANALYZE THE SITUATION:** NNCs should be accomplished only after the malfunctioning system has been positively identified. Review all caution and warning lights 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 NNC directs the crew to plan to land at the nearest suitable airport, or if the situation is so identified in the QRH, NNCL.1, diversion to the nearest airport where a safe landing can be accomplished is required. 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 chapter 9, Human Factors.

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 a light, alert, or other indication to improve or correct a perceived non-normal condition.
- 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.
- 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 the use of alternate flap or landing gear extension systems. Arm spoilers unless precluded by the NNC.

717 Flight Crew Training Manual

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.

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 assists flight crews in the decision making process by indicating those situations where “landing at the nearest suitable airport” is required. These situations are described in the Non-Normal Checklist Instructions or the individual NNC.

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.

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, Jeppessen 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.

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.

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 flaps 25.

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 on Emergency Power

The probability of a total and unrecoverable AC power failure is remote. During training, or in the unlikely event that a landing must be made on emergency power, the following guidelines should be considered:

- Plan
 - Avoid IMC
 - Land at nearest suitable airport
 - Review major items available when reduced to operating on battery only.
 - Battery power cannot be relied on for more than 60 minutes.
- Aviate
 - Manual pressurization/manual temperature control
 - No stabilizer trim or stabilizer trim indication
 - No ATS
 - No autopilot
 - No flight director.

- Navigate
 - VOR1 (no DME), FMC-1 (in standby), GPS-1 and ILS-1 (no DME), outer marker are available
 - DU1, DU2 and DU3 available. (SDs available on DU3)
 - FCP, F/O ECP unpowered
- Communicate
 - Captain's VHF-1 and cockpit speaker are available
 - Captain's ACP (F/O can hear and transmit on VHF-1 and interphone) are available
 - Chime system is inop
 - Transponder inop
- Protection
 - Fire Detection and Protection available
 - Alerting system (EAD and aural) available for powered systems
 - Stall warning inop
 - GPWS inop
 - TCAS inop
- Instrument Approach Capability
 - Raw data ILS
 - Raw data localizer
 - Radio altimeter inop
- Landing
 - Gear and slat operation is normal (no indication).
 - Refer to QRH for flap/slat configuration (no indication).
 - No speed brakes or ground spoilers
 - Anti-skid is available
 - No thrust reverser
 - Stabilizer may not be in trim with landing flaps set
 - If in trim, continue approach and landing.
 - If not in trim, increase VREF by 20 knots and continue approach and landing.

Note: Refer to the QRH, Complete Loss of AC Power or GEN ALL OFF NNC.

Fly the approach on speed. Anti-skid is available, so excess approach speed is undesirable. Do not reduce thrust until landing flare has been initiated and sink rate has been reduced. Brake with caution.

The captain may require verbal assistance with glidepath, rate of descent, and airspeed from the first officer.

Engines, APU

Engine Failure versus Engine Fire After Takeoff

The NNC for an engine failure is normally accomplished after reaching 180 knots and conditions permit.

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 NNC memory items. Due to asymmetric thrust considerations, the PF retards the affected throttle after the PM confirms that the PF has identified the correct engine. Reference items should be accomplished on a non-interfering basis with other normal duties after reaching 180 knots and conditions permit.

Engine Tailpipe Fire

CAUTION: Tailpipe fires are not annunciated in the flight deck. The first notification of a tailpipe fire may be from an external source. Discharging the engine fire extinguishing agent will not extinguish the fire. If the fire cannot be extinguished by motoring, or if motoring is not possible, the use of ground fire fighting equipment may be required.

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. The major challenge the flight crew faces when responding to this malfunction is recognizing the condition and determining which engine has malfunctioned. The Engine Compressor Stall/Surge NNC is written to include this malfunction. This condition can occur during any phase of flight.

Failure of engine or fuel control system components or loss of throttle position feedback has caused loss of engine thrust control. Control loss may not be immediately evident since many engines fail to some fixed RPM or throttle condition. This fixed RPM or throttle condition may be very near the commanded thrust level and therefore difficult to recognize until the flight crew attempts to change thrust. Other engine responses include: shutdown, operation at low RPM, or thrust at the last valid throttle setting (in the case of a throttle feedback fault) depending on altitude or air/ground logic. In all cases, the affected engine does not respond to throttle movement or the response is abnormal.

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 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.

Two Engine Flameout

Dual engine failure is a situation that demands prompt action regardless of altitude or airspeed. Accomplish memory items and establish the appropriate airspeed to immediately attempt a windmill restart. There is a higher probability that a windmill start will succeed if the restart attempt is made as soon as possible (or immediately after recognizing an engine failure) to take advantage of high engine RPM. Use of higher airspeeds and altitudes below 30,000 feet improves the probability of a restart. Loss of thrust at higher altitudes may require descent to a lower altitude to improve windmill starting capability.

The in-flight start envelope defines the region where windmill starts were demonstrated during certification. It should be noted that this envelope does not define the only areas where a windmill start may be successful. The Two Engine Flameout NNC is written to ensure that flight crews take advantage of the high RPM at engine failure regardless of altitude or airspeed. Initiate the memory portion of the Two Engine Flameout NNC before attempting an APU start for the reasons identified above. If the windmill restart is not successful, an APU start should be initiated as soon as practical to provide electrical power and starter assist during follow-on engine start attempts.

During a windmill restart, TGT may exceed the displayed limit for one-engine starts. During restart attempts with both engines failed, use the takeoff TGT limit. A hung or stalled in-flight start is normally indicated by stagnant RPM and increasing TGT. During start, engines may accelerate to idle slowly but action should not be taken if RPM is increasing and TGT is not near or rapidly approaching the limit.

Note: When electrical power is restored, do not confuse the establishment of APU generator power with the establishment of engine generator power at idle RPM and advance the throttle prematurely.

High Engine Vibration

The ENG VIB HI alert displayed on the EAD is typically associated with engine fan blade icing. If the aircraft is in icing conditions the High Engine Vibrations/Ice Shedding NNC should be accomplished. If not in icing conditions and if all other engine indications are normal, continue to operate engine. Should any abnormal indicators occur during the remainder of the flight (airframe vibration, high TGT, etc.), the flight crew should evaluate the condition and, if required, shut down the engine.

Certain engine failures, such as fan blade separation, can cause high levels of airframe vibration. Although the airframe vibration may seem severe to the flight crew, it is extremely unlikely that the vibration will damage the aircraft structure or critical systems. However, the vibration should be reduced as soon as possible by reducing airspeed and descending. As altitude and airspeed change, the aircraft may transition through various levels of vibration. In general, vibration levels decrease as airspeed decreases; however, at a given altitude vibration may temporarily increase or decrease as airspeed changes.

If vibration remains unacceptable, descending to a lower altitude (terrain permitting) allows a lower airspeed and normally lower vibration levels. Vibration will likely become imperceptible as airspeed is further reduced during approach.

The impact of a vibrating environment on human performance is dependent on a number of factors, including the orientation of the vibration relative to the body. People working in a vibrating environment may find relief by leaning forward or backward, standing, or otherwise changing their body position.

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. The following technique is an example that could be used:

When an engine shutdown is needed, the PF disconnects the A/T. The PF then verbally coordinates confirmation of the affected engine with the PM and then slowly retards the throttle of the engine that will be shut down.

Coordinate activation of the fuel switch as follows:

- PM places a hand on and verbally identifies the fuel switch for the engine that will be shut down.
- PF verbally confirms that the PM has identified the correct fuel switch.
- PM moves the fuel switch to cutoff.

If the NNC requires activation of the engine fire handle, coordinate as follows:

- PM places a hand on and verbally identifies the engine fire handle for the engine that is shutdown.
- PF verbally confirms that the PM has identified the correct engine fire handle.
- PM pulls the engine fire handle.

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 TGT 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 TGT is indicated.

TGT Exceedance During Takeoff

If an engine exceedance occurs after thrust is set and the decision is made to continue the takeoff, do not retard the throttle in an attempt to control the exceedance. Retarding the throttles after thrust is set invalidates takeoff performance. When the captain judges that altitude (minimum 400 feet AGL) and airspeed are acceptable, the throttle should be retarded until the exceedance is within limits and the appropriate NNC accomplished. Enter the exceedance in the aircraft logbook.

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. 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.

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717 Flight Crew Training Manual

Pre Landing/Ditching	
Captain	First Officer
• Advise crew to prepare for emergency landing (or ditching) and order distress message sent. • Set course for most logical point of landing under existing circumstances. • Order flightdeck emergency preparation as conditions dictate. • Fasten seat belt and shoulder harness. • Signal cabin crew/passengers when touchdown is imminent, using PA system if operative. • If ditching: don life vest.	• Send distress message (MAY DAY), giving aircraft identification, type, position, heading, airspeed, altitude, fuel remaining in hours and minutes, nature of distress, intentions, and assistance desired. • Assist in flightdeck emergency preparations as directed by the Captain and as conditions dictate. • Fasten seat belt and shoulder harness. • If ditching: don life vest.

Post Landing/Ditching	
Captain	First Officer
• Order evacuation. • Proceed to forward cabin area and assist in evacuating passengers as conditions dictate. • After ensuring that all passengers are off the aircraft or all possible assistance has been given, exit from the rear of the aircraft if able. • When all possible assistance has been given, leave the aircraft and assume command outside. • After exiting, assemble passengers away from the aircraft.	• Assist in opening forward cabin door and exit the aircraft. • Assist in the evacuation of passengers from the exterior of the aircraft as conditions dictate. • Assist in assembling passengers away from the aircraft.

Flight Controls

Leading Edge or Trailing Edge Device Malfunctions

Leading edge or trailing edge device malfunctions can occur during extension or retraction. This section discusses all flaps up and partial or asymmetrical leading/trailing edge device malfunctions for landings.

No Flaps/No Slat Landing

The probability of both leading and trailing edge devices failing to extend is remote. If a flaps up landing situation were to be encountered in service, the pilot should consider the following techniques. Training to this condition should be limited to the flight simulator.

After selecting a suitable landing airfield and prior to beginning the approach, consider reduction of aircraft gross weight (burn off fuel) to reduce touchdown speed.

Fly a wide pattern to allow for the increased turning radius required for the higher speed. Establish final approximately 10 nm from the runway. This allows time to extend the gear and decelerate to the target speed while in level flight and complete all required checklists.

Final Approach

Use an ILS glide slope if available. Before intercepting the descent profile, decrease airspeed to VAPP and maintain this speed until the landing is assured.

The normal rate of descent on final is approximately 900-1,000 fpm due to the higher ground speed. Anticipate possible “SINK RATE” GPWS warning due to the high rate of descent. Final approach body attitude is approximately 6.8°. Do not make a flat approach (shallow glide path angle) or aim for the threshold of the runway. Use a normal aim point approximately 1,000 feet down the runway.

Note: Use of the autopilot during approach phase is acceptable. Do not autoland. FD and ATS GA are not available with flaps less than 5°.

Speedbrakes are not recommended for airspeed reduction at radio altitude less than 1,000 feet. If landing is anticipated beyond the normal touch down zone, go around.

717 Flight Crew Training Manual

Landing

Fly the aircraft onto the runway at the recommended touchdown point. Flare only enough to achieve an acceptable reduction in the rate of descent. Do not allow the aircraft to float. Floating just above the runway surface to deplete additional speed wastes available runway and increases the possibility of a tail strike. Do not risk touchdown beyond the normal touchdown zone in an effort to achieve a smooth landing.

Slight forward pressure on the control column may be needed to achieve touchdown at the desired point and to lower the nose wheels to the runway. After lowering the nose wheels to the runway, hold light forward control column pressure and expeditiously accomplish the landing roll procedure. Full reverse thrust is needed for a longer period of time.

Use normal reverse thrust procedures (reverse thrust is more effective at high speeds). Smoothly apply manual brakes to full pedal deflection. Be alert for excessive brake temperatures after landing.

Jammed or Restricted Flight Controls

Although rare, jamming of the flight control system has occurred on commercial aircraft. A jammed flight control can result from ice accumulation due to water leaks onto cables or components, dirt accumulation, component failure such as cable break or worn parts, improper lubrication, or foreign objects.

A flight control jam may be difficult to recognize, especially in a properly trimmed aircraft. A jam in the pitch axis may be more difficult to recognize than a jam in other axes. In the case of the elevator, the jammed control can be masked by trim. Some indications of a jam are:

- Unexplained autopilot disengagement
- Autopilot that cannot be engaged
- Undershoot or overshoot of an altitude during autopilot level-off
- Higher than normal control forces required during speed or configuration changes.

If any jammed flight control condition exists, both pilots should apply force to try to either clear the jam or activate the override feature. There should be no concern about damaging the flight control mechanism by applying too much force to either clear a jammed flight control or activate an override feature. Maximum force may result in some flight control surface movement with a jammed flight control. If the jam clears, both pilot's flight controls are available.

Note: If a control is jammed due to ice accumulation, the jam may clear when moving to a warmer temperature.

Note: There are override features for the control wheel and the control column.

If the jam does not clear, activation of an override feature allows a flight control surface to be moved independent of the jammed control. Applying force to the non-jammed flight control activates the override feature. When enough force is applied, the jammed control is overridden allowing the non-jammed control to operate. To identify the non-jammed flight control, apply force to each flight control individually. The flight control that results in the greatest aircraft control is the non-jammed control.

Note: The pilot of the non-jammed control should be the pilot flying for the remainder of the flight.

The non-jammed control requires a normal force, plus an additional override force to move the flight control surface. For example, if a force of 10 lbs (4 kgs) is normally needed to move the surface, and 50 lbs (23 kgs) of force is needed to activate the override, a total force of 60 lbs (27 kgs) is needed to move the control surface while in override. Response is slower than normal with a jammed flight control; however, sufficient response is available for aircraft control and landing.

For those controls without override features, limited flight control surface deflection occurs when considerable force is applied to the flight control. This response is due to cable stretch and structural bending. This response may be sufficient for aircraft control and landing.

Trim Inputs

If a jammed flight control condition exists, use manual inputs from other control surfaces to counter pressures and maintain a neutral flight control condition. The following table provides trim inputs that may be used to counter jammed flight control conditions.

Jammed Control Surface	Manual Trim Inputs
Elevator	Stabilizer
Aileron	Rudder
Rudder	Aileron

Note: Asymmetric engine thrust may aid roll and directional control.

717 Flight Crew Training Manual

Approach and Landing

Attempt to select a runway with minimum crosswind. Complete approach preparations early. Recheck flight control surface operation prior to landing to determine if the malfunction still exists. Do not make abrupt thrust, speedbrake, or configuration changes. Make small bank angle changes. On final approach, do not reduce thrust to idle until after touchdown. Asymmetrical braking and asymmetrical thrust reverser deployment may aid directional control on the runway.

Note: In the event of an elevator jam, control forces will be significantly greater than normal and control response will be slower than normal to flare the aircraft.

Go-Around Procedure

If the elevator is known or suspected to be jammed, a go-around should be avoided if at all possible. To execute a go-around with a jammed elevator, smoothly advance throttles while maintaining pitch control with stabilizer and any available elevator. If a go-around is required, the go-around procedure is handled in the same manner as a normal go-around.

Stabilizer Inoperative

A stabilizer may jam as a result of dirt or ice on the jackscrew or due to mechanical failure. Regardless of the stabilizer position, the pilot still has sufficient elevator control to land the aircraft. However, elevator authority is limited. The QRH specifies an adjusted approach speed and landing configuration that ensures adequate elevator control is available for the remainder of the flight. Use normal piloting techniques for landing.

Runaway Stabilizer

Complete the memory items for the Runaway Stabilizer NNC, then refer to the NNC in the QRH.

Flight Instruments, Displays

Airspeed Unreliable

Increased reliance on automation has de-emphasized the practice of setting known pitch attitudes and thrust settings. However, should an airspeed unreliable incident occur, the flight crew should be familiar with the approximate pitch attitude and thrust setting for each phase of flight. This familiarity can be gained by noting the pitch attitude and thrust setting occasionally during normal flight. Any significant change in body attitude from the attitude normally required to maintain a particular airspeed or Mach number should alert the flight crew to a potential airspeed problem.

If abnormal airspeed is recognized, set the memory items pitch attitude and thrust settings indicated in the Airspeed Unreliable NNC. When aircraft control is established, accomplish the Airspeed Unreliable NNC. Refer to the OPERATION WITHOUT AIRSPEED INDICATION tables in the ODM for the correct attitude, thrust settings, and V/S for actual aircraft gross weight and altitude.

Unreliable airspeed indications can result from blocking or freezing of the pitot/static system or a severely damaged or missing radome. When the ram air inlet to the pitot head is blocked, pressure in the probe is released through the drain holes and the airspeed slowly drops to zero. If the ram air inlet and the probe drain holes are both blocked, pressure trapped within the system reacts unpredictably. The pressure may increase through expansion, decrease through contraction, or remain constant. In all cases, the airspeed indications would be abnormal. This could mean increasing indicated airspeed in climb, decreasing indicated airspeed in descent, or unpredictable indicated airspeed in cruise.

If the flight crew is aware of the problem, flight without the benefit of valid airspeed information can be safely conducted and should present little difficulty. Early recognition of erroneous airspeed indications requires familiarity with the interrelationship of attitude, thrust setting, and airspeed. A delay in recognition could result in loss of aircraft control.

Ground speed information is available from the FMS and on the instrument displays. These indications can be used as a crosscheck. Many air traffic control radars can also measure ground speed.

Descent

Idle thrust descents to 10,000 feet can be made by flying body attitude and checking rate of descent in the OPERATION WITHOUT AIRSPEED INDICATION ODM tables. At 2,000 feet above the selected level off altitude, reduce rate of descent to 1,000 FPM. On reaching the selected altitude, establish attitude and thrust for the aircraft configuration. If possible, allow the aircraft to stabilize before changing configuration and altitude.

717 Flight Crew Training Manual

Approach

If available, accomplish an ILS approach. Establish landing configuration early on final approach. At glide slope intercept or beginning of descent, set thrust and attitude per the OPERATION WITHOUT AIRSPEED INDICATION ODM tables and control the rate of descent with thrust.

Landing

Control the final approach so as to touch down approximately 1,000 feet to 1,500 feet beyond the threshold. Fly the aircraft on to the runway, do not hold it off or let it “float” to touchdown.

Maintain adequate brake pedal pressure until a safe stop is assured. Immediately after touchdown, expeditiously accomplish the landing roll procedure.

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.

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 Crossfeed 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, or EAD 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. An engine fuel leak is the most common type of fuel leak since fuel lines are exposed in the strut. Most other fuel lines, such as a crossfeed manifold, are contained within the tanks. A significant fuel leak directly from a tank to the outside is very rare due to the substantial wing structure that forms the tanks.

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, or by some annunciation that occurs because of a leak. 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.

Low Fuel

A FUEL LEVEL LO level 1 alert will appear on the EAD when there is less than 1,000 pounds of fuel in the center tank and either the left or right main tank fuel quantity is below 2,000 pounds for two minutes.

There is no NNC for a Fuel Level Low alert however if the crew anticipates landing with less than 1,000 pounds in either main tank the Approach With Less than 1,000 Pounds Fuel in Either Main Tank NNC should be completed.

717 Flight Crew Training Manual

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.

Note: A go-around is not recommended with less than 500 pounds fuel in each main tank or if both main tank aft pumps are inoperative.

Hydraulics

Proper planning of the approach is important. Consideration should be given to the effect the inoperative system(s) has on crosswind capabilities, autoflight, control response, control feel, reverse thrust, stopping distance, go-around configuration, and performance required to reach an alternate airfield.

Hydraulic System(s) Inoperative - Landing

If nose wheel steering is inoperative and any crosswind exists, consideration should be given to landing on a runway where braking action is reported as good or better. Braking action becomes the primary means of directional control below approximately 60 knots where the rudder becomes less effective. If controllability is satisfactory, taxi clear of the runway using differential thrust and brakes. Continued taxi with nose wheel steering inoperative is not recommended due to aircraft control difficulties and heat buildup in the brakes.

Landing Gear

Braking with Antiskid Inoperative

Note: If Antiskid is inoperative, dispatch is prohibited for most flights. Refer to the MEL for specific procedures and requirements.

When the antiskid system is inoperative, the following techniques apply:

- Ensure that the nose wheels are on the ground and the spoilers are extended before applying the brakes.
- Initiate wheel braking using very light pedal pressure and increase pressure as ground speed decreases.
- Apply steady pressure and do not pump the pedals. This is because each time the brakes are released, the required stopping distance is increased. Also, each time the brakes are reapplied, the probability of a skid is increased.

Antiskid-off braking requires even greater care during lightweight landings.

Flight testing has demonstrated that braking effectiveness on a wet grooved runway is similar to that of a dry runway. However caution must be exercised when braking on any wet, ungrooved portions of the runway with antiskid inoperative to avoid tire failure.

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. Once the nose gear is down, vibration levels may be affected by increasing or decreasing control column 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 is 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. Recycling the landing gear in an attempt to extend the remaining gear is not recommended. 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.

Prior to Approach

If time and conditions permit, reduce weight as much as possible by burning off fuel to attain the slowest possible touchdown speed.

At the captain's command, advise the crew and the passengers of the situation, as needed. Coordinate with all ground emergency facilities. For example, fire trucks normally operate on a common VHF frequency with the aircraft and can advise the crew of the aircraft condition during the landing. Advise the cabin crew to perform emergency landing procedures and to brief passengers on evacuation procedures.

The NNC instructs the crew to inhibit the ground proximity system as needed to prevent nuisance warnings when close to the ground with the gear retracted.

For landing in any gear configuration, establish approach speed early and maintain a normal rate of descent.

Landing Techniques

Attempt to keep the aircraft on the runway to minimize aircraft damage and aid in evacuation. After touchdown lower the nose gently before losing elevator effectiveness. Use all aerodynamic capability to maintain directional control on the runway. At touchdown speed, the rudder has sufficient authority to provide directional control in most configurations. At speeds below 60 knots, use nose wheel/rudder pedal steering, if available, and differential braking as needed.

Use of Spoilers

If the landing will be made with the nose wheel unsafe and the main gear extended, arm the spoilers for landing. If landing with one or both main gear unsafe, do not arm the spoilers.

When landing with any gear that indicates up or partially extended, attempt to fly the area with the unsafe indication smoothly to the runway at the lowest speed possible, but before losing flight control effectiveness. A smooth touchdown at a low speed helps to reduce aircraft damage and offers a better chance of keeping the aircraft on the runway. The aircraft is easier to control before body parts make ground contact. If the spoilers are deployed before all areas have made contact with the runway, the aircraft will complete touchdown sooner and at a higher speed.

After Stop

Accomplish an evacuation, if needed.

717 Flight Crew Training Manual

Gear Disagree Combinations**Both Main Gear Extended with Nose Gear Up**

Establish approach speed early and maintain normal rate of descent. After touchdown at the normal 1,000 foot point, manually extend the spoilers if necessary. Use idle reverse thrust with caution. Hold nose off until approximately 80 KIAS then lower the nose gently before losing elevator effectiveness. Upon nose contact, use maximum braking (within limits of directional control) to stop aircraft.

Nose Gear Only Extended

Establish a normal approach with maximum flaps (for configuration). Land in the center of the runway. Use normal approach and flare attitude maintaining back pressure on the control column until ground contact. Do not use spoilers during landing.

One Main Gear Extended and Nose Gear Extended

Land the aircraft on the side of the runway that corresponds to the extended main gear down. At touchdown, maintain wings level as long as possible. Use rudder and nose wheel steering for directional control. After all gear, or the engine nacelle where the gear is not extended, have made contact with the runway, braking on the side opposite the unsupported wing should be used as needed to keep the aircraft rolling straight.

One Main Gear Only Extended

Land the aircraft on the side of the runway that corresponds to the extended main gear down. At touchdown, maintain wings level as long as possible. Use rudder for directional control. After all gear, or the nose, have made contact with the runway, braking on the side opposite the unsupported wing should be used as needed to keep the aircraft rolling straight.

All Gear Up or Partially Extended

Use a normal approach and flare attitude.

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.

VMO is depicted on the speed tape as an amber band. If airspeed exceeds VMO an aural “clacker” will sound followed by the voice “OVERSPEED.”

During cruise at high altitude, wind speed or direction changes may lead to overspeed events. Although autothrottle 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 autothrottle system to prevent short term overspeeds.

Note: When operating in FMS Speed or Speed Select and a speed greater than VMO is selected a white bow tie will remain at VMO-5 and the selected speed bow tie will turn red. The ATS will maintain VMO-5. If the ATS is off it will automatically reengage to maintain VMO-5. During descent with the throttles at idle the ATS will adjust pitch to maintain VMO-5. There is no overspeed protection when descending in V/S mode.

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 autothrottle corrections are not satisfactory, deploy partial speedbrakes slowly until a noticeable reduction in airspeed is achieved. When the airspeed is below VMO/MMO, retract the speedbrakes at the same rate as they were deployed. The throttles can be expected to advance slowly to achieve cruise airspeed; if not, they should be pushed up more rapidly.

During descents at or near VMO/MMO, most overspeeds are encountered after the autopilot initiates capture of PROF 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 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.

717 Flight Crew Training Manual

When encountering an inadvertent overspeed condition, crews should leave the autopilot engaged unless it is apparent that the autopilot is not correcting the overspeed. However, if manual inputs are required, disengage the autopilot. Be aware that disengaging the autopilot to avoid or reduce the severity of an inadvertent overspeed may result in an abrupt pitch change.

During climb or descent, if PROF or Level Change pitch control is not correcting the overspeed satisfactorily, switching to the V/S mode temporarily may be helpful in controlling speed. In the V/S mode, the selected vertical speed can be adjusted slightly to increase the pitch attitude to help correct the overspeed. As soon as the speed is below VMO/MMO, PROF or Level Change may be re-selected.

Note: Any time VMO/MMO is exceeded, the maximum airspeed should be noted in the logbook.

Smoke/Fumes Principles

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., cargo fire), accomplish that checklist prior to the Smoke, Fire or Fumes or Smoke or Fumes Removal 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 sense of smell. The source identification/elimination steps in the “Smoke, Fire or Fumes” checklist will systematically remove the most probable smoke/fire/fumes sources.

Inordinate depowering of airplane systems is not likely to benefit an unknown smoke/fire/fumes situation. Such action significantly reduces airplane capabilities without commensurate likelihood of depowering the unknown smoke/fire/fumes source.

Smoke/Fumes Priorities

General

The following information is critical to survival in a smoke/fumes situation.

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

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

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 “Smoke, Fire or Fumes” 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 Smoke or Fumes Removal 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: 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.

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

To do the Windshield Cracked or Arcing NNC, the flight crew may need to determine if the inner pane of the affected window is cracked or shattered. This can be done by placing the point of an object such as a pencil on the crack, and then moving the head while focusing on the point of the object. If the crack appears to move relative to the point of the object, the crack is not in the inner pane. If the crack does not appear to move relative to the point of the object, the crack is in the inner pane. A crack in the inner pane may also be detected by running a fingernail across the window's surface.

If both forward windows delaminate or forward vision is unsatisfactory, accomplish an ILS autoland, if available.

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. VMIN + 5 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. However, there is very little turbulence on the flight deck. Because of aircraft design, there is an area of relatively calm air over the open window. Forward visibility can be maintained by looking out of the open window using care to stay clear of the airstream.

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.

- A flight control break-out feature is designed into all Boeing aircraft. If a jammed flight control exists, both pilots can apply force to either clear the jam or activate the break-out feature. There should be no concern about damaging the mechanism by applying too much force. In certain cases, clearing the jam may permit one of the control columns to operate the flight controls with portions of a control axis jammed. It may be necessary to apply break-out forces for the remainder of the flight on the affected control axis.
- Stall margin decreases with angle of bank and increasing load factors. Therefore, it is prudent to respect the bank limiter in the event maneuver capability is in question. Maintaining VMIN foot + 5 or greater 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 NNCs 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.

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. 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.

As a starting point, use the flap/speed schedule as directed in the appropriate NNC. If stick shaker or initial stall buffet are encountered at or before reaching the associated flap speed, or if a rapid increase in wheel deflection and full rudder deflection are necessary to maintain wings level, increase speed to a safe level and consider this speed to be the minimum approach speed for the established configuration.

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 systems may dictate that the check of aircraft handling characteristics be done during the actual approach. Configuration changes made by the alternate systems 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
- 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
Crew Resource Management.....	9.2
CRM Skills	9.3
Error.....	9.8
Error Management.....	9.11
Practical Application of TEM Process	9.12
Threat Management Tools.....	9.12
The Highest Threat	9.13
Unexpected Threat Management Tool	9.14

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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 flight deck. 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.

Crew Resource Management

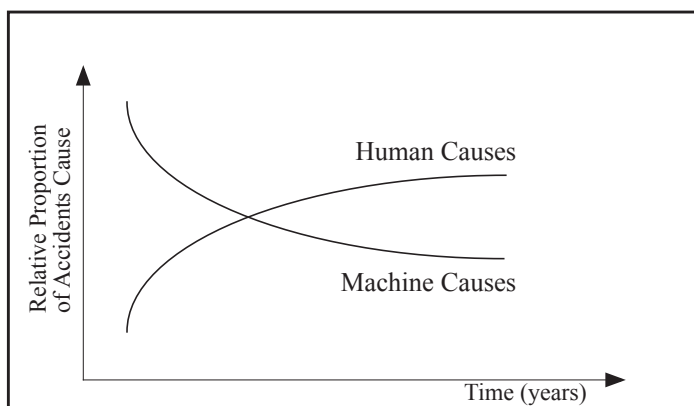
CRM is a discipline within the larger field of Human Factors and can be defined as the effective use of all resources, including hardware, software, and people, to achieve the highest possible level of safety. The use of CRM enhances the safety and effectiveness of your crew (pilots and flight attendants) 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.

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.

- **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.



717 Flight Crew Training Manual

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.



717 Flight Crew Training Manual

- **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.
- **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.

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 Company 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: abnormal, 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.

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.



717 Flight Crew Training Manual

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

 DELTA
717 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.



717 Flight Crew Training Manual

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.

Practical Application of TEM Process

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.



717 Flight Crew Training Manual

- 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."

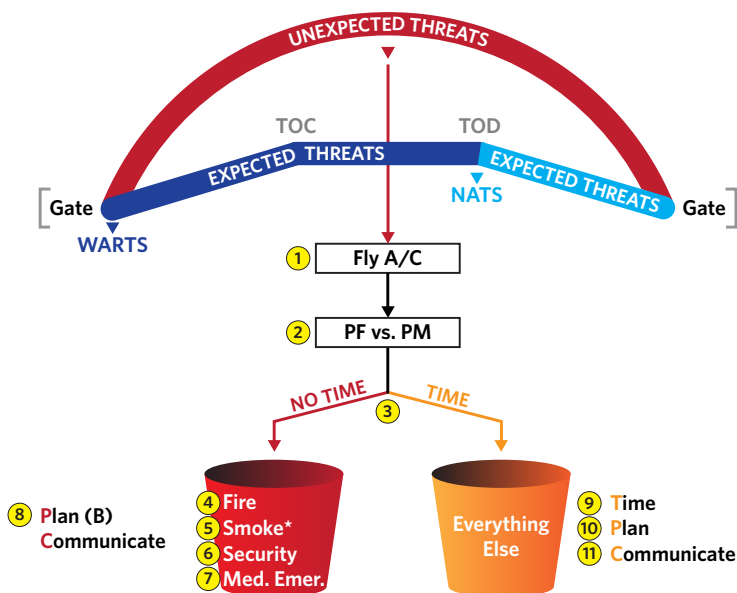
Note: It is not necessary to re-brief the plan to mitigate the highest threat if it was previously covered in WARTS or NATS.

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 Delta Company 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.



717 Flight Crew Training Manual

(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.)

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717 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 chapter 8, Non-Normal Operations, Smoke/Fumes Principles and Smoke/Fumes Priorities for further information.

(6) Security - Refer to FOM, 4.4, Sensitive Security Information, Common Strategy for further information.



717 Flight Crew Training Manual

(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, Medical Emergencies, 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 Airway Manual, Airport Directory & Authorization) 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.

(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
Table of Contents

Chapter 10
Section TOC

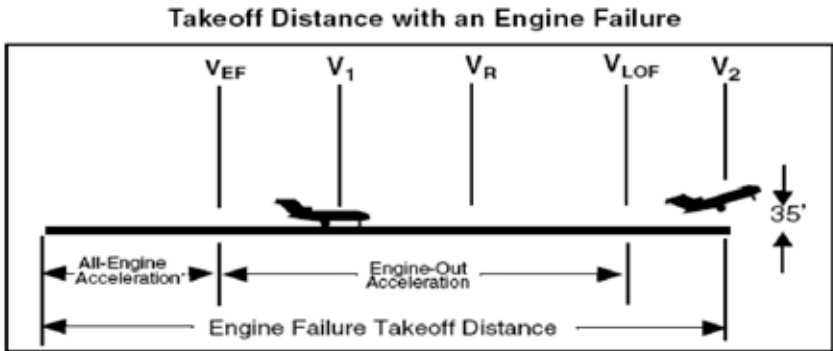
Engine Out.	10.1
Engine Failure Takeoff Performance	10.1
Takeoff Segments	10.2
Optimized V1	10.3
Improved Performance	10.4
Departure Procedures (DPs)	10.5
High Elevation Considerations	10.9
Aircraft Performance Characteristics	10.9
Stopping Dynamics	10.10
Performance Considerations	10.11
Factors Affecting 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	10.25
Aerodynamic Aspects of Maneuver	10.25
Flight Dynamics	10.26

Structural Aspects of Maneuver	10.34

Engine Out

Engine Failure Takeoff Performance

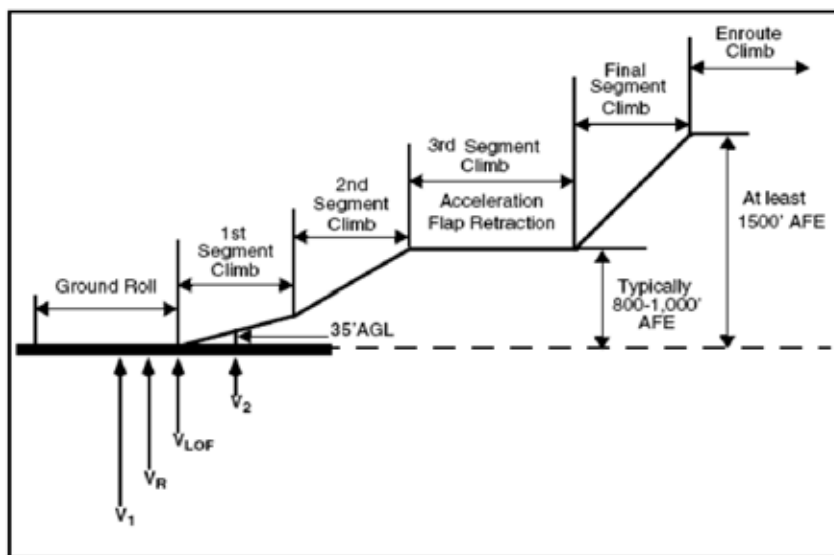
Engine failure takeoff distance is the distance from brake release to the point where the aircraft attains a height of 35 feet, assuming an engine fails at VEF. FAR 25 requires that the length of runway plus clearway be at least equal to the engine failure takeoff distance.



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 VLOF 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
- 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. On airplanes that have FMS Vs speeds calculation capability, the WDR will display V1s that are different from the FMS. The WDR V1s should be used.

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	11889	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 “IMPF” on the runway analysis line when Improved Performance is being utilized, refer to FOM chapter 5.6.

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.



717 Flight Crew Training Manual

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 climbing at least 200 feet per nautical mile, crossing the end of the runway at least 35 feet AGL, 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.



717 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.

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- 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 Company 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.

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High Elevation Considerations

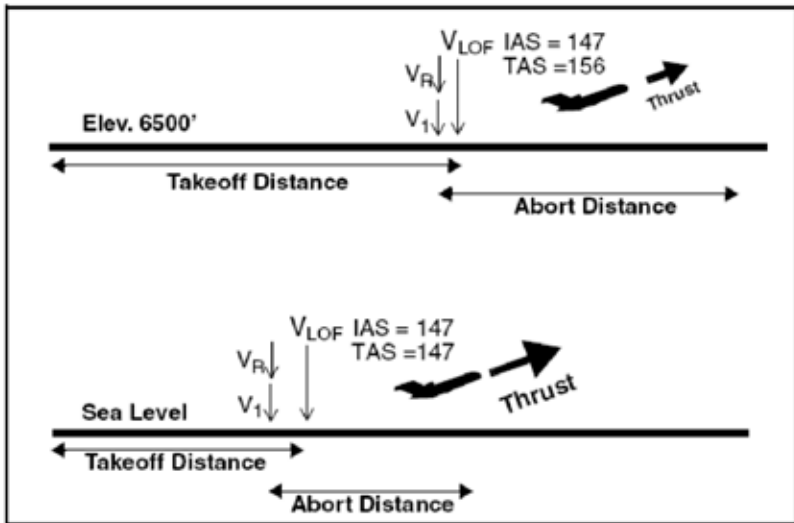
Aircraft Performance Characteristics

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 RPM setting is required to maintain same thrust.
 - Higher RPM 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. When this occurs, a notation indicating the landing flaps to be used will appear on the AWABS. 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 full 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.

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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.).

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. A deterioration of climb performance at higher altitudes should be expected therefore. Steady state wind has no effect on rate of climb, although wind shears can dramatically alter climb rates.

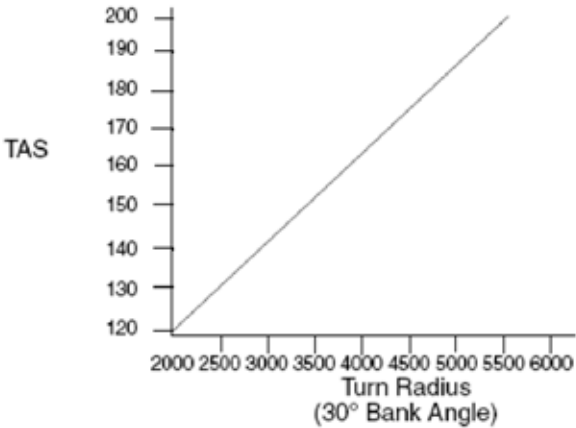
Turning Performance

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.



TAS	Radius
200	6,175
190	5,573
180	5,002
170	4,461
160	3,952
150	3,473
140	3,026
130	2,609
120	2,228



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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

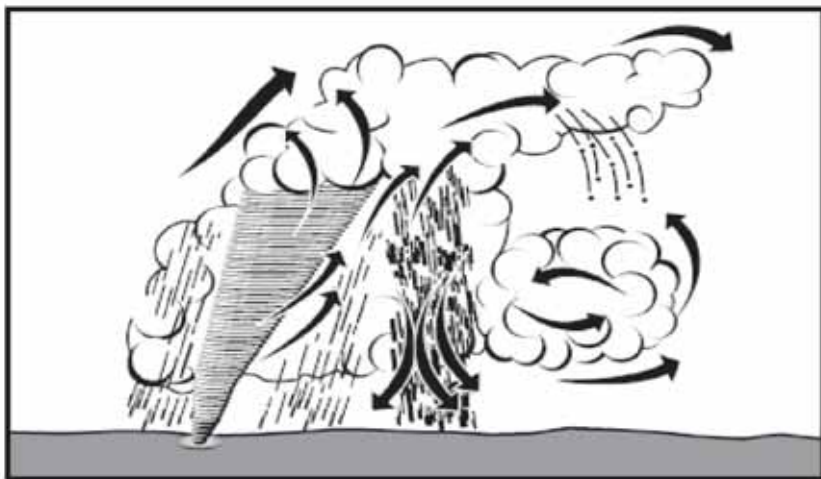
When a minimum radius turn is required or anticipated it is important to slow the aircraft. When the turn is initiated, use the maximum bank angle available. Winds cannot be ignored. Turns into the wind reduce turn radius in relation to terrain.

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.



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Turbulent Activity

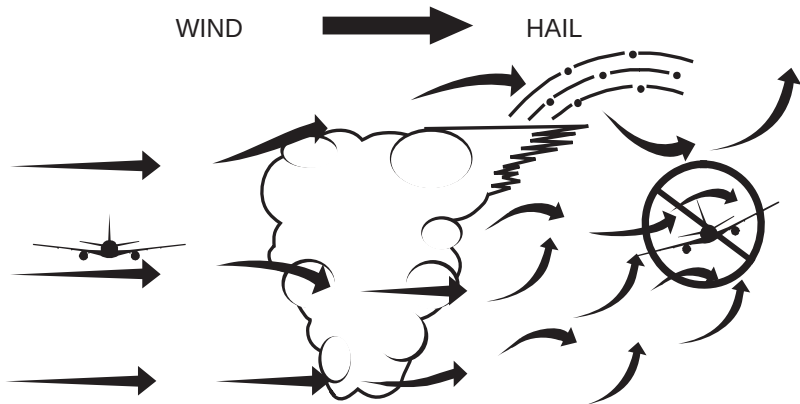
Turbulent activity occurs away from the heavy rain core. Enroute deviations should be made upwind of the storm whenever possible, especially if winds aloft are strong. Deviating downwind greatly increases the chance of encountering hail and turbulence. Turbulence can be expected to exist downwind of 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 to direct the beam will above the flight path.
 - 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

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.

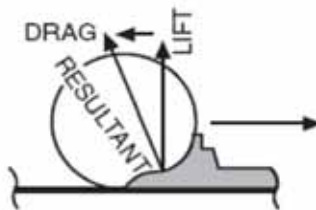
Experts generally agree that there are three types of hydroplaning: dynamic (or hydrodynamic), viscous, and steam (or reverted rubber). It is to be noted that these may be indistinguishable from the flight deck. All three types can seriously degrade the braking effectiveness and directional capability 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.

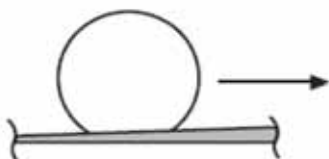
At the same time, the friction-induced spin-up moment is decreasing with decreased footprint area until, at some vehicle speed, the wheel will begin to slow down and stop. This can occur before hydroplaning commences and at this point the effectiveness of wheel braking is lost. The small residual footprint disappears at VP along with all tire-to-surface friction and cornering effects.

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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.

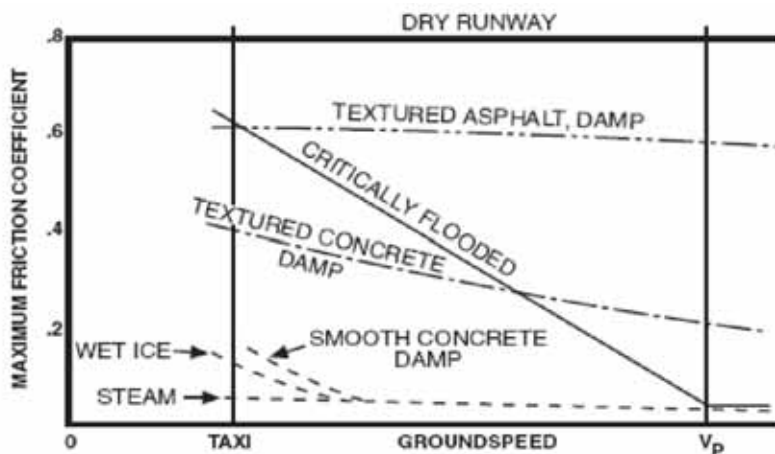
Steam Hydroplaning (Reverted Rubber)

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.

Landing Gear

In tandem-wheel landing gear arrangements, the patch clearing action of the front tire tends to reduce the fluid depth for the rear tire, increasing its traction capabilities.



717 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.

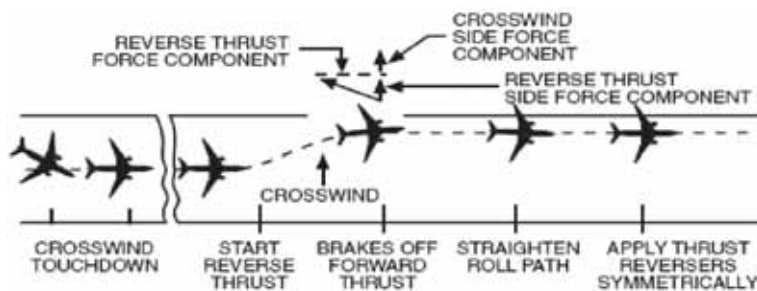
- Use minimum safe touchdown speed.
- Make early runway contact and early nosewheel contact to get maximum directional capability. A firm landing is better than a "grease job," which may induce hydroplaning in marginal conditions.

- Make early use of spoilers for better wheel spin-up acceleration and to remove lift from the wings.
- Make early use of maximum allowable reverse thrust, which is most effective at the higher speeds.
- Use autobrakes if installed.
- Make early use of wheel brakes, applied at a smooth, steady rate up to maximum braking. Do not “jump” on brakes.
- 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 (wing-down method) and initial directional control maintained aerodynamically. If the airplane weathercocks and drifts sideways during reversing, return all engines to low power forward thrust, straighten aircraft path, then resume reverse thrust.



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 crosswind limits on a contaminated runway, refer to Vol. 1, SP.16, Adverse Weather.

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717 Flight Crew Training Manual

Delta Maneuver Training

The following information is compiled from Boeing's Upset Recovery Training Aid (September 1998) and Boeing Flight Operations Technical Bulletin (May 2002). This information is provided so pilots may better understand the key aerodynamic and structural issues concerning maneuver of transport category aircraft.

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:

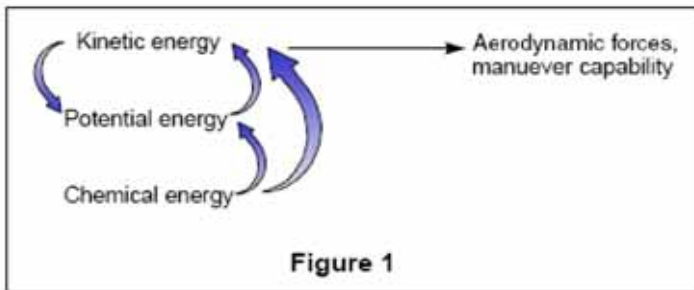
- Recognition to avoid or recognition to recover
- Protect from a stall
- Orient the lift vector
- Stabilize post recovery

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:

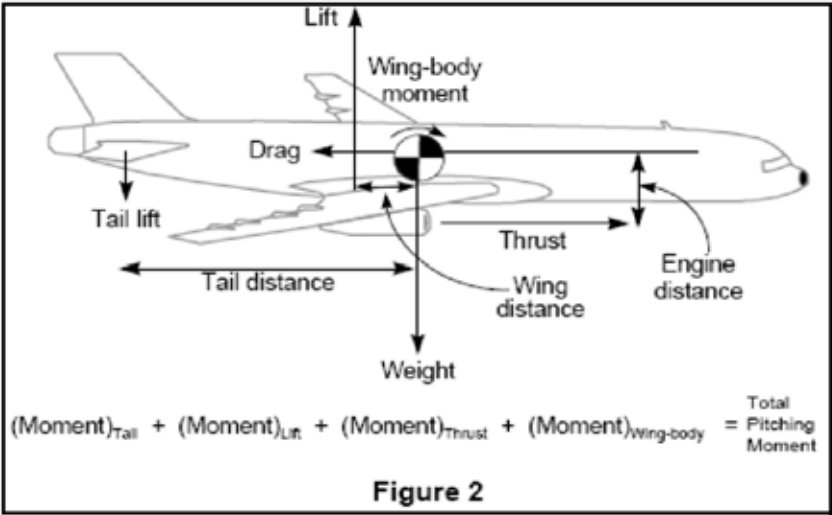
- Kinetic energy stays between the limits (stall and placards),
- Potential energy remains within limits (terrain to buffet altitude), and
- Chemical energy remains present (above fuel exhaustion).

Only within these parameters will you be able to generate the aerodynamic forces necessary to maneuver an aircraft to return it to normal flight.

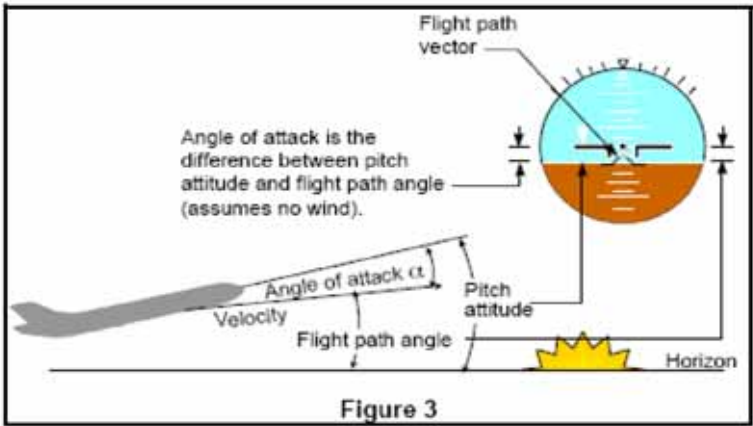
Flight Dynamics

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.





717 Flight Crew Training Manual

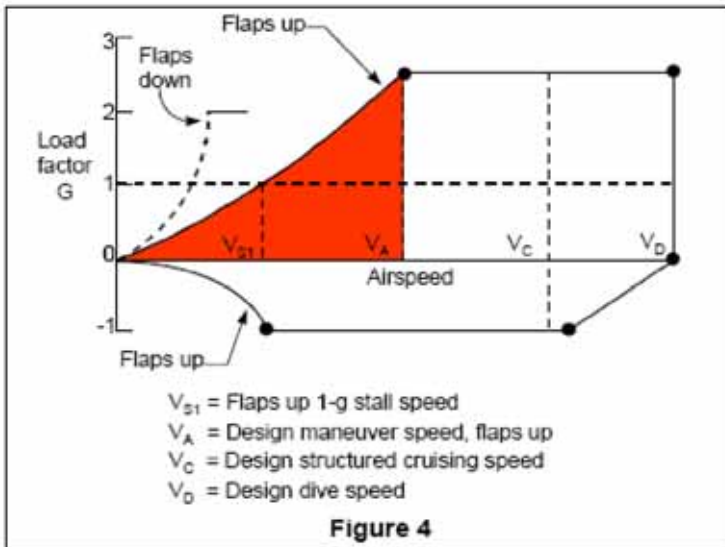
Load Factor

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.

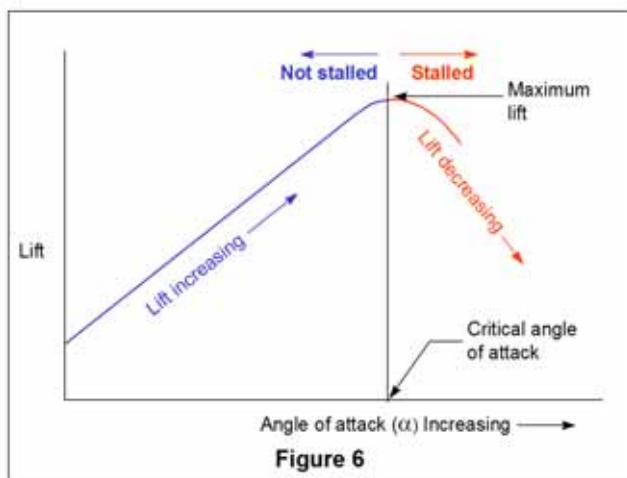
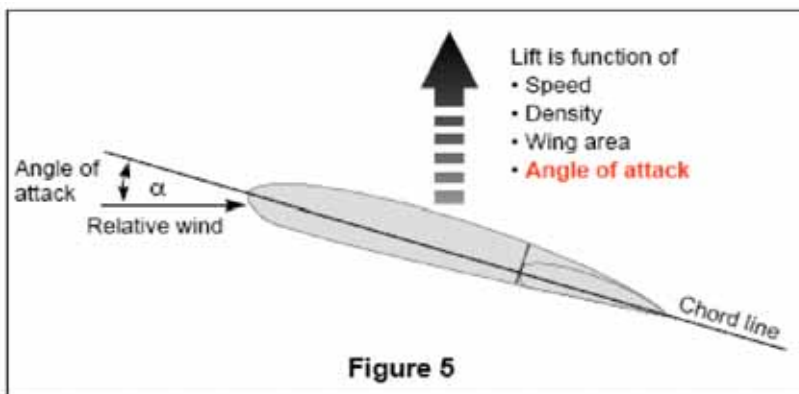
This idea is best captured in a classic speed vs. load factor diagram for a typical swept wing aircraft.



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.



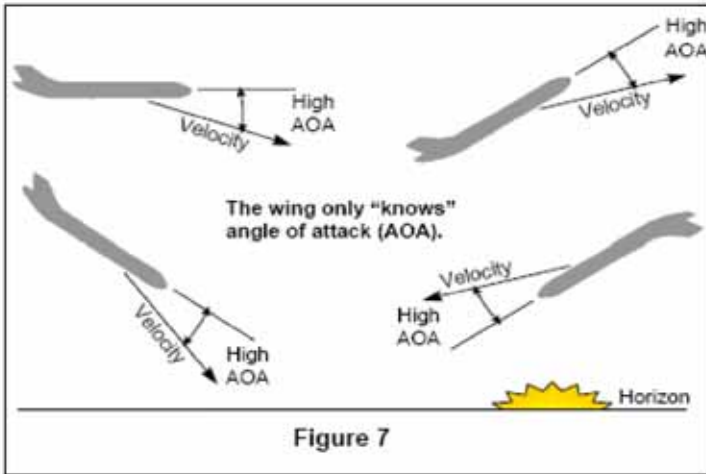
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Stalled Condition

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.

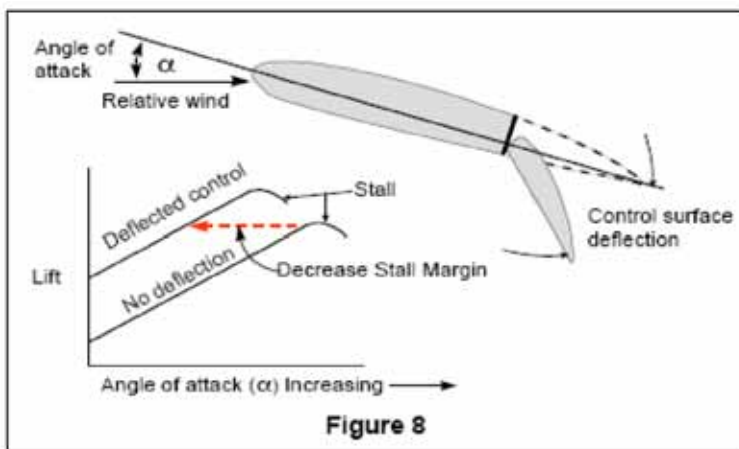
Note: Most upsets are quite dynamic in nature and involve elevated load factors and large speed rate changes.

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.

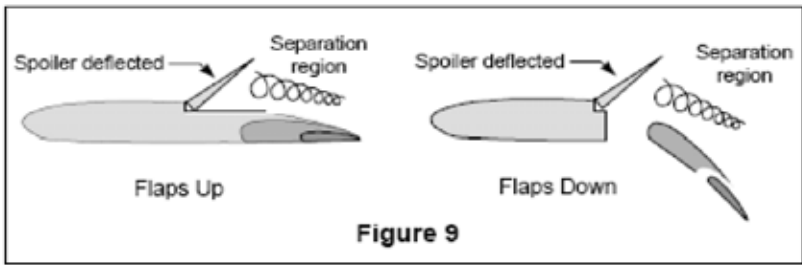
Lateral Control

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.

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The rudder may also be used for lateral control, especially at higher AOA's, but must be used with caution.

CAUTION: Rudder is never the preferred initial response to induce a roll in a transport category aircraft.

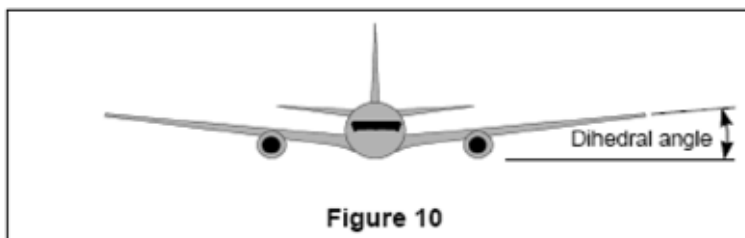
Only under an extreme condition such as loss of a flap, midair collision, or when an aircraft has pitched to a very high pitch attitude and a pushover or thrust change has already been unsuccessful should careful rudder input be considered. Rudder input should be used in the direction of the desired 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.

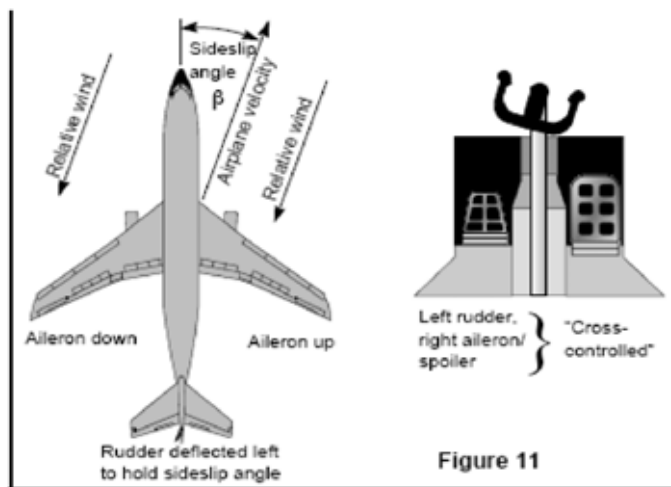
Boeing aircraft have demonstrated entry and recovery from full stalls without the need for rudder. In fact, the use of rudder beyond its intended use during engine out situations or in a crosswind takeoff/landing is almost never indicated.

Wing Dihedral and Sideslip

Dihedral refers to the positive angle between the center of the wing and the lateral axis of the aircraft.



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.



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.

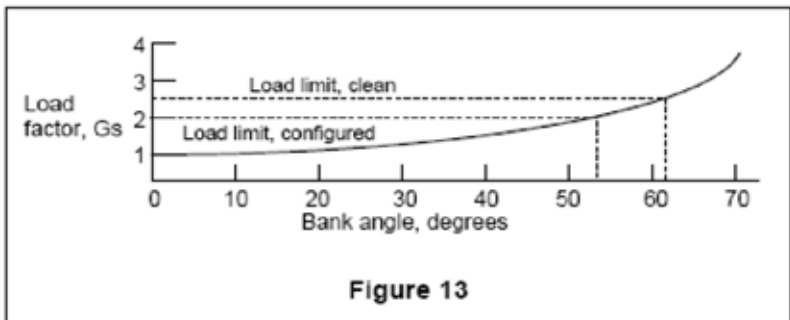
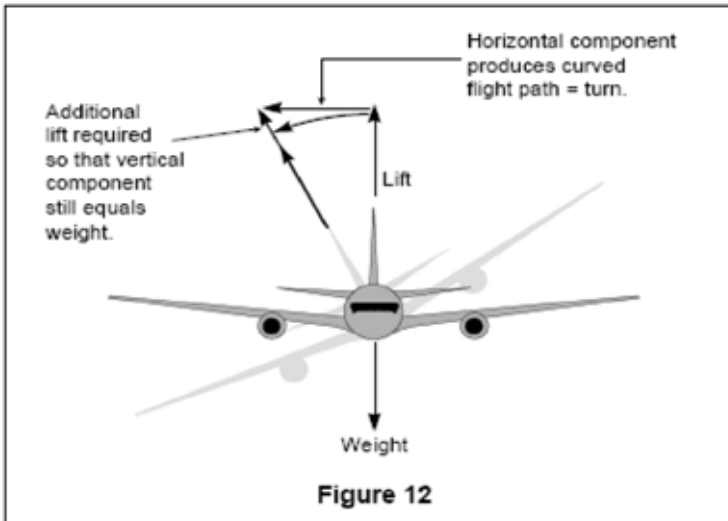


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CAUTION: Too much rudder applied too quickly or held too long may result in loss of lateral and directional control. Cyclic rudder pedal inputs can result in very large amplitude sideslip oscillations as well as very large, possibly excessive airframe 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. Most of these are not well understood by pilots and are repeated here from a Boeing Operations Technical Bulletin.

Boeing 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.



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Pilots must remain aware that Boeing aircraft have been designed to structurally accommodate a rapid and immediate rudder pedal input going in one direction from zero (neutral) input to full input. Likewise, Boeing aircraft can withstand the structural loads if the rudder is rapidly returned to a neutral position from either a full dynamic or static sideslip. However, the aerodynamic necessity for such large-scale rudder inputs is almost never indicated or required!

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 Boeing 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.

 DELTA
717 Flight Crew Training Manual

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Index

Chapter Index

A

Acceleration to and Deceleration from VMO	7.1
Adverse Runway Conditions - Takeoff	3.11
AFDS Autoland Capabilities	5.20
AFDS Faults	5.23
AFDS Guidelines.	1.36
After Landing Flow Pattern	1.11
After Start Flow Pattern.	1.5
After Takeoff Flow Pattern.	1.8
Airspeed Unreliable.	8.20
Antiskid Inoperative - Landing.	8.24
Antiskid Inoperative - Taxi.	2.13
Approach Category	5.2
Approach Clearance	5.2
Automatic Flight - AFDS	1.36
Autopilot Engagement - After Takeoff	3.22
Autothrottle Use.	1.37

B

Before Takeoff Flow Pattern	1.7
Bird Strikes	8.11
Bounced Landing Recovery	6.10
Breakout Procedure	5.27

C

CAT III Operations.	5.20
Category III Operations.	5.20
Center-Of-Gravity Effects on Takeoff	3.7
Circling Approach - One Engine Inoperative	5.74
Circling Approach	5.51
Climb Constraints	4.3
Climb Modes	4.1
Command Speed - Non-Normal Conditions	1.23
Command Speed	1.20

 DELTA
717 Flight Crew Training Manual

Crew Resource Management	1.1
Crosswind Guidelines - Takeoff	3.7
Crosswind Landings	6.21
Crosswind Takeoff	3.7
Cruise Altitude Changes	4.15
Cruise Performance Economy	4.20

D

Damage Assessment and Aircraft Handling Evaluation	8.35
Decision Altitude or Height - DA(H)	5.19
Delayed After Start Flow Pattern	1.5
Derated Takeoff Thrust (Fixed Derate)	3.10
Descent Constraints	4.33
Descent Flow Pattern	1.9
Descent Path	4.30
Descent Planning	4.25
Descent Rates	4.42
Descent Speed Determination	4.27
Ditching	8.4
Dutch Roll	7.5

E

Economy Climb Schedule - FMS Data Unavailable	4.7
Economy Climb	4.6
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	3.29
Engine Failure versus Engine Fire After Takeoff	8.7
Engine Icing During Climb	4.6
Engine Icing During Descent	4.43
Engine Inoperative Climb	4.7
Engine Inoperative Cruise/Driftdown	4.21
Engine Inoperative, Rudder Trim - All Instrument Approaches	5.66
Engine Out Familiarization	7.2
Engine Out Taxi	2.11
Engine Start Flow Pattern	1.4

DELTA
717 Flight Crew Training Manual

Engine Tailpipe Fire	8.7
Engine Vibration	8.10
ETOPS	4.24
Evacuation.	8.13

F

Fail Operational.	5.20
Fail Passive	5.20
Flap Configurations for Approach and Landing.	5.7
Flap Maneuver Speeds	1.16
Flap Maneuver Speeds	1.16
Flap Retraction - One Engine Inoperative	3.33
Flap Retraction Schedule	3.22
Flaps and Landing Gear	4.43
Flaps Up Landing	8.16
Flare and Touchdown	6.8
Flight in Moderate to Heavy Rain, Hail, or Sleet	1.38
Flight Path Vector	1.27
Flow Pattern - After Landing	1.11
Flow Pattern - After Start/Delayed After Start	1.5
Flow Pattern - After Takeoff	1.8
Flow Pattern - Before Takeoff	1.7
Flow Pattern - Descent	1.9
Flow Pattern - Engine Start	1.4
Flow Pattern - Landing	1.10
Flow Pattern - Pushback	1.3
Flow Pattern - Shutdown	1.12
Flow Pattern - Taxi	1.6
Flow Pattern Diagrams	1.1
FMS Preflight.	2.3
Fuel Balance	8.21
Fuel for Enroute Climb	4.16
Fuel Leak.	8.22
Fuel Temperature	4.18

G

DELTA
717 Flight Crew Training Manual

Go-Around after Touchdown	5.86
Go-Around and Missed Approach - All Engines Operating	5.82
Go-Around and Missed Approach - All Instrument Approaches	5.80
Go-Around and Missed Approach - Engine Failure During	5.79
Go-Around and Missed Approach - One Engine Inoperative	5.77
Go/Stop Decision Near V1.	3.17

H

High Altitude High Speed Flight.	4.23
High Altitude Maneuvering, "G" Buffet.	7.4
High Altitude Visual Approach	5.62
Holding Pattern Exit.	4.48
Holding.	4.44
Hydraulic System(s) Inoperative - Landing	8.23

I

ILS - One Engine Inoperative	5.66
ILS Approach - Landing Geometry	5.29
ILS Approach.	5.15
ILS or GLS Approach.	5.9
ILS Performance	5.20
ILS PRM Approach	5.24
Immediate Turn after Takeoff - All Engines	3.19
Immediate Turn after Takeoff - One Engine Inoperative	3.32
Initial Climb - All Engines.	3.19
Initial Climb - One Engine Inoperative	3.31
Instrument Approaches	5.1

J

Jammed or Restricted Flight Controls	8.17

L

Landing at the Nearest Suitable Airport.	8.3
Landing Distance (Factors Affecting).	6.13
Landing Distance (Non-Normal)	6.13
Landing Flare Profile	6.10
Landing Flow Pattern.	1.10
Landing on a Flat Tire	8.25

▲ DELTA
717 Flight Crew Training Manual

Landing Roll	6.11
Liftoff - Effect of Rotation Speed and Pitch Rate	3.6
LNAV - Non-ILS Approach	5.46
Loss of Engine Thrust Control	8.8
Loss of Thrust on Both Engines	8.9
Low Altitude Level Off - During Climb	4.4
Low Fuel Operations In-flight	8.22
Low Visibility Takeoff	3.11

M

Mach Buffet	7.4
Mach Tuck	7.5
Maneuver Margin - Landing and Go-Around	5.5
Maneuver Speeds and Margins	1.16
Manual Flight	1.37
Maximum Altitude - Cruise	4.13
Maximum Angle Climb	4.7
Maximum Angle Climb	4.7
Maximum Operating Speed (VMAX)	1.19
Minimum Maneuver Speed	1.18

N

NAV or LOC ONLY & PROF Modes	5.32
NAV or LOC ONLY & PROF Modes	5.38
Noise Abatement Takeoff	3.28
Non - ILS Instrument Approaches	5.30
Non-ILS Instrument Approach Using FPA or V/S	5.50
Non-ILS Instrument Approach Using PROF	5.48
Non-Normal Operations	5.63
Non-Normal Situation Guidelines	8.1
Nose Wheel/Rudder Pedal Steering	2.13

O

Optimum Altitude - Cruise	4.14
Overspeed	8.28
Overweight Landing	6.22

P

▲ DELTA
717 Flight Crew Training Manual

Partial or Gear Up Landing	8.25
Pitch and Roll Limit Conditions	6.10
Pitch Modes - Takeoff	3.21
Precision Approach Path Indicator (PAPI).	6.3
Preflight	2.1
Procedure Turn and Initial Approach - ILS	5.19
Procedure Turn	5.3
Push Back or Towing.	2.4
Pushback Flow Patterns	1.3

Q

Quick Reference Landing Length	5.6

R

Radio Altimeter	5.4
Radio Altimeter	5.6
Rapid Descent	7.6
Raw Data - (No Flight Director) - ILS.	5.23
Raw Data Monitoring Requirements - Non-ILS	5.43
Recommended Technique for an In-Flight Engine Shutdown	8.11
Reduced and Derated Takeoff Thrust	3.9
Reduced Takeoff Thrust (ATM)	3.9
Reduced Thrust Climb.	4.1
Rejected Landing.	6.11
Rejected Takeoff Decision.	3.13
Rejected Takeoff Maneuver.	3.15
Reverse Thrust Operation - Landing Roll	6.17
RNAV Operations	1.30
RNAV (GPS or GNSS), GPS, LOC, LDA (without GS), LOC (BACK CRS), VOR, or NDB Approach Guide.	5.32
RNAV (GPS or GNSS), GPS, LOC, LDA (without GS), LOC (BACK CRS), VOR, or NDB Approach Guide.	5.38
Roll Modes - Takeoff	3.20
Rotation and Liftoff - All Engines	3.5
Rotation and Liftoff - One Engine Inoperative	3.30
Rudder Trim Technique - Recommended	1.29

DELTA
717 Flight Crew Training Manual

Runaway Stabilizer	8.19
Runway Markings (Typical)	6.5

S

Shutdown Flow Pattern	1.12
Shutdown	6.24
Situations Beyond the Scope of Non-Normal Checklists	8.33
Smoke/Fumes Principles	8.30
Smoke/Fumes Priorities - General	8.30
Smoke/Fumes Priorities	8.30
Smoke/Fumes Priorities	8.31
Speedbrakes	4.42
Stabilizer Trim Inoperative	8.19
Stall Recovery	7.12
Stall Recovery	7.12
Steep Turns	7.17
System Display	1.13

T

Tail Strike	3.18
Takeoff - Adverse Runway Conditions	3.11
Takeoff - Crosswind	3.7
Takeoff - Engine Failure	3.29
Takeoff - Reduced and Derated Takeoff Thrust	3.9
Takeoff Crosswind Guidelines	3.7
Takeoff Profile	3.23
Takeoff Profile	3.26
Takeoff	3.1
Taxi - Adverse Weather	2.24
Taxi - Engine Out	2.11
Taxi - Minimum Radius	2.18
Taxi Flow Pattern	1.6
Taxi Speed and Braking	2.11
Terrain Avoidance	7.18
Threshold Height	6.6
Thrust Use - Taxi	2.9

 DELTA
717 Flight Crew Training Manual

Tire Failure during or after Takeoff	8.24
Traffic Alert and Collision Avoidance System	7.21
Transition to Climb.	4.4
Troubleshooting	8.2
Turbulent Air Penetration.	1.39
Turning Radius Diagrams	2.16

U

Upset Recovery	7.25

V

Visual Aim Point.	6.4
Visual Approach Slope Indicator (VASI/T - VASI)	6.1
Visual Traffic Pattern	5.59

W

Window Damage	8.32
Window(s) Open	8.32
Windshear	7.31