



757

Flight Crew Training Manual

APPROVED BY: _____ (Original signed by)

J. S. Arnold
Senior Technical Pilot - 757

APPROVED BY: _____ (Original signed by)

R. N. Sweeney
Chief Pilot - Flight Training

APPROVED BY: _____ (Original signed by)

L. E. Robert
Chief Pilot - 757

APPROVED BY: _____ (Original signed by)

J. O. Creighton
Chief Pilot - Training, Technical, and Standards

APPROVED BY: _____ (Original signed by)

J. M. Eitel
FAA Principal Operations Inspector

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General

The airplane models listed in the table below are covered in this flight crew training manual.

Model
757-200
757-300

Model numbers are used to distinguish information peculiar to one or more, but not all of the airplanes. Where information applies to all models, no reference is made to individual model numbers.

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Preface
Introduction

Chapter 0
Section 2

General

The Flight Crew Training Manual provides information and recommendations on maneuvers and techniques. The manual is divided into eight chapters: General Information; Ground Operations; Takeoff and Initial Climb; Climb, Cruise, Descent and Holding; Approach and Missed Approach; Landing; Maneuvers; and Non-Normal Operations.

General Information covers procedures and techniques not associated with a particular maneuver or phase of flight. Ground Operations covers information associated with airplane preflight, engine starting and taxi operations to include taxi operations in adverse weather conditions. Chapters 3 through 6 are titled by phase-of-flight and contain information about airplane operations in that phase. The Maneuvers chapter covers maneuvers associated with climb, cruise, and descent, i.e., stall recovery and emergency descent. The Non-Normal Procedures chapter covers non-normal situations that may occur during any phase of flight. Each of the chapters has a preface which describes the chapter in more detail.

It is the responsibility of the individual airline to determine applicability of this manual to its operation.

Any questions about the content or use of this manual can be directed to:

Chief Pilot - Training, Technical, and Standards

Flight Crew Operations

Boeing Commercial Airplane Group

P. O. Box 3707, M/S 14-HA

Seattle, Washington 98124-2207 USA

Airplane Configuration

The Flight Crew Training Manual 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 Airplane 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.



Preface

Abbreviations

Chapter 0

Section 3

Abbreviations

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.

A	
ACT	Active
ADF	Automatic Direction Finder
ADI	Attitude Director Indicator
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)
AGL	Above Ground Level
AH	Alert Height
ALT ACQ	Altitude Acquire
ALT HOLD	Altitude Hold
ANP	Actual Navigational Performance
APU	Auxiliary Power Unit
ASA	Autoland Status Annunciator
ASI	Airspeed Indicator

ASR	Airport Surveillance Radar
A/T	Autothrottle
ATC	Air Traffic Control
ATM	Assumed Temperature Method
B	
B/CRS	Back Course
C	
C	Captain Celsius Center
CG	Center of Gravity
CAA/JAA	Civil Aviation Authority/Joint Aviation Authority
CDU	Control Display Unit
CFIT	Controlled Flight Into Terrain
CLB	Climb
CRT	Cathode Ray Tube
CRZ	Cruise
CWS	Control Wheel Steering
D	
D/D	Direct Descent

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DDG	Dispatch Deviations Guide
DES	Descent
DA(H)	Decision Altitude (Height)
DIR	Direct
DME	Distance Measuring Equipment
E	
EADI	Electronic Attitude Director Indicator
ECON	Economy
EEC	Electronic Engine Control
EFB	Electronic Flight Bag
EGT	Exhaust Gas Temperature
EHSI	Electronic Horizontal Situation Indicator
EICAS	Engine Indication and Crew Alerting System
ENG OUT	Engine Out
EPR	Engine Pressure Ratio
ETOPS	Extended Range Operation With Twin Engine Airplanes
EXT	Extend
F	
F	Fahrenheit
F/D	Flight Director
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FAR	Federal Aviation Regulation

FCC	Flight Control Computer
FMA	Flight Mode Annunciator
FMC	Flight Management Computer
FMS	Flight Management System
FPA	Flight Path Angle
FPM	Feet Per Minute
FPV	Flight Path Vector
G	
GLS	GPS Landing System
GP	Glide Path
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
G/S	Glide Slope
GS	Ground Speed
H	
HAA	Height Above Airport
HDG SEL	Heading Select
HSI	Horizontal Situation Indicator
HUD	Head Up Display
I	
IAF	Initial Approach Fix
IAN	Instrument Approach Navigation
IAS	Indicated Airspeed
IFR	Instrument Flight Rules
IGS	Instrument Guidance System

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ILS	Instrument Landing System
IM	Inner Marker
IMC	Instrument Meteorological Conditions
IP	Instructor Pilot
IRS	Inertial Reference System
IRU	Inertial Reference Unit
ISFD	Integrated Standby Flight Display
K	
K	Knots
KCAS	Knots Calibrated Airspeed
KIAS	Knots Indicated Airspeed
L	
LDA	Localizer-type Directional Aid
LNAV	Lateral Navigation
LOC	Localizer
LRC	Long Range Cruise
M	
MAP	Missed Approach Point
MASI	Mach/Airspeed Indicator
MCP	Mode Control Panel
MCT	Maximum Continuous Thrust
MDA(H)	Minimum Descent Altitude (Height)
MEA	Minimum Enroute Altitude

MEL	Minimum Equipment List
MM	Middle Marker
MMO	Maximum Mach Operating Speed
MOCA	Minimum Obstruction Clearance Altitude
MOD	Modify
MORA	Minimum Off Route Altitude
MSL	Mean Sea Level
N	
ND	Navigation Display
NM	Nautical Mile
NNC	Non-Normal Checklists
NNM	Non-Normal Maneuvers
NPS	Navigation Performance Scales
O	
OM	Outer Marker
P	
PAPI	Precision Approach Path Indicator
PAR	Precision Approach Radar
PF	Pilot Flying
PFD	Primary Flight Display
PI	Performance Inflight
PIP	Product Improvement Package
PMC	Power Management Control
PNF	Pilot Not Flying

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Q	
QRH	Quick Reference Handbook
R	
RA	Radio Altitude Resolution Advisory
RNV	Area Navigation (RNAV)
RNP	Required Navigation Performance
RTO	Rejected Takeoff
RVR	Runway Visual Range
RVSM	Reduced Vertical Separation Minimum
S	
SAT	Static Air Temperature
SDF	Simplified Directional Facility
T	
TE	Trailing Edge
TA	Traffic Advisory
TACAN	Tactical Air Navigation
TCA	Terminal Control Area
TCAS	Traffic Alert and Collision Avoidance System
TO	Takeoff
TOC	Top of Climb
TOD	Top of Descent
TO/GA	Takeoff /Go Around
TR	Traffic Resolution
U	
U.S.	United States
V	

VASI	Visual Approach Slope Indicator
VDP	Visual Descent Point
VEF	Speed at Engine Failure
VFR	Visual Flight Rules
VHF	Very High Frequency
VLOF	Lift Off Speed
VMC	Visual Meteorological Conditions
VMCA	Minimum Control Speed Air
VMCG	Minimum Control Speed Ground
VMO	Maximum Operating Speed
VNAV	Vertical Navigation
VOR	VHF Omnidirectional Range
VR	Rotation Speed
VREF	Reference Speed
V/S	Vertical Speed
VSI	Vertical Speed Indicator
VSD	Vertical Situation Display
V1	Takeoff Decision Speed
V2	Takeoff Safety Speed
W	
WGS-84	World Geodetic system of 1984

**Preface**
Revision Record**Chapter 0**
Section 4**Revision Record**

No.	Revision Date	Date Filed
Initial	December 1, 1999	
2	October 31, 2002	

No.	Revision Date	Date Filed
1	October 31, 2001	
3	October 31, 2003	

General

The Boeing Company issues Flight Crew Training Manual revisions to provide new or revised recommendations on maneuvers and techniques, or information supporting changes in operations manual procedures. Revisions may also incorporate appropriate information from previously issued flight technical bulletins. Revisions reflect the most current information available to The Boeing Company through the subject revision date.

Revisions include 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 Flight Crew Training Manual content.

Pages containing revised technical material have revision bars associated with the changed text or illustration. Editorial revisions (for example, spelling corrections) may have revision bars with no associated highlight.

This revised FCTM is provided in quantities as specified in each operator's contract. Additional copies are available through the Boeing Data and Services Management (DSM) Catalog. The manual is also available in FRAME format for use in airline modification. Advise if information about FRAME format is required.

Filing Instructions

This revision is a complete reprint of the FCTM as indicated on the List of Effective Pages (0.5). Remove all old pages and replace all new pages. Replacement tabs are included with this revision.

Revision Highlights

Chapter 0 - Preface

Section 0 - Table of Contents

0.0.1 - Modified to reflect new chapter organization.

Section 2 - Introduction

0.2.1 - Modified to reflect new chapter organization.

0.2.2 - Added section to clarify the depth of coverage that can be expected in the FCTM and to explain that airplane configuration is presented differently in the FCTM than in the Operations Manual.

Section 3 - Abbreviations

0.3.2 - Added new definitions.

Chapter 1 - General Information

Events Requiring Maintenance Inspection

1.1 - Added guidance about flight events that should be reported to maintenance.

Landing

1.11 - Clarified description of autothrottle operation during wind gusts and turbulence.

1.12 - Modified note concerning setting command speed with tailwind for clarity.

Callouts

1.15 - Added general guidance on deviations from command airspeed or flight path and abnormal instrument indications.

Standard Callouts

1.15 - Modified to display separate tables for ILS and Non-ILS approaches and to optimize use of approach and runway lighting as allowed by regulations.

Electronic Flight Bag (EFB)

1.19 - Added section providing guidance on the use of the electronic flight bag..

Training Flights

1.21 - Modified discussion about extended operation in icing conditions during training flights for clarity.

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Recommended Rudder Trim Technique

1.22 - Modified section for clarity. Identified differences between the primary and alternate techniques and provided more detailed explanation of steps.

FMC Route Verification Techniques

1.24 - Added section on FMC route verification techniques.

Required Navigation Performance (RNP) Operations

1.25 - Modified discussion on RNP values to more clearly describe what the FMC displays.

Manual Flight

1.28 - Simplified callout example to be more practical.

Automatic Flight

1.29 - Modified discussion concerning pilot actions when automatic systems do not perform as expected. Pilot actions may include establishing manual flight, or establishing an intermediate level of automation as the situation dictates.

Chapter 2 - Ground Operations**Preface**

2.1 - Modified to reflect new chapter organization.

Takeoff Briefing

2.1 - Added special engine out departure procedures. Special engine out departure procedures exist at some airports that may differ significantly from the standard instrument departure and may include a requirement to restrict takeoff weight.

Push Back

2.2 - Modified paragraph to more closely follow normal pushback sequence events.

Taxi Speed and Braking

2.5 - Deleted recommendation to use rudder pedal steering only above 20 knots. Operator input indicates that use of the nose wheel steering tiller up to 30 knots is normal on long straight taxi routes.

2.5 - Removed recommendation to avoid use of reverse thrust during landing when above 60 knots. This statement was inconsistent with the landing procedure.



Minimum Radius 180 Degree Turns

2.9 - Modified recommended groundspeed during minimum radius 180 degree turns to "5 knots or less". Nose wheel scrubbing can occur at speeds above 5 knots.

Taxi - Adverse Weather

2.9 - Modified information on use of anti-ice. Anti-ice is used in accordance with Normal and Supplementary Procedures rather than immediately after engine start.

2.10 - Added a section discussing taxi during low visibility conditions.

2.10 - Added section discussing taxi during low visibility.

Chapter 3 - Takeoff and Initial Climb

Preface

3.1 - Modified to reflect new chapter organization.

Initiating Takeoff Roll

3.4 - Modified to clearly indicate that the initial thrust setting is made after the airplane is aligned with the runway centerline and the nose wheel steering tiller is released. Section reorganized for clarity.

3.5 - Modified maximum recommended speed for use of nose wheel steering tiller inputs to 30 knots. Operator input indicates that use of the nose wheel steering tiller up to 30 knots is normal during landing rollout and runway exit.

3.5 - Expanded the discussion concerning the procedural step requiring the captain's hand to be on the thrust levers until V1.

3.6 - Corrected VMCG to V1(MCG) to match AFM and PI section of the QRH.

Rotation and Liftoff - All Engines

3.8 - Modified chapter identification to reflect new chapter organization.

Crosswind Takeoff

3.11 - Added source for crosswind guidelines. Relocated paragraph discussing directional control to section titled Directional Control.

Directional Control

3.12 - Modified section by relocating information about directional control during crosswind takeoff found in earlier paragraphs to this section. Removed reference to maintaining light forward pressure on the control column until 80 knots because this is normal takeoff technique. Corrected VMCG to V1(MCG) to match AFM and PI section of the QRH.

Wind Corrections

3.12 - Modified discussion on V1 corrections to clarify that wind and runway slope corrections are made when performance analysis is not used. Provided a specific QRH reference for corrections.

Gusty Wind and Strong Crosswind Conditions

3.12 - New section added in response to operator questions and a recent tailstrike incident.

Assumed Temperature Method (ATM)

3.13 - Modified order of references for takeoff speeds to place more commonly used references first. Added reference to FPPM.

Fixed Derate (As Installed)

3.14 - Clarified when fixed derate takeoffs are permitted on wet or contaminated runways.

Low Visibility Takeoff

3.14 - Added a section discussing takeoff during low visibility conditions.

Adverse Runway Conditions

3.15 - Modified note to add airport analysis and change "with nacelle anti-ice on" to "with adverse runway conditions". Although a minor correction is made for nacelle anti-ice, the limit weight correction for runway condition is much more significant.

Effect of Deicing/Anti-Icing Fluids on Takeoff

3.15 - Modified discussion to identify specific types of fluids that are applied undiluted and reference lowest operational use temperatures provided by the fluid manufacturer.

Federal Aviation Regulation (FAR) Takeoff Field Length

3.16 - Added reference to autobrakes during operational rejected takeoff.

Rejected Takeoff Decision

3.17 - Corrected reference to the diagram containing the effects of improper RTO execution to match the title of the section containing the diagram.

Rejected Takeoff Maneuver

3.18 - Clarified guidance when the captain is the PNF.

Go/Stop Decision Near V1

3.18 - Removed unnecessary reference to Vef.



Immediate Turn after Takeoff - All Engines

3.23 - Removed reference to climb performance during a turn. The airport analysis does not consider obstacles in all directions.

3.23 - Added a note to consider the possibility of an engine failure that must be considered during flight planning.

Roll Modes

3.24 - Added reference to PIP FMC equipped airplanes that allow LNAV to be armed before takeoff.

Flap Retraction Schedule

3.25 - Clarified maneuver speed language to match language in chapter 1.

3.25 - Adjusted speed column in the Takeoff Flap Retraction Speed Schedule to read VREF30 instead of VREF. All speeds on this schedule are based upon VREF30.

Immediate Turn after Takeoff - One Engine Inoperative

3.28 - Removed reference to climb performance during a turn and added reference to special engine out departure procedures.

Autopilot Engagement - One Engine Inoperative

3.29 - Clarified autopilot engagement criteria.

Chapter 4 - Climb, Cruise, Descent and Holding

Preface

4.1 - Modified to reflect new chapter organization.

Climb

4.1 - Removed section titled Climb thrust. This section contains information located in the Operations Manual and the QRH.

Economy Climb

4.3 - Removed reference to the Maximum Rate Climb Table. If performance data is not available from the FMC, the crew can use speeds shown in the Economy Climb Schedule.

Maximum Altitude

4.5 - Changed reference to flight above maximum altitude to clarify that it is not recommended.

Polar Operations

4.14 - Moved Polar Operations to the end of the Cruise section. This is the normal chapter and section format where special situations follow normal operations.

4.14 - Modified discussion on raw data orientation for clarity.

Descent Rates

4.18 - Added a more specific recommendation on when to complete the Approach checklist for clarity.

Speed Restrictions

4.20 - Removed specific reference to speeds and altitudes in the USA airspace. Paragraph is applicable to worldwide operations.

Procedure Holding

4.21 - Removed discussion about on approach logic. FMC updates have changed on approach logic on some airplanes. Refer to the applicable Operations Manual for correct FMC logic.

Chapter 5 - Approach and Missed Approach

Preface

5.1 - Modified to reflect new chapter organization.

Stabilized Approach Recommendations

5.3 - Changed title to clarify that the stabilized approach information is recommended rather than required.

Landing Minima

5.5 - Expanded explanation of visibility requirements, DA(H), and MDA(H) for clarity.

Determination of a MAP

5.6 - Added section discussing timing requirements during approaches.

Instrument Approach using VNAV

5.7 - Expanded discussion on VNAV approach minimums.

Decision Altitude/Height - DA(H)

5.9 - Added information on applicability of DA(H).

Alert Height - AH

5.9 - Added definition of alert height.

Fail Operational

5.9 - Added definition of fail operational AFDS. Several changes in terminology made throughout the chapter to help clarify fail operational operations.

Fail Passive

5.9 - Added definition of fail passive AFDS.

Procedure Turn

5.10 - Modified for clarity.

Approach

5.13 - Removed the unnecessary restriction to performing a delayed flap approach when in icing condition. Removed reference to approach being stabilized by 500 feet AFE. The approach should be stabilized by 1,000 feet AFE when in IMC.

Decision Altitude/Height - DA(H)

5.13 - Added information on applicability of DA(H).

AFDS Autoland Capabilities

5.14 - Modified wording to clearly indicate that vehicle and aircraft restrictions discussed in the paragraph apply when the RVR is 2,000 or less.

5.16 - Modified discussion about autolands on contaminated runways to add reference to low visibility crosswind limits imposed by controlling regulatory agencies.

Low Visibility Approaches

5.17 - Expanded discussion of low visibility approaches to include information on RVR measuring devices and expanded guidance on use of approach and runway lighting.

AFDS Faults

5.22 - Corrected EICAS message text.

5.22 - Added "as installed" to the Flashing G/S or LOC Indicators to indicate this is an optional feature.

Non-Normal Operations (ILS or GLS)

5.23 - Modified recommendation when to center rudder trim for directional control. The rudder trim should not be centered until the aircraft slows to taxi speed.

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Non - ILS Instrument Approaches - General

- 5.27 - Added general guidance on the advantages of flying a constant angle approach.
- 5.29 - Modified text in accordance with a change to the AFM. Clarified GPS/DME requirements.
- 5.30 - Modified text in accordance with a change to the AFM. Reduced requirement to use HSI VOR mode. Use of the MAP mode enhances situational awareness and allows better use of EGPWS and TCAS displays.
- 5.30 - Added new section discussing FMC use during an RNAV approach.
- 5.32 - Removed specific roll modes and referred to the operations manual procedure.
- 5.33 - Added a named waypoint as a defining point for a missed approach fix on approaches where no GP angle is defined.
- 5.33 - Modified paragraph for clarity.
- 5.33 - Added a note to emphasize that approaches designated for circling only are not VNAV compatible.

Vertical Path Construction

- 5.35 - Added section describing how the FMC builds an instrument approach vertical profile.

Instrument Approach Using VNAV

- 5.39 - Added recommendation to establish pitch mode and configure earlier than the FAF when the FAF is too close to the runway to permit a stabilized approach.
- 5.40 - Added a note to explain VNAV path guidance after passing the missed approach fix.
- 5.40 - Added new section to provide guidance when practicing instrument approaches using VNAV procedures.

Instrument Approach Using V/S

- 5.43 - Added recommendation to establish pitch mode and configure earlier than the FAF when the FAF is too close to the runway to permit a stabilized approach.
- 5.43 - Replaced "missed approach point" and "MDA(H)" with "minimums" to correctly reflect a constant angle approach method.
- 5.44 - Added a named waypoint with an altitude constraint as a point that can be used to identify MDA(H) at or near the VDP.

Minimum Descent Altitude (MDA (H))/ Decision Altitude (DA(H))

5.45 - Expanded discussion on VNAV approach minimums.

5.46 - Added a note to explain VNAV path guidance after passing the missed approach fix.

Visual Descent Point

5.46 - Changed text from "VDP" to "the point where to begin the visual descent" when a VDP is not published.

Obstruction Clearance

5.49 - Added discussion on obstruction clearance during circling approach.

Missed Approach - Circling

5.50 - Modified discussion on initiation of the missed approach for clarity.

Missed Approach/Go-Around - All Engines Operating

5.58 - Modified information about using VNAV during the missed approach for clarity. Added as installed reference to VNAV ALT.

5.58 - Removed word "cruise" because note applies to more than cruise speeds.

Chapter 6 - Landing

Preface

6.1 - Modified to reflect new chapter organization.

Maneuver Margin

6.1 - Removed reference to turbulent flight conditions. These speeds allow full maneuvering capability in all conditions.

6.1 - Modified text to clarify that go-around thrust is required to ensure full maneuver margin with flaps 20 at VREF 30 + 5 during a go-around.

Visual Approach Slope Indicator (VASI/T - VASI)

6.2 - Clarified the description of lighting that should be visible to provide additional wheel clearance.

Three Bar VASI/T - VASI

6.3 - Removed reference to "Low Cockpit Airplanes" and replaced it with "Standard" to match Approach Chart Legend.

VASI Landing Geometry

6.4 - Added reference to long wheelbase to help define the term "high cockpit" which is found in the Aeronautical Information Manual.

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Landing Runway Markings (Typical)

6.8 - Added clarification that runway markings are for runways served by a precision approach.

Threshold Height

6.9 - Reference to recommended callouts from 100 feet when the automatic callouts are not available moved to Chapter 1, Standard Callouts.

Factors Affecting Landing Distance

6.20 - Modified description of actual information contained in the PI section of the QRH.

6.21 - Modified paragraph to clarify that the PI section of the QRH contains advisory information.

Crosswind Landings

6.31 - Removed sentence describing crosswind guidelines source. This information is contained in the first paragraph.

Crosswind Landing Techniques

6.32 - Combined sideslip technique and crab and sideslip technique. Commented on problems associated with these techniques during crosswinds/turbulence. Modified discussion of touchdown in a crab to highlight the problems associated with touchdown using crab only in a strong crosswind on a dry runway.

6.32 - Modified discussion of touchdown in a crab or crab and sideslip to highlight the problems associated with touchdown using crab only in strong crosswinds on a dry runway.

Chapter 7 - Maneuvers**Rudder and Lateral Control**

7.3 - Deleted paragraph about flying the airplane. This information is contained in the Non-Normal Operations chapter.

Rapid Descent

7.5 - Removed reference to the rapid descent being a specialized case in the event of an uncontrollable loss of cabin pressurization. The rapid descent could be accomplished due to other situations such as a medical emergency.

7.5 - Removed reference to engine anti-ice. Use engine or wing anti-ice as required.

Approach to Stall Recovery

7.8 - Removed section about instructor pilot responsibilities. The FCTM is not intended to be an instructional guide.

Attitude Indicator

7.17 - Corrected discussion about precession error to indicate it does not exist rather than it is not apparent.

Terrain Avoidance

7.18 - Removed overboost discussion. This information is being added to the Terrain Avoidance section of the Non-Normal Maneuvers chapter of the QRH.

Resolution Advisory (RA)

7.19 - Deleted note concerning a conflict between RA and air traffic. This information is added as a warning to the Traffic Avoidance maneuver in the QRH.

7.20 - Modified existing text about visual confirmation to a note for emphasis.

Airplane Performance in Windshear

7.25 - Modified paragraph for clarity.

Avoidance, Precautions and Recovery

7.25 - Removed information on windshear avoidance, precautions and recovery. This information is contained in the Operations Manual and QRH.

Chapter 8 - Non-Normal Operations

Approach and Landing on Standby Power

8.4 - Corrected description of thrust reverser availability.

Dual Engine Failure

8.6 - Removed section titled Engine Fire On the Ground. This information is located in the NNC.

Landing on a Flat Tire

8.15 - Modified for clarity and added discussion about taxi with a single tire failure.

Partial or Gear Up Landing

8.16 - Section rewritten for clarity.

Passenger Evacuation

8.18 - Modified to remove steps contained in the NNC and clarify guidance for accomplishing the NNC.



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Flight Path Control

8.24 - Added discussion of control inputs needed to maintain desired ground path after landing.

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Preface

Chapter 0

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General Information

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Preface

This chapter outlines Boeing operational policies used during training. Recommended procedures for Crew Coordination, Flap/Speed Schedule, Thrust Management, Turbulent Air Penetration, and Crew Resource Management are covered. This provides a basis for standardization. Conditions beyond the control of the flight crew may preclude following a maneuver exactly. The maneuvers are not intended to replace good judgment and logic.

Operational Philosophy

The normal procedures are designed for use by trained flight crewmembers. The procedure sequence follows a definitive panel scan pattern. Each crewmember is assigned a flight deck area to initiate action in accordance with Normal and Supplementary Procedures. Non-normal procedural actions and actions outside the crewmembers' area of responsibility are initiated at the direction of the captain.

Non-normal checklists are provided to cope with or resolve non-normal situations on the ground or in flight.

Supplementary Procedures are accomplished as required rather than on each flight sector. They are not included in the Quick Reference Handbook (QRH).

Status messages are checked during preflight to assess acceptability of the airplane for dispatch. After engine start it is not necessary to check the Status page as any message having adverse effect on safe continuation of the flight, requiring crew attention appears as an EICAS alert message. Status messages are checked after engine shutdown to determine if maintenance action should be initiated prior to the next flight.

Events Requiring Maintenance Inspection

During ground or flight operations, events may occur which require a maintenance inspection after flight. Most operators have established a procedure/policy to ensure that aircrews document these events so that proper maintenance can take place.

Chapter 5 of the Airplane Maintenance Manual refers to such events as "Conditional Inspections". These include, but are not limited to:

- hard landing
- severe turbulence
- (landing gear, flap/slat, MMO/VMO) overspeed
- high-energy stop (Refer to the maintenance manual for guidance.)
- lightning strike



- extreme dust
- tail strike
- overweight landing

Additional events, that are not listed in chapter 5 but may require maintenance inspection, should also be reported. An example of such an event is an overly aggressive pitch up during a TCAS event or a Terrain Avoidance maneuver that could cause structural damage. The best course of action is; if in doubt, report it.

Pilot Area of Responsibility

From takeoff to landing the terms PF (pilot flying), and PNF (pilot not flying) are used to define areas of responsibility in lieu of captain/first officer.

Training Objectives

The flight-training program prepares the student for airplane qualification and/or the FAA rating checkride (or equivalent). Flight safety, passenger comfort and operational efficiency are emphasized.

Qualification Requirements (Checkride)

Following satisfactory completion of transition training and when recommended by an authorized instructor, each pilot must satisfactorily demonstrate the ability to perform maneuvers and procedures prescribed in FAA or other applicable governing regulations. Throughout the prescribed maneuvers, command ability and good judgment commensurate with a high level of safety must be demonstrated. In determining whether such judgment has been shown, the evaluator considers adherence to approved procedures, actions based on the analysis of situations, and care and prudence in selecting the course of action.

Evaluation

An evaluation may be given at the end of simulator training. The content of the evaluation varies with the capabilities of the simulator used and the requirements of the governing regulatory agency.

An evaluation in the airplane may be required if the training has not been accomplished under the prescribed requirements of FAA or other applicable governing regulations.

Crew Resource Management (CRM)

Crew resource management is the application of team management concepts and the effective use of all available resources to operate a flight safely. In addition to the aircrew, it includes all other groups routinely working with the aircrew who are involved in decisions required to operate a flight. These groups include, but are not limited to, aircraft dispatchers, flight attendants, maintenance personnel, and air traffic controllers.

Throughout this manual, techniques that help build good CRM habit patterns on the flight deck are discussed. For example, situational awareness and communications are stressed. Situational awareness, or the ability to accurately perceive what is going on in the flight deck and outside the aircraft, requires ongoing questioning, crosschecking, communication, and refinement of perception.

It is important that all flight deck crewmembers identify and communicate any situation that appears unsafe or out of the ordinary. Experience has proven that the most effective way to maintain safety of flight and resolve these situations is to combine the skills and experience of all crewmembers in the decision making process to determine the safest course of action.

Policies on Headphone and Flight Deck Speaker Use

In the airplane, headphones or boom microphones/headsets are worn during takeoff until the top of climb and from the start of descent throughout approach and landing. During cruise, flight deck speakers may be used. Speaker volume should be kept at the minimum usable level adequate to avoid interference with normal crew flight deck conversation, but still assure reception of relevant communications.

Flap Usage

For takeoffs, when conditions permit, consider using larger flap settings to provide shorter takeoff distance. Refer to the Typical Takeoff Tail Clearance table, chapter 2, to determine aft body clearance for different takeoff flap settings.

During maneuvering for an approach, when the situation dictates an earlier than normal speed reduction, the use of flaps 15 or flaps 20 with the gear up is acceptable.

For normal landings, when conditions permit, use flaps 30 to minimize landing speed, landing distance, and maximize ground tail clearance. Flaps 25 provides better noise abatement and reduced flap wear.



Flap - Speed Schedule/Maneuvering Speeds

The flap maneuvering speed schedule provides the recommended maneuvering speed for various flap settings. When recommended maneuvering speeds are followed, the schedule provides margin to stick shaker for at least an inadvertent 15° overshoot beyond the normal 25° angle of bank.

The schedule provides speeds that are close to minimum drag and in climb are close to maximum angle of climb speed. In level flight it provides relatively constant pitch attitudes and requires little change in thrust at different flap settings.

Flap Maneuvering Speed Schedule

The flap maneuvering speed schedule is based upon VREF 30 and provides adequate maneuver margin to stick shaker at all weights.

Flap Position	All Weights
Flaps UP	VREF 30 + 80
Flaps 1	VREF 30 + 60
Flaps 5	VREF 30 + 40
Flaps 15	VREF 30 + 20
Flaps 20	VREF 30 + 20
Flaps 25	VREF 25
Flaps 30	VREF 30

During flap retraction/extension, selecting the next flap setting should be initiated when reaching the maneuver speed for the existing flap position. The airplane should be accelerating when flaps are retracting to the next position. Adequate maneuver margin is retained at a speed 20 knots below the recommended speed for all bank angles up to 30°. During flap extension, selection of the flaps to the next position should be made prior to decelerating below the recommended flap speed for the current flap setting.

For airplanes equipped with an ADI speed tape, the maneuver speed for the existing flap position is indicated by the “F” symbol on the speed tape.

Maneuver Margins to Stick Shaker

The following figures illustrate airplane maneuvering capability or margin to stick shaker as a function of airspeed. This includes an engine inoperative departure scenario (Takeoff) and an all engine approach scenario (Landing).

When reviewing the maneuver margin illustrations, note that:

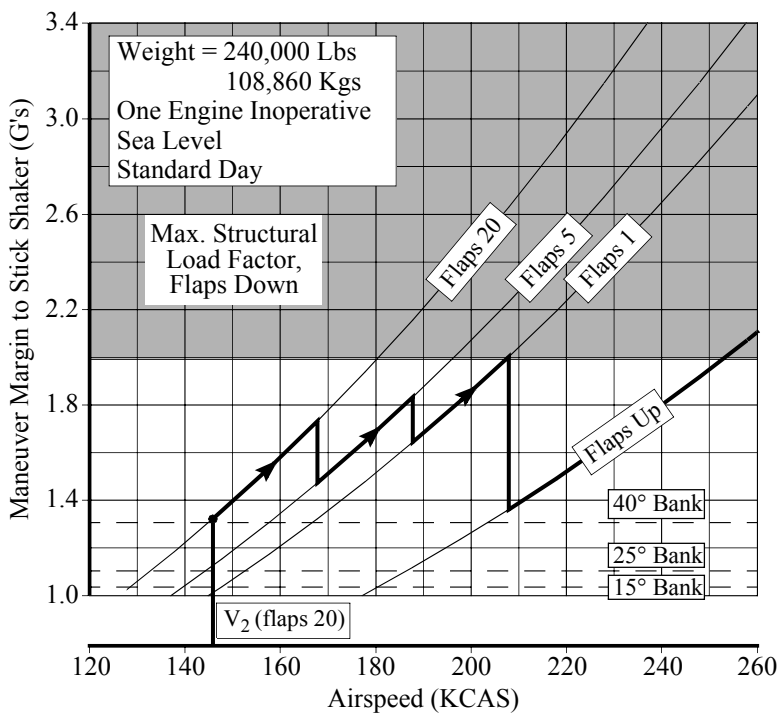
- there is a direct correlation between bank angle and load factor (G's) in level, constant speed flight. For example, 1.1G corresponds to 25° of bank, 1.3G ~ 40°, 2.0G's ~ 60°
- the illustrated bank maneuver capability assumes a constant speed, level flight condition
- stick shaker activates prior to actual stall speed
- the bold line designates flap configuration changes at the scheduled flap transition speeds.

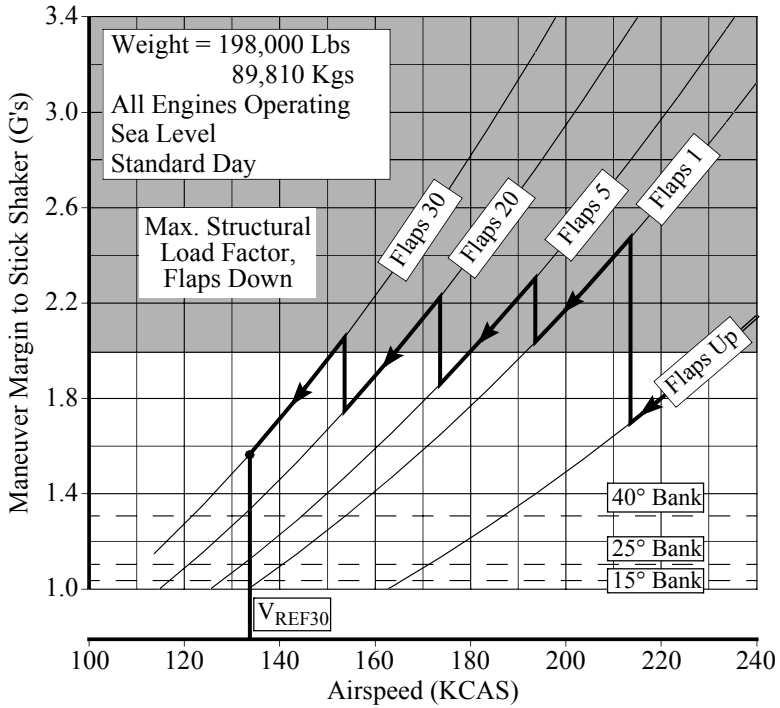
The distance between the bold line representing the flap retraction (Takeoff) or extension schedule (Landing) and a given bank angle represents the maneuver margin between stick shaker and the flap schedule for level constant speed flight. Where the flap extension/retraction schedule extends below a depicted bank angle, stick shaker activation can be expected prior to reaching that bank angle.

The takeoff figures assume a single engine climbout and takes into account the vertical component of the thrust vector of one engine at full power. These figures are an example of a heavy weight, sea level standard day condition. The unshaded region of the chart represents the area within the certified structural load factor for flaps down operation.



Maneuver Margins to Stick Shaker Takeoff
757-200

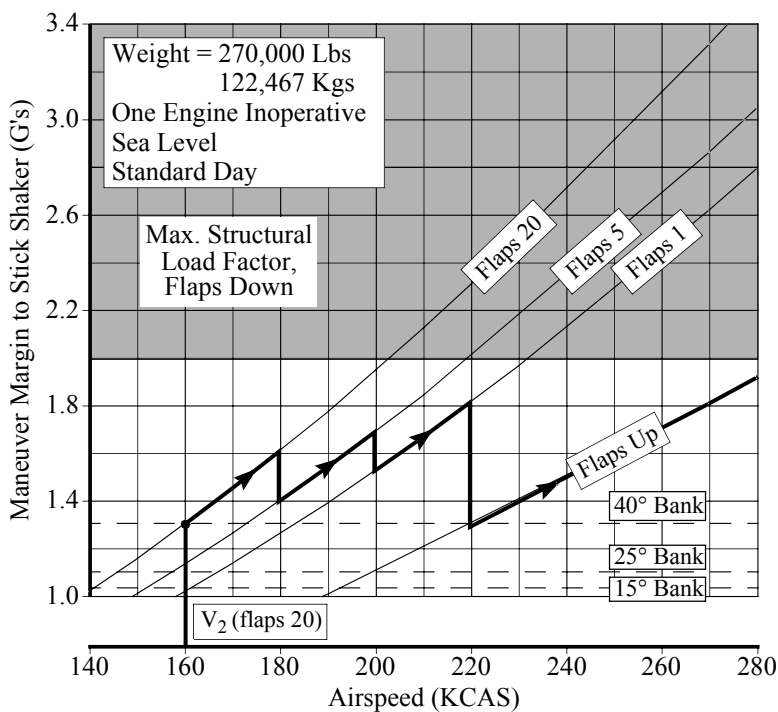


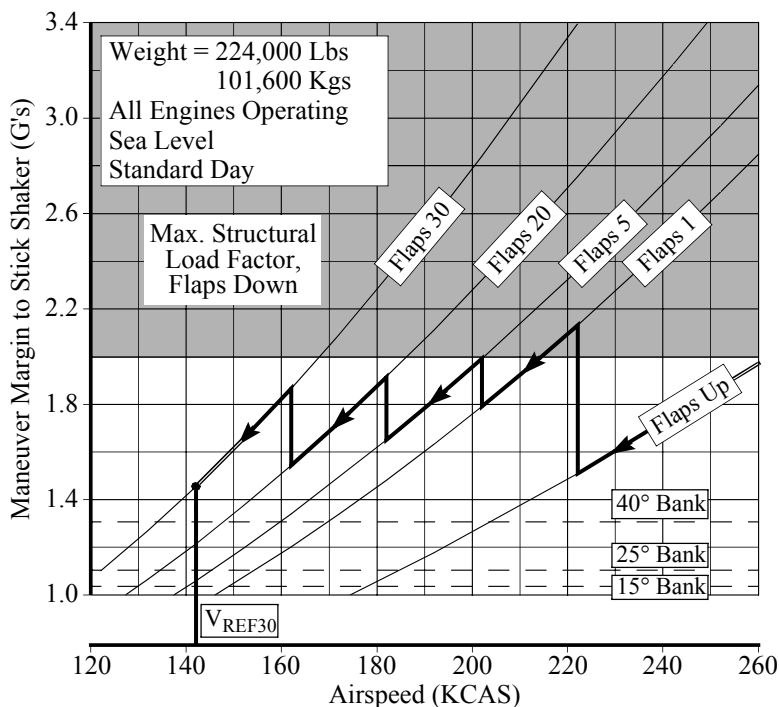
757 Flight Crew Training Manual
Maneuver Margins to Stick Shaker Landing
757-200




Maneuver Margins to Stick Shaker Takeoff

757-300



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Maneuver Margins to Stick Shaker Landing
757-300


Note: With speedbrakes fully extended, flaps up maneuver margin to stick shaker is reduced. Additional airspeed (up to 5 knots) may be added to flaps up maneuvering speed to ensure full maneuver margin (40° bank capability).



Flap Operation

Acceleration Height - All Engines

The altitude selected for acceleration and flap retraction may be specified for each airport. Safety, obstruction clearance, airplane performance or noise abatement requirements are usually the determining factors. Some operators have adopted a single climb profile for all of their operations based on the airport which requires the greatest height for level off to clear a close-in obstacle with an engine failure.

The minimum altitude for flap retraction is 400 feet. Boeing recommends 1000 feet for the standard flap retraction altitude used in training.

Acceleration Height - Engine Out

Acceleration height for a takeoff with an engine failure after V1 is based on accelerating to the recommended flaps up speed while retracting flaps and selecting maximum continuous thrust limits within 5 minutes (10 minutes optional) after initiating takeoff. 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.

At typical training weights, adequate performance exists to climb to 1000 feet before beginning flap retraction. Therefore, during training, 1000 feet is used as the acceleration height for engine failure after V1.

Command Speed

Command speed may be set by the pilot through the MCP or FMC and is displayed by a command airspeed bug on the airspeed indicator. On speed tape equipped airplanes, command speed is displayed by an FMC/MCP command airspeed bug. On PFD airplanes, command speed is displayed by a speed bug on the airspeed display.

Takeoff

Command speed remains set at V2 until changed by the pilot for acceleration or until Flight Level Change (FLCH) or Vertical Navigation (VNAV) is engaged. When using FLCH, increase command speed to the desired speed to initiate acceleration for flap retraction.

Climb, Cruise and Descent

Command speed is set to the appropriate speed by the FMC during VNAV operation or manually using the MCP. The white airspeed bugs (if installed) are positioned to the appropriate airspeeds for approach and landing.

Approach

Command speed is set to the maneuvering speed for the selected flap position by the FMC during VNAV operation or manually using the MCP.

Landing

When using the autothrottle, position command speed to VREF + 5 knots. Sufficient wind and gust protection is available with the autothrottle engaged because the autothrottle is 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.

If the autothrottle is disengaged, or is planned to be disengaged 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. One half of the reported 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°.



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

The minimum command speed setting with autothrottle disconnected is VREF + 5 knots. The gust correction should be maintained to touchdown while the steady headwind correction should be bled off as the airplane approaches touchdown.

Note: Do not apply wind corrections for tailwinds. Set command speed at VREF + 5 knots (autothrottle engaged or disconnected).

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 VREF 20 + 20. When VREF has been adjusted by the non-normal procedure, the new VREF is called the adjusted VREF and becomes the new VREF for landing (adjusted VREF does not include wind corrections). For example, if a non-normal checklist specifies “Use flaps 20 and VREF 30 + 20 for landing”, the flight crew would select flaps 20 as the landing flaps and look up the VREF 30 speed in the FMC or QRH and add 20 knots to that speed.

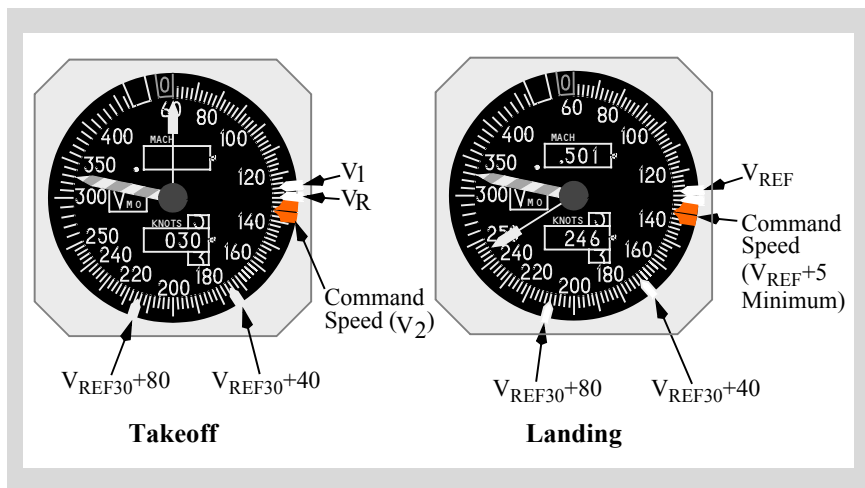
When not using the autothrottle, appropriate wind corrections must be added to the adjusted VREF to arrive at command speed, the speed used to fly the approach. For example, if the checklist states “use VREF 30 + 20 knots”, command speed should be positioned to adjusted VREF (VREF 30 + 20) + wind correction (5 knots minimum, 20 knots maximum).

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Reference Bugs

The following figure shows the positioning of the reference bugs on the airspeed indicator for takeoff and approach.

Bug Setting (MASI)



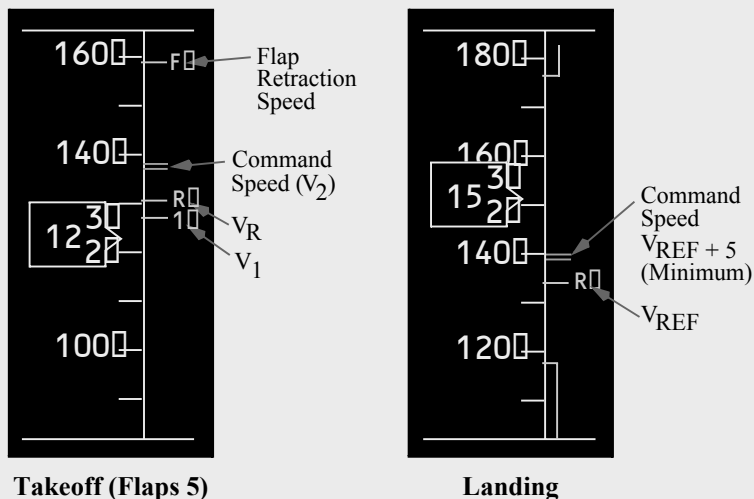
Takeoff

White movable reference airspeed bugs are set at V_1 , V_R , the takeoff flap maneuvering speed ($V_{REF} 30 + 40$ knots) and the flaps up maneuvering speed ($V_{REF} 30 + 80$ knots). Command speed should be set at V_2 using the MCP. V_2 is the minimum takeoff safety speed and provides at least 30° bank capability ($15^\circ + 15^\circ$ overshoot) for all takeoff flaps.

Approach - Landing

Position two white reference airspeed bugs at V_{REF} for landing flaps and single white reference airspeed bug at the flap 5 maneuvering speed ($V_{REF} 30+40$ knots) and flaps up maneuvering speed ($V_{REF} 30+80$ knots).

Bug Setting (EFIS/Speed Tape)



Takeoff

When V₁, V_R and gross weight are entered into the FMC, airspeed bugs are automatically displayed at V₁, V_R and the minimum flap retraction speed “F” for the next flap position. Command speed is set to V₂ using the MCP. V₂ is the minimum takeoff safety speed and provides at least 30° bank capability (15° + 15° overshoot) for all takeoff flaps.

Approach - Landing

V_{REF} is displayed upon entry of landing flaps/speed in the FMC. Command speed is set by the FMC during VNAV or manually by the MCP.

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Callouts

Both crewmembers should be aware of altitude, airplane position and situation.

Avoid nonessential conversation during critical phases of flight, particularly during taxi, takeoff, approach and landing. Unnecessary conversation reduces crew efficiency and alertness and is not recommended when below 10,000 feet MSL / FL100. At high altitude airports, adjust this altitude upward, as required.

The pilot not flying makes callouts based on instrument indications or observations for the appropriate condition. The pilot flying should verify the condition/location from the flight instruments and acknowledge. If the pilot not flying does not make the required callout, the pilot flying should make it.

The pilot not flying calls out significant deviations from command airspeed or flight path. Either pilot should call out any abnormal indications of the flight instruments (flags, loss of deviation pointers, etc.).

One of the basic fundamentals of Crew Resource Management is that each crewmember must be able to supplement or act as a back-up for the other crewmember. Proper adherence to standard callouts is an essential element of a well-managed flight deck. These callouts provide both crewmembers required information about airplane systems and about the participation of the other crewmember. The absence of a standard callout at the appropriate time may indicate a malfunction of an airplane system or indication, or indicate the possibility of incapacitation of the other pilot.

The pilot flying should acknowledge all GPWS voice callouts during approach except altitude callouts while below minimums. If the automatic electronic voice callout is not heard by the flight crew, the pilot not flying should make the callout.

Note: If automatic callouts are not available, the PNF may call out radio altitude at 100 feet, 50 feet and 30 feet (or other values as required) to aid in developing an awareness of eye height at touchdown.

Standard Callouts

	CONDITION / LOCATION	CALLOUT (Pilot Not Flying, unless noted)
Climb And Descent	Approaching Transition Altitude/Transition Level	“TRANSITION ALTITUDE/ LEVEL, ALTIMETERS RESET _____” (in. or mb)
	1000 ft. above/below assigned altitude/Flight Level (IFR)	“1000 FT TO LEVEL OFF”
Descent	10,000 ft. MSL / FL100 (Reduce airspeed if required) (IFR and VFR)	“10,000 / FL100”



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Standard Callouts - ILS Approach

CONDITION / LOCATION	CALLOUT (Pilot Not Flying, unless noted)
First positive inward motion of localizer pointer	“LOCALIZER ALIVE”
First positive motion of Glide Slope pointer	“GLIDE SLOPE ALIVE”
Final approach fix inbound	“OUTER MARKER/FIX, ____ FT”
500 ft. AFE (Check autoland status annunciator, if applicable)	“500 FEET” (F/D or single autopilot approach) Autoland status “LAND 2 or LAND 3 or NO AUTOLAND”
100 ft. above DA(H) (fail passive airplanes)	“APPROACHING MINIMUMS”
Individual sequence flasher lights visible	“STROBE LIGHTS”
At AH (fail operational airplanes) - check autoland status annunciator	“ALERT HEIGHT”
At DA(H) with individual approach light bars visible	“MINIMUMS - APPROACH LIGHTS / RED BARS” (if installed)
At DA(H) - Suitable visual reference established, i.e, PNF calls visual cues	PF: “CONTINUE”
At DA(H) - Suitable visual reference not established, i.e, PNF does not call any visual cues or only strobe lights	PF: “GO AROUND”
At minimums callout - If no response from PF	“I HAVE CONTROL _____” (state intentions)
Below DA(H) - Suitable visual reference established	“THRESHOLD/RUNWAY TOUCHDOWN ZONE”
Below DA(H) - Suitable visual reference established	PF: “LANDING”
Below DA(H) - Suitable visual reference not established, i.e, PNF does not call any visual cues	PF: “GO AROUND”

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Standard Callouts - Non-ILS Approach

CONDITION / LOCATION	CALLOUT (Pilot Not Flying, unless noted)
First positive inward motion of VOR or LOC course deviation indication	“COURSE/LOCALIZER ALIVE”
Final approach fix inbound	“VOR/NDB/FIX”
500 ft. AFE	“500 FEET”
100 ft. above DA(H) or MDA(H)	“APPROACHING MINIMUMS”
Individual sequence flasher lights visible	“STROBE LIGHTS”
At DA(H) or MDA(H) with individual approach light bars visible	“MINIMUMS - APPROACH LIGHTS / RED BARS” (if installed)
At DA(H) or MDA(H) - Suitable visual reference established, i.e, PNF calls visual cues	PF: “CONTINUE”
At DA(H) or MDA(H)- Suitable visual reference not established, i.e, PNF does not call any visual cues or only strobe lights	PF: “GO AROUND”
At minimums callout - If no response from PF	“I HAVE CONTROL _____” (state intentions)
Below DA(H) or MDA(H)- Suitable visual reference established	“THRESHOLD/RUNWAY TOUCHDOWN ZONE”
Below DA(H) or MDA(H)- Suitable visual reference established	PF: “LANDING”
Below DA (H) or MDA(H)- Suitable visual reference not established, i.e, PNF does not call any visual cues	PF: “GO AROUND”

Standard Phraseology

A partial list of recommended words and phrases follows:

Thrust:

- “SET TAKEOFF THRUST”
- “SET GO-AROUND THRUST”
- “SET MAXIMUM CONTINUOUS THRUST”
- “SET CLIMB THRUST”
- “SET CRUISE THRUST”

Flap Settings:

- “FLAPS UP”
- “FLAPS ONE”
- “FLAPS FIVE”
- “FLAPS FIFTEEN”
- “FLAPS TWENTY”
- “FLAPS TWENTY-FIVE”
- “FLAPS THIRTY”

Airspeed:

- “80 KNOTS”
- “V₁”
- “ROTATE”
- “SET ____ KNOTS”
- “SET VREF PLUS (additive)”
- “SET FLAPS ____ SPEED”

Electronic Flight Bag (EFB)

This section provides guidance on the use of the optional Electronic Flight Bag (EFB).

Airport Moving Map

The airport map display is intended to enhance crew positional awareness while planning taxi routes and while taxiing. The system is not intended to replace normal taxi methods including the use of direct visual observation of the taxiways, runways, airport signs and markings and other airport traffic. Prior to taxi, NOTAMS and airport charts (using EFB terminal charts or paper) should be consulted for the latest airport status to include closed taxiways, runways, construction, etc., since these temporary conditions are not shown on the airport map.

Note: Crews must avoid fixation on the display or distraction from primary crew duties while using any EFB application.

Crews must use direct visual observation out flight deck windows as the primary taxi navigation reference. Use the airport Heading-Up or North-Up map to provide enhanced positional awareness by:

- verifying taxi clearance and assisting in determining taxi plan (both pilots)
- monitoring taxi progress and direction (both pilots)
- alerting and updating the pilot taxiing with present position and upcoming turns and required stops (pilot not taxiing).

In flight, the airport North-Up (fixed) fixed map may be used to aid in runway exit planning and anticipating the taxi route to the gate or parking spot.

If one airport map display is inoperative at dispatch, the crewmember with the inoperative display may wish to keep a paper copy of the airport diagram readily available. During taxi in this situation, one pilot should continue to use the airport map display for positional awareness while the other pilot monitors progress on the paper chart. If an airport map display fails after dispatch and no paper backup airport diagrams are available, the crew should consider having the pilot not taxiing provide progressive taxi and positional updates to the pilot taxiing or request progressive taxi instruction from ground control. In any case, the pilot taxiing should always devote primary attention to taxiing the airplane by external visual observation. If the airport map display is inoperative on both sides, use normal taxi procedures.

Note: GPS position must be available to use the Heading-Up map.



Terminal Charts

Electronic terminal charts may be used in place of paper charts. Enroute charts are not available in the EFB at this time. Should the airplane dispatch with one or both displays inoperative, the crew should comply with the provisions of the MEL regarding the use of backup charts.

Airplane Performance

When all appropriate entries are made, the airplane performance application provides runway specific performance information equivalent to AFM-DPI data or airline airport analysis. During approach preparation, the system can provide advisory landing distance information.

Video Surveillance

The video surveillance display may be used at the discretion of the crew to identify individuals requesting flight deck entry or for other airline-specific purposes such as passenger cabin or cargo compartment observation.

Electronic Logbook and Other Documents

The electronic logbook and other electronic documents should be used as defined by operator policy and procedures.

Cold Temperature Altitude Corrections

If the outside air temperature (OAT) is different from standard atmospheric temperature (ISA), barometric altimeter errors result due to non-standard air density. Larger temperature differences from standard result in larger altimeter errors. When the temperature is warmer than ISA, true altitude is higher than indicated altitude. When the temperature is colder than ISA, true altitude is lower than indicated altitude. Extremely low temperatures create significant altimeter errors and greater potential for reduced terrain clearance. These errors increase with higher airplane altitudes above the altimeter source.

Generally, operators should consider altitude corrections when altimeter errors become appreciable, especially where high terrain and/or obstacles exist near airports in combination with very cold temperatures (-30°C/ -22°F or colder). Further, operators should also consider correcting en route minimum altitudes and/or flight levels where terrain clearance is a factor. In some cases corrections may be appropriate for temperatures between 0°C and -30°C.

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Operators should coordinate with local and en route air traffic control facilities for each cold weather airport or route in their system. Coordination should include:

- confirmation that minimum assigned altitudes or flight levels provide adequate terrain clearance for the coldest expected temperatures
- cold weather altitude correction procedures to be used for published procedures, to include the table being used
- a determination of which procedures or routes, if any, that have been designed for cold temperatures and can be flown as published (without altitude corrections).

Pilots should note that for very cold temperatures, when flying published minimum altitudes significantly above the airport, altimeter errors can exceed 1000 feet, resulting in potentially unsafe terrain clearance if no corrections are made.

Operation in Icing Conditions

Boeing airplanes are certified to all applicable airworthiness regulations regarding flight in icing conditions. Operators are required to observe all operational procedures concerning flight in these conditions.

Although the process of certifying jet transport airplanes for operation in icing conditions involves many conservative practices, these practices have never been intended to validate operations of unlimited duration in severe icing conditions. The safest course of action is to avoid prolonged operation in moderate to severe icing conditions.

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Note: If the wing anti-ice is selected on at any time during the flight, the flaps up maneuver margin to stick shaker is reduced. Additional airspeed (up to 5 knots) may be added to flaps up maneuvering speed. This additive ensures full maneuver margin (40° bank capability).

Training Flights

Multiple approaches and/or touch and go landings in icing conditions may result in significant ice accumulations beyond those experienced during typical revenue flights. This may result in fan blade damage as a result of ice accumulation on unheated surfaces shedding into the engines.



Recommended Rudder Trim Technique

This section describes two techniques for properly trimming the rudder. It is assumed that the airplane 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 airplane. 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 should be documented for maintenance. (Refer to the maintenance manual for guidance.)

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, airplane 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 disconnected, the airplane should maintain a constant heading.

The following steps define the primary rudder trim technique:

- set symmetrical thrust
- balance fuel if required

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- ensure the autopilot is engaged in HDG SEL or HDG HOLD 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 top of the control wheel should be used to ensure a level wheel condition. The airplane 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 axis 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 HDG SEL or HDG HOLD 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 airplane is properly trimmed when the bank angle on the bank pointer indicates zero. If the airplane is properly rigged, the control wheel should indicate approximately level. The resultant control wheel condition indicates the true aileron (roll) trim of the airplane being used by the autopilot.

After completing the alternate rudder trim technique, if the autopilot is disengaged the airplane may have a rolling tendency. Hold the wings level using the sky pointer as reference. Trim out any control wheel forces using the aileron trim switches. If properly trimmed, the airplane 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.



Flight Management Computer(s)/CDUs

The Flight Management System provides the crew with navigation and performance information that can result in a significant crew workload reduction. This workload reduction is fully realized when the system is operated as intended, including proper preflight and timely changes in flight. FMC guidance must always be monitored after any in flight changes. In the event flight plan changes occur at inopportune times or in areas of high traffic density, the crew should not hesitate to revert to modes other than LNAV/VNAV.

During preflight, all flight plan or performance related FMC CDU entries made by one pilot must be verified by the other pilot. In flight FMC CDU changes should be made by the pilot not flying and executed only after confirmation by the pilot flying.

FMC Route Verification Techniques

After entering the route into the FMC, the crew should verify that the entered route is correct. There are several techniques that may be used to accomplish this. The crew should always compare:

- the filed flight plan with the airways and waypoints entered on the ROUTE pages
- the computer flight plan total distance and estimated fuel remaining with the FMC-calculated distance to destination and the calculated fuel remaining at destination on the PROGRESS page.

For longer flights and flights that are planned to transit oceanic airspace, the crew should cross-check each leg on the LEGS page with the computer flight plan to ensure that the waypoints, magnetic or true tracks, and distances between waypoints match.

If there is a discrepancy noted in any of the above, correct the LEGS page to match the filed flight plan legs. A cross check of the map display using the plan mode may also assist in verification of the flight plan.

Required Navigation Performance (RNP) Operations

RNP defines navigation accuracy required for a specified route or terminal area procedure. This accuracy is specified in NM (for example RNP 0.3 where the accuracy required is "within 0.3 NM"). RNP values are usually smaller for terminal area procedures (SIDs, STARs, approach transitions, and approaches) than enroute procedures. Small RNP values can require navigation accuracy that is more precise than current VOR/ADF navigation, allowing lower weather minima for departures and/or approaches.

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The FMC can use one of the following as the displayed RNP:

- default RNP - FMC default values are set by the FMC and are displayed if no RNP is available from the navigation data base.
- manually entered RNP - A manually entered RNP remains until changed or deleted. The crew may need to make a manual RNP entry if the RNP for the route or procedure is incorrect.

Note: Future navigation data bases will be capable of providing an RNP for each route or procedure.

Setting a RNP smaller than what is specified for the procedure, airspace, or route, may cause inappropriate crew alerts. Operators should select FMC default values that meet the requirements of their route structure. However, AFM requirements may specify RNPs for certain approaches. (For example, RNP 0.3 is required for GPS approaches).

The FMC calculates its Actual Navigation Performance (ANP) and displays this as ACTUAL. ACTUAL is displayed in NM and specifies the accuracy associated with the FMC position. This accuracy is based on a 95% probability that the FMC position is within the ANP value. This calculation is based on the source of updating (GPS, DME-DME, VOR-DME, LOC-GPS, LOC-DME-DME, LOC VOR-DME, or LOC) and the time since the last update to the FMC position from one of these sources. When the FMC is not updating from one of these sources the indicated mode is INERTIAL. ANP is smaller with more accurate updating sources. GPS updating provides the smallest ANP and the highest position accuracy while INERTIAL updating provides the highest ANP value and the lowest position accuracy.

When the ANP exceeds the RNP a crew alert is provided. When this occurs on a route or terminal area procedure where the RNP is published, the crew should verify position and consider requesting an alternate clearance. This may mean transitioning to a non-RNP procedure or route or transitioning to a procedure or route with a RNP higher than the displayed ANP value.

Crews should note that ANP is only related to the accuracy of FMC position. Lateral deviation from the route or procedural track is indicated by the XTK ERROR (cross-track error) value shown by the FMC. LNAV should be used with the autopilot engaged to minimize cross-track error. Excessive XTK ERROR does not result in a crew alert.



GPS Use in Non-WGS-84 Reference Datum Airspace

In non-WGS-84 airspace, the local datum (position basis) used to survey the navigation data base position information may result in significant position errors from a survey done using the WGS-84 datum. To the pilot, this means that the position of runways, airports, waypoints, nav aids, etc., may not be as accurate as depicted on the map display and may not agree with the GPS position. Operators should consult appropriate sources to determine the current status of airspace in which they operate.

A worldwide survey has been conducted which determined that using the FMC while receiving GPS position updating during SIDS, STARS and enroute navigation meets the required navigation accuracy in non-WGS-84 airspace. This navigation position accuracy may not be adequate for approaches, therefore the airplane flight manual requires the crew to inhibit GPS position updating while flying approaches in non-WGS-84 airspace “unless other appropriate procedures are used.”

Boeing's recommendations for operators are as follows:

- Provided operational approval has been received and measures to ensure their accuracy have been taken, RNAV approaches may be flown with GPS updating enabled. Options available to operators may include surveys of the published approaches to determine if significant differences or position errors exist, developing special RNAV procedures complying with WGS-84 or equivalent, or inhibiting GPS updating.
- For approaches based upon ground-based navigation aids such as ILS, VOR, LOC, NDB, etc., the GPS updating need not be inhibited provided that appropriate raw data is used throughout the approach and missed approach as the primary navigation reference. LNAV and VNAV may be used. As always, when a significant difference exists between the airplane position, raw data course, DME and/or bearing information, discontinue use of LNAV and VNAV. Provided the FMC is not used as the primary means of navigation for approaches, this method can be used as the “other appropriate procedure” in lieu of inhibiting GPS updating.

Operators are encouraged to survey their navigation data bases and have all non-WGS-84 procedures eliminated or modified to WGS-84 standards.

Weather Radar and Terrain Display Policy

Whenever the possibility exists for adverse weather and terrain/obstacles near the intended flight path, one pilot should monitor the weather radar display and the other pilot should monitor the terrain display. The use of the terrain display during night or IMC operations, on departure and approach when in proximity to terrain/obstacles, and at all times in non-radar environments is recommended.

Note: It may be useful to show the terrain display at other times to enhance terrain/situational awareness.



AFDS Procedures

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

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

Autothrottle Use

To simplify thrust setting procedures, autothrottle use is recommended during takeoff and climb in either automatic or manual flight. During all other phases of flight, autothrottle use is recommended only when the autopilot is engaged.

Manual Flight

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

Ensure the proper flight director modes are selected for the desired maneuver. If the flight director commands are not to be followed, it should be turned off.

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 LNAV, VNAV, and instrument approaches using VNAV are some of the reduced workload features. Varied levels of automation are available. The pilot decides what level of automation to use to achieve these goals by selecting the level that provides the best increase in safety and reduced workload.

Note: When the autopilot is in use, the PF makes AFDS mode selections. The PNF may select new altitudes. Both pilots must monitor AFDS mode annunciations and the current FMC flight plan.

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Automatic systems give excellent results in the vast majority of situations. Deviations from expected performance are normally due to an incomplete understanding of their operations 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 airplane will turn outbound in the holding pattern instead of initiating the approach. At this point, the pilot may select HEADING SELECT and continue the approach while using other automated features. A second example, if the airplane levels off unexpectedly during climb or descent with VNAV engaged, FLCH may be selected to continue the climb or descent until the FMC can be programmed.

Early intervention prevents unsatisfactory airplane performance or degraded flight path. Reducing the level of automation as far as manual flight may be necessary to ensure proper control of the airplane is maintained. The pilot should attempt to restore higher levels of automation only after airplane control is assured.

Note: In the event the flight crew overrides the autopilot, the autopilot should be disconnected as soon as practical. Continued flight overriding the autopilot is not recommended.

Recommended Pitch and Roll Modes

If the LEGS page and map display reflect the proper sequence and altitudes, LNAV and VNAV are recommended. If LNAV is not used, use an appropriate roll mode. When VNAV is not used, the following modes are recommended:

FLCH 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 VNAV may induce an excessive workload. If this occurs, use FLCH or V/S as appropriate.

Pilot Incapacitation

Pilot incapacitation occurs frequently compared with other routinely trained non-normal conditions. It has occurred in all age groups and during all phases of flight. Incapacitation occurs in many forms ranging from sudden death to subtle, partial loss of mental or physical performance. Subtle incapacitations are the most dangerous and they occur the most frequently. Incapacitation effects can range from loss of function to unconsciousness or death.



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The key to early recognition of pilot incapacitation is the regular use of crew resource management concepts during flight deck operation. Proper crew coordination involves checks and crosschecks using verbal communications. Routine adherence to standard operating procedures and standard profiles can aid in detecting a problem. Suspicion of some degree of gross or subtle incapacitation should also be considered when a crewmember does not respond to any verbal communication associated with a significant deviation from a standard procedure or standard flight profile. Failure of any crewmember to respond to a second request or a checklist response is cause for investigation.

If you do not feel well, let the other pilot know and let that pilot fly the airplane. During flight, crewmembers should also be alert for incapacitation of the other crewmember.

Crew Action Upon Confirming Pilot Incapacitation

If a pilot is confirmed to be incapacitated, the other pilot shall take over the controls and check the position of essential controls and switches.

- an emergency should be declared and the autopilot engaged to reduce workload
- after ensuring the airplane is under control, engage the autopilot and use the cabin crew (if available). When practical, try to restrain the incapacitated pilot and slide the seat to the full-aft position. The shoulder harness lock may be used to restrain the incapacitated pilot
- flight deck duties should be organized to prepare for landing
- consider using help from other pilots or crewmembers aboard the airplane.

Turbulent Air Penetration

Severe turbulence should be avoided if at all possible. However, if severe turbulence is encountered, use the turbulent air penetration procedure listed in the Operations Manual. Turbulent air penetration speeds provide high/low speed maneuver 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. Set ignition as directed by the operations manual. Flap extension in an area of known turbulence should be delayed as long as possible because the airplane can withstand higher gust loads with the flaps up.

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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.



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Ground Operations
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Preface

This chapter outlines the recommended operating practices and techniques during ground operations, including pushback, engine start and taxi. Taxi operations during adverse weather are also addressed. The recommended operating practices and techniques discussed in this chapter improve crew coordination, enhance safety and provide a basis for standardization.

Takeoff Briefing

The takeoff briefing shall be accomplished as soon as practical so as not to interfere with the final takeoff preparations.

The takeoff briefing is a description of the departure flight path with emphasis on anticipated track and altitude restrictions. It assumes normal operating procedures are used. Therefore, it is not necessary to brief normal or standard takeoff procedures. Additional briefing items may be required when any elements of the takeoff and/or departure are different from those routinely used. These may include:

- adverse weather
- adverse runway conditions
- unique noise abatement requirements
- dispatch using the minimum equipment list
- special engine out departure procedures (if applicable)
- any other situation where it is necessary to review or define crew responsibilities.

Push Back

Each operator should develop specific pushback procedures and policy which are tailored for their specific operations. The flight operations and maintenance departments need to be primary in developing these procedures.

Pushbacks present a serious hazard to ground personnel. There have been many accidents where personnel were run over by the airplane wheels during the pushback process.

Pushback or towing involves three phases:

- positioning and connecting the tug and tow bar
- moving the airplane
- disconnecting the tow bar.

Proper training of both pilots and ground maintenance and good communication between the flight deck and ground personnel is essential for a safe pushback operation.

The headset operator, who is walking in the vicinity of the nose wheel, is usually the person injured or killed in the majority of the accidents. Procedures that do not have personnel in the vicinity of the nose wheels are key to reducing the possibility of these type accidents.

Note: Pushback or tow out is normally accomplished with all hydraulic systems pressurized and the nose wheel steering locked out.

The captain should ensure that all appropriate checklists are completed prior to airplane movement. All passengers should be in their seats, all doors closed and all equipment away from the airplane. After tow tractor and tow bar have been connected obtain a pushback clearance from ground control. Engine start may be accomplished during the pushback or delayed until the pushback is completed. Ground personnel should be on headset to observe and communicate to the flight crew any possible safety hazards.

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

Backing with Reverse Thrust

Backing with reverse thrust is not recommended and may be prohibited by the AFM.

Taxi

Taxi General

An airport diagram should be kept in a location readily available to both crewmembers during taxi. The following guidelines aid in conducting safe and efficient taxi operations:

Prior to Taxi

- both pilots verify the correct airplane parking position is entered into the FMC
- brief applicable items from airport diagrams and related charts
- ensure both crewmembers understand the expected taxi route
- write down the taxi clearance when received.

During Taxi

- progressively follow taxi position on the airport diagram
- during low visibility conditions, call out all 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 written clearance or with ATC. Stop the airplane if the clearance is in doubt
- when ground/obstruction clearance is in doubt, stop the airplane and 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
- verify the runway is clear (both directions) and clearance is received prior to entering a runway
- be constantly aware of the equipment, structures, and aircraft behind the airplane when the engines are above idle thrust
- consider using the taxi light to visually indicate movement
- at night use all appropriate airplane lighting
- when entering any active runway ensure the exterior lights specified in the operations manual are illuminated

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 company communications until clear of all runways.

Flight Deck Perspective

There is a large area near the airplane 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.

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. Airplane response to thrust lever movement is slow, particularly at high gross weights. Engine noise level in the flight deck is low and not indicative of thrust output. Idle thrust is adequate for taxiing under most conditions. A slightly higher thrust setting is required to begin taxiing. Allow time for airplane response before increasing thrust further.

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

Taxi Speed and Braking

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

The airplane 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.

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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 tiller 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.

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

When the airplane is equipped with steel brakes, avoid prolonged brake application to control taxi speed as this causes high brake temperatures and increased wear of brakes. If taxi speed is too high, reduce speed with a steady brake application and then release the brakes to allow them to cool. Braking to approximately 10 knots and subsequent release of the brakes results in less heat build-up in the tires and brakes than when the brakes are constantly applied.

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.

Note: During taxi, the use of reverse thrust above reverse idle is not recommended due to the possibility of foreign object damage and/or engine surge. Idle reverse thrust may be necessary on slippery surfaces to control speed while taxiing.

Carbon Brake Life

Brake wear is primarily dependent upon the number of brake applications. For example, one firm brake application causes less wear than several light applications. Continuous light applications of the brakes to keep the airplane from accelerating over a long period of time (riding the brakes) to maintain a constant taxi speed produces more wear than proper brake application.

During taxi, proper braking should involve a steady application of the brakes to decelerate the airplane. Release the brakes as lower speed is achieved. After the airplane accelerates, repeat the braking sequence.

Antiskid Inoperative

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



Tiller/Rudder Pedal Steering

The captain's and first officer's (if installed) positions are equipped with a tiller steering control. The tiller is used to turn the nosewheel through the full range of travel at low taxi speeds. Maintain a positive pressure on the tiller at all times during a turn to prevent the nose wheel from abruptly returning to center. Rudder pedal steering turns the nose wheel through a limited range of travel. Straight ahead steering and large radius turns may be accomplished with rudder pedal steering.

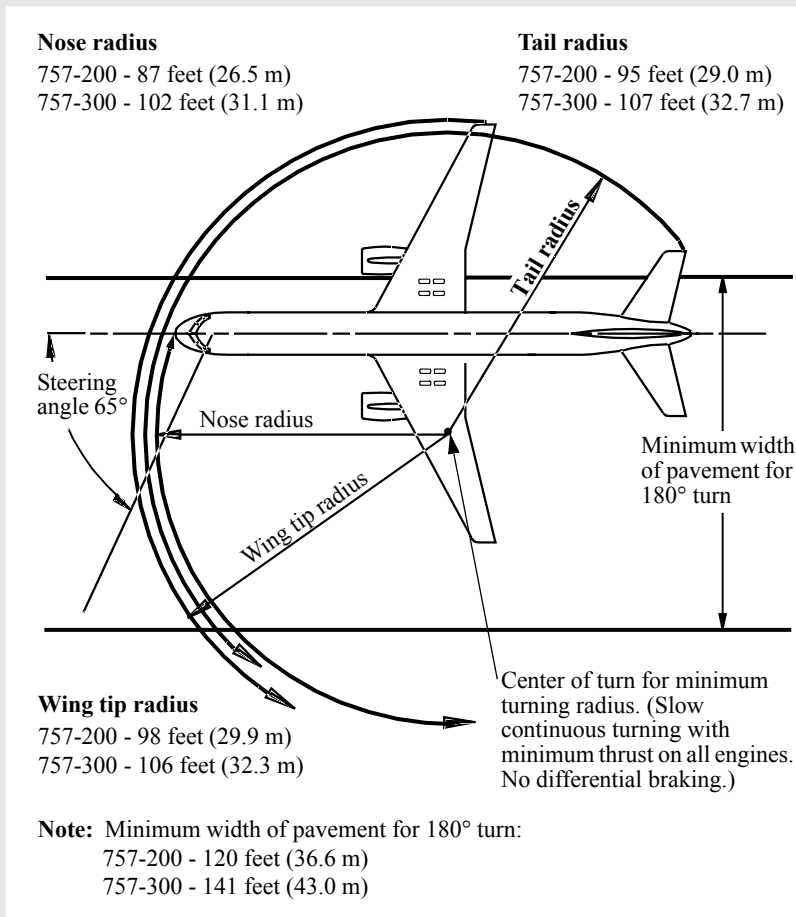
If nose wheel “scrubbing” occurs while turning, reduce steering angle and/or taxi speed. Avoid stopping the airplane in a turn as excessive thrust is required to start taxiing again.

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 wheel and allow the airplane to roll straight ahead. This relieves stresses in the main and nose gear structure prior to stopping.

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Turning Radius

The wing tip of the 757-200 and the tail of the 757-300 (not shown in the drawing below) swing the largest arcs while turning and determine the minimum obstruction clearance path. All other portions of the airplane structure remain within these arcs.



CAUTION: Do not attempt to make a turn away from an obstacle within (15 feet/4.6 m) of the wing tip for the 757-200, or (16 feet/4.9 m) for the 757-300, or within (26 feet/7.9 m) of the nose for the 757-200, or (20 feet/6.1 m) for the 757-300.



Visual Cues and Techniques for Turning while Taxiing

The following visual cues assume the pilot’s seat is adjusted for proper 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 tiller required for each turn. Except for turns less than approximately 30°, speed should be 10 knots or less prior to turn entry. For all turns, keep in mind the main gear are located behind the nose wheels, which causes them to track inside the nose wheels during turns. The pilot position forward of the nose wheel and main gear is depicted in the table below.

Model	Pilot Seat Position (forward of nose gear) feet (meters)	Pilot Seat Position (forward of main gear) feet (meters)
757 - 200	12 (3.7)	72 (22)
757 - 300	12 (3.7)	85 (25.9)

Turns less than 90 degrees

Use a technique similar to other large airplanes: 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 as the intersecting taxiway centerline (or intended exit point) approaches the aft edge of the number 2 window. Initially use approximately full nose wheel steering tiller displacement. Adjust the tiller input as the airplane 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 tiller input as the airplane lines up with the intersecting taxiway centerline or intended taxi path.

Minimum Radius 180 Degree Turns

Coordination with ATC and ground support personnel may be required to complete the operation safely. In some cases (for example: heavy weight, pilot uncertainty of runway and/or taxiway edge margins, nearby construction, vehicles, etc.), towing the airplane to the desired location may be the safest option.

If a minimum radius 180° turn is necessary, a ground crew should be used to monitor the wheel path and provide relevant information to the flight crew. 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 also be aware of the area directly behind the airplane as well as the area being swept by jet blast during the turn.

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Approach the edge of the taxi surface at a shallow angle until the outboard side of the main gear wheels are near the edge. The lower outboard corner of the pilot's number 1 window is a good visual reference for the outboard side of the main gear wheels on the same side. The lower inboard corner of the pilot's number 1 window is also a good reference for the opposite side main gear wheels.

Turning radius during 180° turns can be reduced with lower engine thrust and less nose gear tire wear by following a few specific taxi techniques. Taxi the airplane so that the main gear tires are as close as possible to the runway edge. This provides more runway surface to make the turn. Stop the airplane completely with the thrust at idle. Stopping the airplane in a turn is not normally recommended due to higher nose landing gear loads and the increased thrust required to start the airplane moving again. However, since a minimum radius turn is generally beyond the scope of normal taxi operations, it can be treated as a special case. Hold the tiller 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 knots or less during the turn to minimize turn radius. Light intermittent braking on the inside main gear helps decrease turn radius. As the airplane passes through 90° of turn, gradually reduce the tiller input as required to align the airplane with the new direction of taxi. These actions result in a low speed turn and less runway being used. Wind, slope, runway or taxiway surface conditions, and center of gravity may also affect the turning radius.

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 airplane momentum through the turn. 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.

During cold weather operations, nose gear steering should be exercised in both directions during taxi. This circulates warm hydraulic fluid through the steering cylinders and minimizes the steering lag caused by low temperatures. If icing conditions are present, use anti-ice as required by operations manual procedures.



During prolonged ground operation, periodic engine run-up should be accomplished to minimize ice build-up. These engine run-ups should be performed as defined in the operations manual.

Engine exhaust may form ice on the ramp and takeoff areas of the runway, or blow snow or slush which may freeze on airplane surfaces. If the taxi route is through slush or standing water in low temperatures, or if precipitation is falling with temperatures below freezing, taxi with flaps up. Extended or prolonged taxi times in heavy snow may necessitate de-icing prior to takeoff.

To reduce the possibility of flap damage after making an approach in icing conditions or landing on a runway covered with snow or slush, do not retract the flaps until the flap area has been checked free of debris by maintenance.

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 1200ft (350m) RVR are required to have a low visibility taxi plan.

Taxi - One Engine

Because of additional operational procedural requirements and crew workload, taxiing out for flight with an engine shut down is not recommended. High bypass engines require warm up prior to applying takeoff thrust and cool down prior to shutting down. If the engine has been shut down for several hours, it is desirable to operate at as low a thrust setting as practical for several minutes prior to takeoff.

If taxiing in after landing with an engine shut down, the crew must be aware of systems requirements, (hydraulics, brakes, electrical). If possible, make minimum radius turns in a direction that puts the operating engine on the outside of the turn. In operational environments such as uphill slope, soft asphalt, high gross weights, congested ramp areas, and wet/slippery ramps and taxiways, taxi with both engines operating.



Takeoff and Initial Climb

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Preface

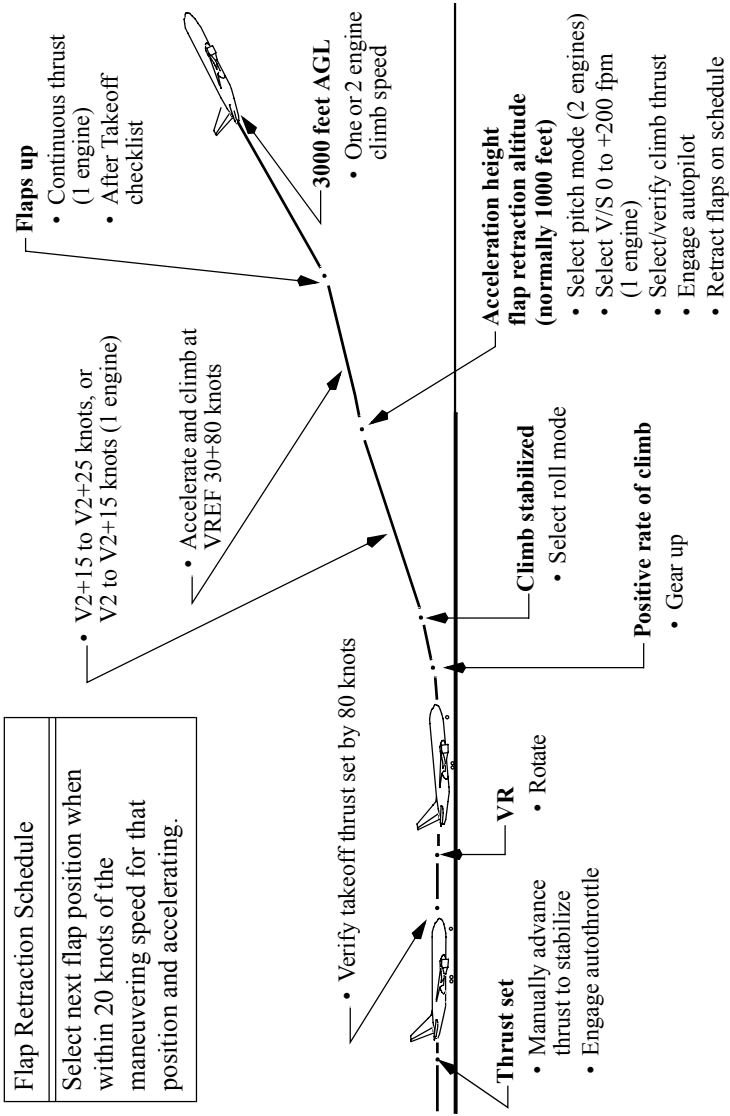
This chapter outlines the recommended operating practices and techniques for takeoff, and initial climb. Engine failure during takeoff/initial climb is also addressed. The discussion portion of each illustration highlights important information.

The flight profile illustrations represent the recommended basic configuration during the accomplishment of the flight maneuvers, and provides a basis for standardization and crew coordination.



Takeoff

Takeoff Profile



Takeoff - General

Normal takeoff procedures satisfy typical noise abatement requirements. Some airports may have special procedures which require modification of the takeoff profile.

As part of the before start procedure, review the TAKEOFF REF page to ensure the entries are correct and the preflight is complete. Ensure V2 is set on the MCP. The map display, map range and LEGS page sequence should be consistent with the departure procedure.

Review the LEGS page for any climb constraints. Ensure the CLB page contains the appropriate altitude and airspeed restriction consistent with the departure procedure.

Note: Some airplanes require display of secondary engine instruments during takeoff. If the vibration display is not required by the operations manual, the lower center EICAS display is normally blank for takeoff to reduce display of unnecessary information.

Although flaps up speed to 3,000 feet is generally recommended for noise abatement reasons, it may not be required except at heavy weights. At lighter weights the performance of the airplane is such that 3,000 feet is usually reached before flap retraction is complete.

The pilot flying should normally display the TAKEOFF REF or CLB page. To reduce heads down activity, climb constraint modification immediately after takeoff should normally be accomplished on the mode control panel. Modify the CLB page when workload permits. The pilot not flying should display the LEGS page of the FMC for departure to allow timely route modification if necessary.

Thrust Management

The Electronic Engine Control (EEC) simplifies thrust management procedures. Having the EEC functioning does not relieve the pilots from monitoring the engine parameters and verifying proper thrust is obtained.

High thrust settings from jet engine blast over unpaved surfaces or thin asphalt pavement intended only to support occasional aircraft movements can cause structural blast damage from loose rocks, dislodged asphalt pieces, and other foreign objects. Ensure run ups and takeoff operations are only conducted over well maintained paved surfaces and runways.



Initiating Takeoff Roll

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

Note: If a possibility exists of a windshear being encountered on takeoff, flight directors should be turned off for airplanes not equipped with a windshear warning system.

A rolling takeoff procedure is recommended for setting takeoff thrust. It expedites takeoff and reduces 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.

Rolling takeoffs are accomplished in two ways:

- if cleared for takeoff prior to or while entering the runway, maintain normal taxi speed. When the airplane is aligned with the runway centerline ensure the nose wheel steering tiller is released and apply takeoff thrust by advancing the thrust levers to approximately 1.1 EPR. Allow the engines to stabilize momentarily then promptly advance the thrust levers to takeoff thrust (autothrottle EPR or THR). There is no need to stop the airplane prior to adding thrust.
- if holding in position on the runway, ensure the nose wheel steering tiller is released, release brakes, then apply takeoff thrust as described above.

Note: Brakes are not normally held with thrust above idle unless a static run-up is required in icing conditions.

A standing takeoff procedure may be accomplished by holding the brakes until the engines are stabilized, ensure the nose wheel steering tiller is released, then release the brakes and promptly advance the thrust levers to takeoff thrust (autothrottle EPR or THR).

Allowing the engines to stabilize 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.

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

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

If thrust is to be set manually, smoothly advance thrust levers toward takeoff thrust. Final thrust adjustments should be made, with reference to the digital readouts, by 80 knots.

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During takeoff, if an engine exceedance occurs after thrust is set and the decision is made to continue the takeoff, do not retard the thrust lever in an attempt to control the exceedance. Retarding the thrust levers after thrust is set invalidates takeoff performance. When the PF judges that altitude (minimum 400 feet AGL) and airspeed are acceptable, the thrust lever should be retarded until the exceedance is within limits and the appropriate NNC accomplished.

Use of the nose wheel steering tiller is not recommended above 30 knots. However, pilots must use caution when using the nose wheel steering tiller above 20 knots to avoid over-controlling the nose wheels resulting in possible loss of directional control. Limited circumstances such as inoperative rudder pedal steering may require the use of the nose wheel steering tiller at low speeds during takeoff and landing when the rudder is not effective. Reference the airplane Dispatch Deviations Guide (DDG) for more information concerning operation with rudder pedal steering inoperative.

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

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

The pilot not flying should monitor engine instruments and both primary and standby airspeed indications during the takeoff roll and announce any abnormalities. The pilot not flying should announce passing 80 knots and the pilot flying should verify that his airspeed indicator is in agreement. The pilot not flying should verify that takeoff thrust has been set and the throttle hold mode (THR HOLD) is engaged.

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. If there are any questions, another source of speed information is the ground speed indication. Early recognition of a malfunction is important in making a sound go/stop decision. Refer to the unreliable airspeed section in chapter 6 for an expanded discussion of this subject.

Note: Once THR HOLD annunciates, the A/T cannot change thrust lever position, but thrust levers can be positioned manually. Takeoff into headwind of 20 knots or greater may result in THR HOLD before the autothrottle can make final thrust adjustments.

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This mode protects against thrust lever movement if a system fault occurs. Lack of the THR HOLD annunciation means the protective feature may not be active. If THR HOLD annunciation does not appear, no crew action is required unless a subsequent system fault causes unwanted thrust lever movement. As with any autothrottle malfunction, the autothrottles should then be disconnected and desired thrust set manually.

The THR HOLD mode remains engaged until another thrust mode is selected.

If full thrust is desired when THR HOLD mode is displayed, the thrust levers must be manually advanced. When making a V1(MCG)-limited takeoff, do not exceed the fixed derate thrust limit except in an emergency.

After the airplane is in the air, pushing a GA switch advances the thrust to maximum available thrust and GA is annunciated.

Rotation and Liftoff - All Engines

Takeoff speeds are established based on minimum control speed, stall speed, and tail clearance margins. Shorter bodied airplanes are normally governed by stall speed margin while longer bodied airplanes 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 QRH, airport analysis, or FMC, are adjusted to provide adequate tail clearance.

Above 80 knots, relax the forward control column pressure to the neutral position. For optimum takeoff and initial climb performance, initiate a smooth continuous rotation at VR toward 15° of pitch attitude. After liftoff use the flight director as the primary pitch reference cross checking indicated airspeed and other flight instruments.

Note: Do not adjust takeoff speeds or rotation rates to compensate for increased body length.

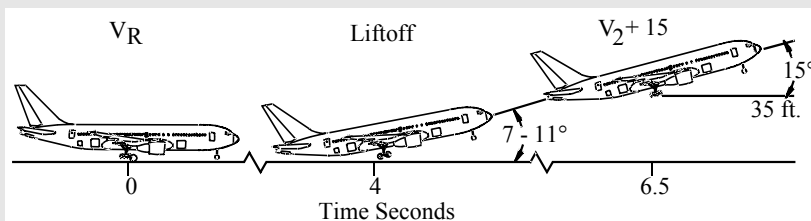
With a consistent rotation technique, where the pilot uses approximately equal control forces and similar visual cues, the resultant rotation rate differs slightly depending upon airplane body length.

Using the technique above, liftoff attitude is achieved in approximately 4 seconds. Resultant rotation rates vary from 2 to 2.5 degrees/second with rates being lowest on longer airplanes.

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

Typical Rotation, All Engines

The following figure shows typical rotation with all engines operating.



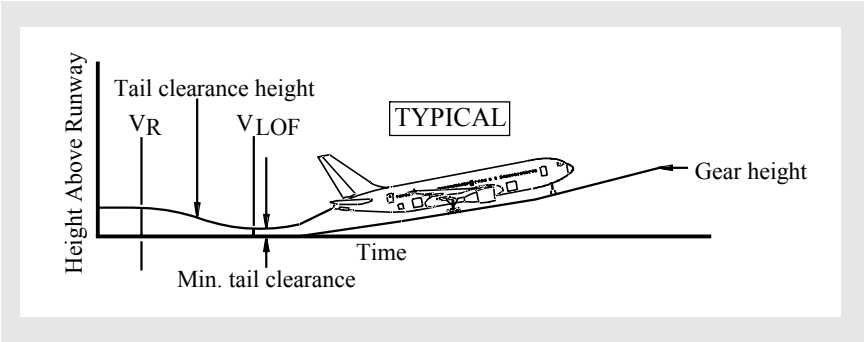
Retract the landing gear after a positive rate of climb is indicated on the altimeter. Retract flaps in accordance with the technique described in this chapter.



Typical Takeoff Tail Clearance

The following diagram and table show the effect of flap position on liftoff pitch attitude and aft fuselage clearance during takeoff. Additionally, the last column shows the pitch attitude for aft fuselage contact with wheels on runway and landing gear struts extended. For a discussion of tail strike procedures see chapter 8 and the Operations Manual.

Note: Use of flap 1 as a takeoff flap setting is restricted to airplanes delivered with this capability or to airplanes having flap 1 installed as a takeoff flap setting.



Model	Flap	Liftoff Attitude (degrees)	Minimum Tail Clearance inches (cm)	Tail Strike Pitch Attitude (degrees)
757-200	1	10.3	30 (76)	12.3
	5	10.0	33 (84)	
	15	9.5	38 (97)	
	20	8.5	47 (119)	
757-300	5, 15, 20	7.5	26 (66)	9.5

Note: Flaps 1 (-200) takeoffs have the least clearance. Consider using a larger flap setting for takeoffs at light gross weights.

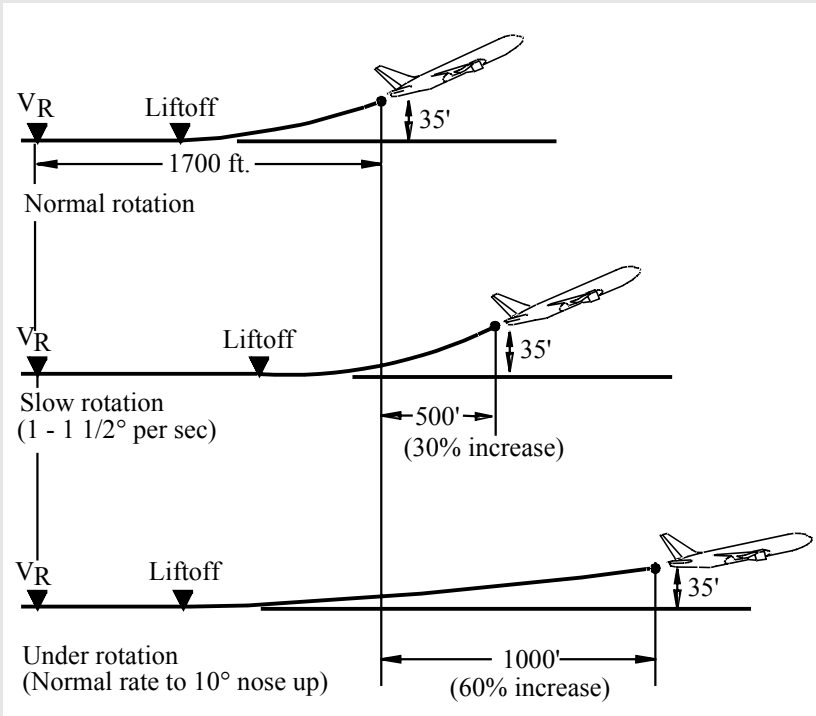
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Effect of Rotation Speed and Pitch Rate on Liftoff

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. If the rotation is delayed beyond $V_2 + 15$, the speed commanded by the flight director is rotation speed up to a maximum of $V_2 + 25$. An earlier liftoff does not affect the commanded initial climb speed, however, either case degrades overall takeoff performance.

Slow or Under Rotation (Typical)





Center-Of-Gravity (C.G.) Effects

When taking off at light weight and with an aft C.G., the combination of full thrust, rapid thrust application, and sudden brake release may tend to pitch the nose up, reducing nosewheel steering effectiveness. With C.G. 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 C.G., use of reduced thrust and rolling takeoff technique is recommended whenever possible.

■ The rudder becomes effective between 40 and 60 knots.

Crosswind Takeoff

The crosswind guidelines shown below were derived through flight test data and engineering analysis.

Note: Engine surge can occur with a strong crosswind component if takeoff thrust is set prior to brake release. Therefore, the rolling takeoff procedure is strongly advised when crosswind exceeds 20 knots.

Takeoff Crosswind Guidelines

Crosswind guidelines are not considered limitations. Crosswind guidelines are provided to assist operators in establishing their own crosswind policies.

Takeoff crosswind guidelines are based upon the most adverse airplane loading (light weight and aft center of gravity) and assume an engine out RTO. On slippery runways, crosswind guidelines are a function of runway surface condition, and assume proper pilot technique.

Runway Condition	Crosswind – Knots*
Dry	40
Wet	25
Standing Water/Slush	15
Snow - No Melting **	20
Ice - No Melting **	15

*Winds measured at 33 feet (10 m) tower height and apply for runway 148 feet (45m) or greater in width.

** Takeoff on untreated ice or snow should only be attempted when no melting is present.



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 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 can have an adverse effect on directional control near V₁(MCG) due to the additional drag of the extended spoilers.

Note: During wet and slippery runway conditions, the PNF should give special attention to assuring the engines have symmetrically balanced thrust indications.

Wind Corrections

Wind corrections are not made to VR and V₂ speeds. If airport analysis is not used, V₁ must be corrected for headwind or tailwind components and runway slope in accordance with the PI section of the QRH.

Rotation and Takeoff

Maintain wings level throughout the takeoff roll by applying control wheel displacement into the wind. During rotation continue to apply control wheel in the displaced position to keep the wings level during liftoff. The airplane 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.

Gusty Wind and Strong Crosswind Conditions

For takeoff in gusty or strong crosswind conditions, maximum takeoff thrust is recommended. This maximizes available runway and minimizes the airplane exposure to gusty conditions during the rotation and takeoff maneuver.

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Avoid rotation during a gust. If a gust is experienced near VR, as indicated by stagnant airspeed or rapid airspeed acceleration, momentarily delay rotation. This slight delay allows the airplane 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 may cause spoilers to rise which has the effect of reducing tail clearance limits. All of these factors provide maximum energy to accelerate through gusts while maintaining tail clearance margins at liftoff. The airplane 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 Thrust Takeoff

Many operators use reduced thrust takeoff whenever performance limits and noise abatement procedures permit. Thrust reduction or derate lowers EGT and extends engine life.

Assumed Temperature Method (ATM)

This method achieves a takeoff thrust less than the full rated takeoff thrust by using an assumed temperature that is higher than the actual temperature. The maximum thrust reduction authorized by most regulatory agencies is 25% below any certified rating. Use the takeoff speeds provided by the airport analysis, FMC (if available), QRH (PI chapter), Flight Planning Performance Manual (FPPM), AFM, or other approved sources corresponding to the assumed (higher) temperature.

The thrust setting parameter (EPR/N1) is not considered a limitation. If conditions are encountered during the takeoff where additional thrust is desired, such as windshear or temperature inversion, the crew should not hesitate to manually advance thrust levers to maximum rated thrust.

Do not use the ATM if conditions exist that affect braking such as a runway contaminated by slush, snow, standing water, or ice, or if potential windshear conditions exist. ATM procedures are allowed on a wet runway if suitable performance accountability is made for increased stopping distance on a wet surface.

Note: An increase in elevator column force during rotation and initial climb may be required for ATM takeoffs.

Fixed Derate (As Installed)

This method uses a takeoff thrust less than full rated thrust for which complete and independent performance data are provided in the AFM. Derated thrust is obtained by selection of TO 1 or TO 2. Takeoff derates 1 and 2 normally correspond to fixed thrust reductions, and are variable from operator to operator.

In both cases, the derate is considered a limitation for takeoff, therefore, throttles should not be advanced further except in an emergency. A further thrust increase following an engine failure could result in a loss of directional control. Use the takeoff speeds specified in the airport analysis, FMC (if available), QRH (PI chapter), Flight Planning Performance Manual (FPPM), AFM, or other approved sources for the selected derate.

Note: Although fixed derate takeoffs are permitted on wet or contaminated runways provided takeoff performance accounts for runway surface conditions, they are not recommended if potential windshear conditions exist.

Improved Climb Performance Takeoff

When not field length limited, an increased climb limit weight is achieved by using the excess field length to accelerate to higher takeoff and climb speeds. This improves the climb gradient, thereby raising the climb limit weight. V1, VR and V2 are increased to maintain consistent performance relationships. V1, VR and V2 must be obtained from dispatch or the airport analysis.

Low Visibility Takeoff

Low visibility takeoff operations, below landing minima, 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. Operators, who have authorization for engine inoperative Category II/III operations, may be authorized lower alternate minima.

With proper crew training and appropriate runway lighting, takeoffs with visibility as low as 500ft/150m RVR may be authorized (FAA). With takeoff guidance systems and centerline lighting that meets FAA or ICAO criteria for Category III operations, takeoffs with visibility as low as 300ft/75m RVR may be authorized. Regulatory agencies may impose takeoff crosswind limits specifically for low visibility takeoffs.

All RVR readings must be equal to or greater than required takeoff minima. If the touchdown or rollout RVR system is inoperative, the mid RVR may be substituted for the inoperative system. When the touchdown zone RVR is inoperative, pilot estimation of RVR may be authorized by regulatory agencies.

Adverse Runway Conditions

Slush, standing water, or deep snow reduces the airplane takeoff performance because of increased rolling resistance and the reduction in tire-to-ground friction.

Most operators specify weight reductions to the AFM field length and or obstacle limited takeoff weight based upon the depth of powdery snow, slush, wet snow or standing water and a maximum depth where the takeoff should not be attempted.

Slush or standing water may cause damage to the airplane. The recommended maximum runway depth for slush, standing water, or wet snow is 0.5 inch (12.7 mm). For dry snow the maximum depth is 4 inches (102 mm).

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. 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.

Note: Check the airport analysis or the PI section of the QRH for performance degradation for takeoff with adverse runway conditions.

During wet runway or slippery conditions, the PNF must give special attention to assuring 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 airplane 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.

Effect of Deicing/Anti-Icing Fluids on Takeoff

Testing of undiluted Type II and Type IV fluids has shown that some of the fluid remains on the wing during takeoff rotation and during initial climb out. The residual fluid causes a temporary decrease in lift and increase in drag. These effects are more significant at lower ambient temperatures where the fluid tends to stay on the wing longer. Operators must comply with the lowest operational use temperatures provided by the fluid manufacturer to ensure a relatively clean wing.

No performance adjustments are required for the application of deicing/anti-icing fluids. Takeoff operations with reduced thrust based on derates and/or the assumed temperature method are permitted. Use normal rotation rates.

Federal Aviation Regulation (FAR) Takeoff Field Length

The FAR takeoff field length is the longest of the following:

- the distance required to accelerate with all engines, experience an engine failure 1 second prior to V₁, continue the takeoff and reach a point 35 feet above the runway at V₂ speed. (Accelerate-Go Distance).
- the distance required to accelerate with all engines, experience an event 1 second prior to V₁, recognize the event, 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.

Stopping distance includes the distance traveled while initiating the stop and is based on the measured stopping capability as demonstrated during certification flight test.

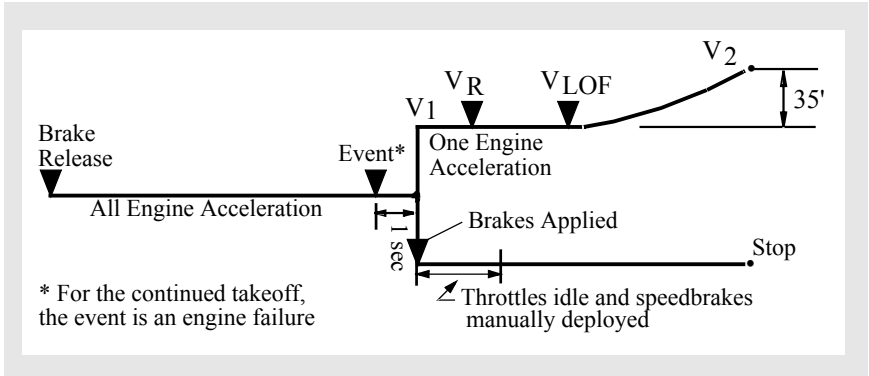
During certification maximum manual braking and speedbrakes are used. Thrust reversers are not used. Although reverse thrust and autobrakes are not used in determining the FAR accelerate-stop distance, thrust reversers and RTO autobrakes should be used during any operational rejected takeoff.

Calculating a V₁ speed that equates accelerate-go and accelerate-stop distances allows the maximum takeoff weight for dispatch from a given runway length. This is known as a “balanced field length.” The associated V₁ speed is called the “balanced V₁” and is the V₁ speed listed in the QRH and the Flight Management Computer. The V₁ speeds depicted for derated takeoffs are also “balanced V₁” speeds.

When using reduced thrust for takeoff, the “assumed temperature” for a given runway (either the field limit weight or climb limit weight) dictates the maximum weight or assumed temperature to be used. When using derated thrust for takeoff, the derate must also take performance calculations into account. The resulting assumed temperature V₁ is the equivalent “balanced V₁” for that particular takeoff.

Takeoff gross weight must not exceed the climb limit weight, field limit weight, obstacle limit weight, tire speed limit, or brake energy limit.

FAR Takeoff



757-300

Note: The graphic above refers to dry runway conditions only. Refer to the AFM for detailed wet runway performance information.

Rejected Takeoff Decision

The total energy that must be dissipated during an RTO is proportional to the square of the airplane velocity. At low speeds (up to approximately 80 knots), the energy level is low. Therefore, the airplane 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.

Note: Refer to the Rejected Takeoff NNM in the QRH for guidance concerning the decision to reject a takeoff below and above 80 knots.

As the airspeed approaches V_1 during a balanced field length takeoff, the effort required to stop can approach the airplane maximum stopping capability. Therefore, the decision to stop must be made prior to V_1 .

Historically, rejecting a takeoff near V_1 has often resulted in the airplane stopping beyond the end of the runway. Common causes include initiating the RTO after V_1 and failure to use maximum stopping capability (improper procedures/techniques). Effects of improper RTO execution are shown in the diagrams located in the RTO Execution Operational Margins section, this chapter. 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 V_1 is not recommended unless the captain judges the airplane incapable of flight. Even if excess runway remains after V_1 , there is no assurance that the brakes have the capacity to stop the airplane prior to the end of the runway.

Rejected Takeoff Maneuver

The rejected takeoff (RTO) maneuver is initiated during the takeoff roll to expeditiously stop the airplane on the runway. The pilot not flying should closely monitor essential instruments throughout 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 prior to V1 speed. If the captain is the pilot not flying, he should initiate the RTO and announce the abnormality simultaneously.

Note: If the decision is made to reject, the flight crew should accomplish the procedure in the NNM chapter of the QRH.

During the rejected takeoff, the first officer calls “60 KNOTS” during deceleration. If the takeoff is rejected prior to the THR HOLD annunciation, the autothrottle should be disengaged as the thrust levers are moved to idle. If the autothrottle is not disengaged, the thrust levers advance to the selected takeoff thrust position when released. After THR HOLD is annunciated, the thrust levers, when retarded, remain in idle. For procedural consistency, disengage the autothrottles for all rejected takeoffs.

If rejecting due to fire, in windy conditions consider positioning the aircraft so the fire is on the downwind side. After an RTO, comply with brake cooling requirements before attempting a subsequent takeoff.

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 the 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 airplane within the accelerate-stop distance; and,
- V1 also means the minimum speed in the takeoff, following a failure of the critical engine at which the pilot can continue the takeoff and achieve the required height above the takeoff surface within the takeoff distance.

Part 1 defines the critical engine as “the engine whose failure would most adversely affect the performance or handling qualities of an aircraft.”

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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 airplane can be stopped prior to reaching the end of the runway. See RTO Execution Operational Margins diagrams for consequences of initiating reject after V1 and/or using improper procedures.

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 airplane 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 airplane is lower than 35 feet at the end of the runway, but it is still flying. For instance if the engine fails 2 seconds prior to V1 and the decision is made to go, the airplane 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.

What's important to note here is that the majority of past RTO accidents were not engine failure events. Full takeoff power from all engines was available. With normal takeoff power, the airplane 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 airplane if an air turnback is required.

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

RTO Execution Operational Margins

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

The data in the following diagrams, extracted from the 1992 Takeoff Safety Training Aid, are provided as a reference. The individual diagrams show the approximate effects of various configuration items and procedural variations on the stopping performance of the airplane. These calculations are frequently based on estimated data and are intended for training discussion purposes only. The data are generally typical of the airplane at heavy weights, and except as noted otherwise, are based on the certified transition time.



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Each condition is compared to the baseline condition. The estimated speed at the end of the runway and the estimated overrun distance are indicated at the right edge of each figure. The distance estimates assume an overrun area that can produce the same braking forces as the respective runway surface. If less than the baseline FAA accelerate-stop distance is required, the distance is denoted as a negative number.

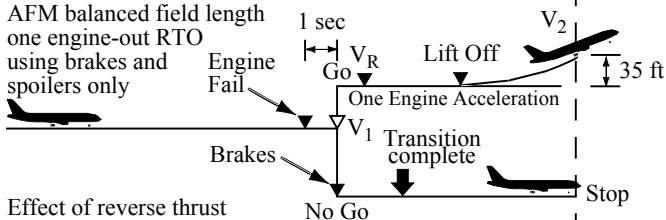
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Available Runway (DRY)

Baseline

AFM balanced field length
one engine-out RTO
using brakes and
spoilers only



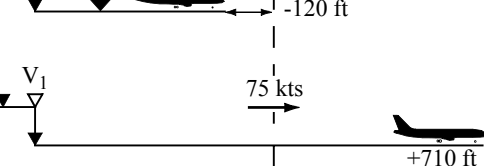
Effect of reverse thrust
engine-out RTO,
brakes, spoilers, and
1 Thrust Reverser



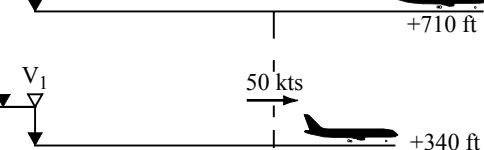
Effect of reverse thrust
all-engine RTO,
brakes, spoilers, and
2 Thrust Reversers



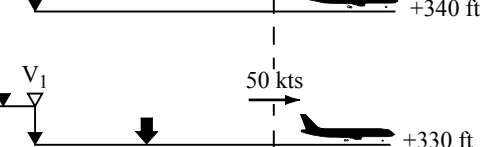
Effect of no speedbrakes
engine-out RTO,
brakes only,
no Thrust Reverse



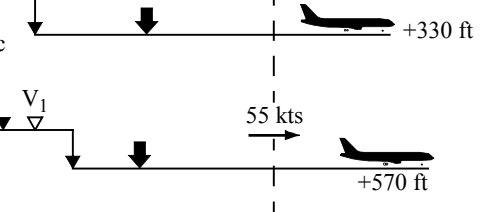
Effect of no speedbrakes
engine-out RTO,
brakes, and
1 Thrust Reverser



Effect of late speedbrake
engine-out RTO,
S/B deployment 5 seconds
after V_1 , no Thrust Reverse



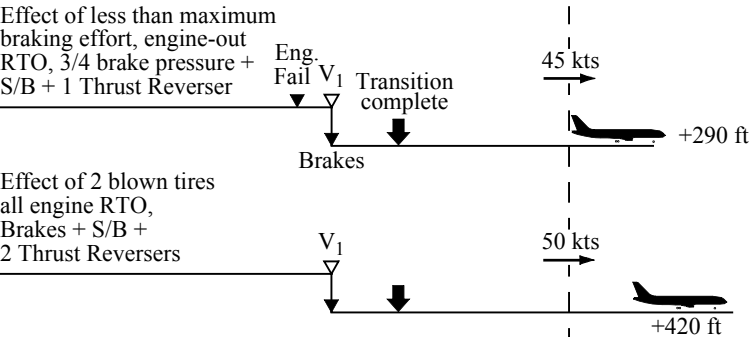
Effect of late RTO initiation
engine-out RTO, initiated 2 sec
after V_1 , AFM transition,
brakes and spoilers only,
no Thrust Reverse



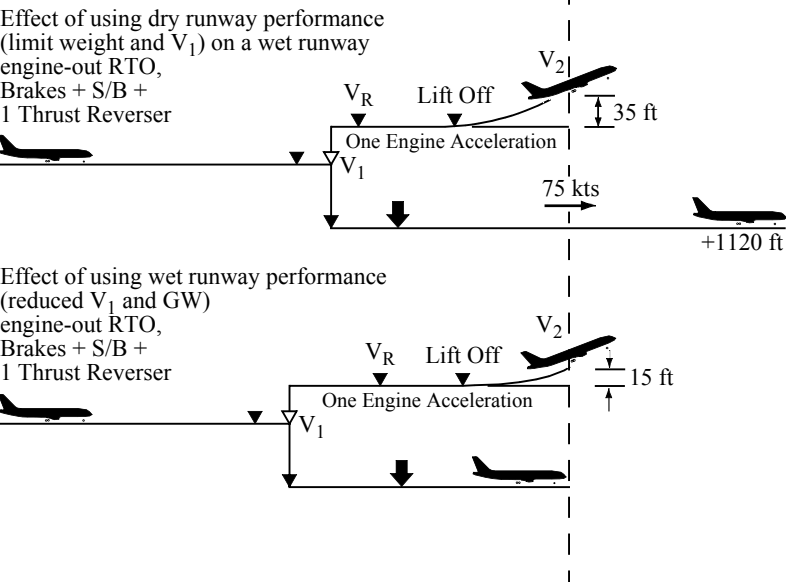


757

Available Runway (DRY)



Available Runway (WET)



Initial Climb - All Engines

After liftoff use the flight director as the primary pitch reference cross checking indicated airspeed and other flight instruments. If the flight director is not used, indicated airspeed and attitude become the primary pitch references.

After liftoff, the flight director commands pitch to maintain an airspeed of $V_2 + 15$ to 25 knots until another pitch mode is engaged.

$V_2 + 15$ 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 $V_2 + 15$ during the initial climb, stop the acceleration but do not attempt to reduce airspeed to $V_2 + 15$. Any speed between $V_2 + 15$ and $V_2 + 25$ knots results in approximately the same takeoff profile. 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. Braking is automatically applied when the landing gear lever is placed in the up position. After gear and flaps are retracted, the PNF should verify the gear and flaps indications are normal.

Minimum Fuel Operation - Takeoff

The minimum fuel recommended for takeoff is trip fuel plus reserves. On very short flights this fuel quantity may not be enough to prevent forward fuel pump low pressure lights from illuminating after takeoff.

If any main tank fuel pump indicates low pressure do not turn off fuel pump switches. Avoid rapid acceleration of the airplane, reduce nose-up body attitude and maintain minimum nose-up body angle required for a safe climb gradient.

Immediate Turn after Takeoff - All Engines

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 $V_2 + 15$ to $V_2 + 25$ with takeoff flaps.

Note: A maximum bank angle of 30° is permitted at $V_2 + 15$ knots with takeoff flaps.

After completing the turn, and at or above flap retraction altitude, 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

After takeoff and climb is stabilized, select LNAV after passing 400 feet AGL. If the departure procedure or route does not begin at the end of the runway, it may be necessary to use the HDG SEL mode at 400 feet AGL to intercept the desired track for LNAV capture. When the departure procedure is not a part of the active flight plan, use HDG SEL or HDG HOLD mode. When an immediate turn after takeoff is necessary, the desired heading may be preset before takeoff.

Note: On Pegasus and PIP FMC equipped airplanes, LNAV may be armed before takeoff and engages automatically at 50 feet.

Nav aids and appropriate radials or tracks required for use during the departure may be displayed on the navigation display using the FIX page feature. Use of the STA and WPT switches on the EFIS control panel provides additional information on the map display.

Autopilot Engagement

The autopilot is FAA certified to allow engagement at or above 200 feet AGL after takeoff. Other regulations or airline operating directives may specify a higher minimum altitude. The airplane should be in trim, and the flight director commands should be satisfied prior to autopilot engagement. This prevents unwanted changes from the desired flight path during autopilot engagement.

Flap Retraction Schedule

During training flights, 1,000 feet AFE is normally used as acceleration height to initiate thrust reduction and flap retraction. For noise abatement considerations during line operations, thrust reduction typically occurs at approximately 1,500 feet AFE and acceleration typically occurs between 1,500 and 3,000 feet AFE, or as specified by individual airport noise abatement procedures.

At acceleration height, select climb thrust, accelerate and retract flaps on the Flap Retraction Schedule. Selection of VNAV is the recommended technique for acceleration.

Note: On early models, climb thrust must be selected on the Thrust Mode Select panel. On later models, selecting a pitch mode (other than V/S) or an autothrottle mode automatically selects climb thrust.

With VNAV engaged, an acceleration is automatically commanded. Retract flaps on schedule. Check that the thrust reference changes from TO to CLB on the EICAS. If the thrust reference does not change automatically, manually select climb thrust.

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If VNAV is not used, at acceleration height select FLCH and set the command speed to flaps up maneuvering speed. Check that the thrust reference changes from TO to CLB on the EICAS. If the thrust reference does not change automatically, manually select climb thrust.

With airspeed increasing, additional flap retraction should be initiated:

- for airplanes with Mach/Airspeed indicators; when airspeed reaches the fixed maneuvering speed for the existing flap position.
- for airplanes with speed tape; when airspeed reaches the maneuvering speed “F” for the existing flap position.

For flaps up maneuvering, maintain at least:

- flaps up maneuvering speed (Mach/Airspeed indicator airplanes)
- “F” with flaps in the up position (speed tape airplanes)

Note: The maneuver speed provides margin to stick shaker for at least an inadvertent 15° overshoot beyond the normal 25° angle of bank.

Takeoff Flap Retraction Speed Schedule

T/O Flaps	Select Flaps	Speed (knots)
20 or 15	5	VREF 30 + 20
	1	VREF 30 + 40
	UP	VREF 30 + 60
5	1	VREF 30 + 40
	UP	VREF 30 + 60
1 (-200 only)	UP	VREF 30 + 60
Final Climb	VREF 30 + 80	

Noise Abatement Takeoff

Normal takeoff procedures satisfy typical noise abatement requirements. Maintain flaps up maneuvering speed until the noise abatement profile is satisfied, until clear of obstacles or above any minimum crossing altitude. This is normally achieved through the FMC speed restriction entered on the CLB page. It may also be accomplished using speed intervention or FLCH.

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 (VMCAs) are below VR and VREF.

Engine Failure Recognition

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 airplane 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 - One Engine Inoperative

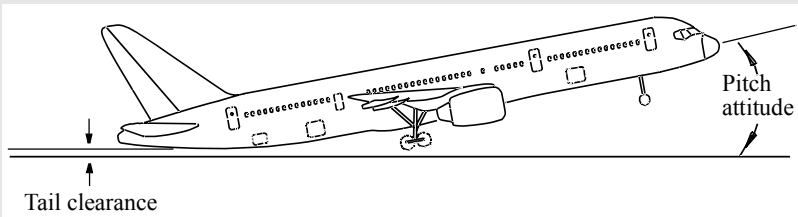
If an engine fails between V1 and liftoff, maintain directional control by smoothly applying rudder proportionate with thrust decay.

During a normal all engine takeoff, a smooth continuous rotation toward 15° 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° to 13°, or approximately 2° to 3° below the normal all engine pitch attitude. 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.

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.

Liftoff Pitch Attitude - One Engine Inoperative

Liftoff attitude depicted in the following tables should be achieved in approximately 5 seconds. Adjust pitch attitude, as required, to maintain desired airspeed of V2 to V2+15.

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Model	Flap	Liftoff Attitude (degrees)	Minimum Tail Clearance inches (cm)
200	1	10.9	14 (36)
	5	10.4	16 (41)
	15	10.2	16 (41)
	20	9.8	24 (61)
300	5, 15, 20	8.5	13 (33)



Initial Climb - One Engine Inoperative

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

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

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 $V_2 + 15$, climb at the airspeed at which the failure occurred. If engine failure occurs above $V_2 + 15$, increase pitch to reduce airspeed to $V_2 + 15$ and maintain until flap retraction altitude.

The flight director roll mode commands ground track after liftoff until LNAV engagement or another roll mode is selected. If ground track is not consistent with desired flight path, use HDG SEL/LNAV to achieve the desired track.

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 recall checklist items as soon as the airplane is under control, the gear has been retracted and a safe altitude (typically 400 feet AGL or above) has been attained. Accomplish the reference checklist items after the flaps have been retracted and conditions permit.

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

Immediate Turn after Takeoff - One Engine Inoperative

Obstacle clearance or departure procedures may require an immediate turn after takeoff. If applicable, fly the special engine out departure procedure. Initiate the turn at the appropriate altitude (normally at least 400 feet AGL). Maintain V_2 to $V_2 + 15$ with takeoff flaps while maneuvering.

Note: Limit bank angle to 15° until $V_2 + 15$ knots. Bank angles up to 30° are permitted at $V_2 + 15$ knots with takeoff flaps.

After completing the turn, and at or above flap retraction altitude, accelerate and retract flaps.

Flap Retraction - One Engine Inoperative

The minimum altitude for flap retraction with an engine inoperative is 400 feet AGL. During training, flap retraction is initiated at 1,000 feet AGL.

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At engine out flap retraction altitude, select V/S and set 0-200 fpm on the MCP. Engine-out acceleration and climb capability for flap retraction are functions of airplane thrust to weight ratio. The flight director commands a near level or a slight climb (0-200 fpm) flap retraction segment. Accelerate and retract flaps on the flap-speed schedule.

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

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

Flaps Up - One Engine Inoperative

After flap retraction, at flaps up maneuvering speed, select FLCH, set maximum continuous thrust (CON) and continue climb to obstacle clearance altitude.

Initiate the appropriate engine failure non-normal checklist followed by the After Takeoff checklists when the flaps are up and thrust is set. Remain at flaps up maneuvering speed until all obstructions are cleared, then select the engine-out schedule from the CDU CLB page (depending on the next course of action). Ensure autothrottle is disconnected prior to reaching level off altitude. After level off, set thrust as required.

Autopilot Engagement - One Engine Inoperative

When at a safe altitude above 200 feet AGL with correct rudder pedal or trim input, the autopilot may be engaged.

Note: On most airplanes, the TO roll and pitch modes are flight-director-only modes. The autopilot does not engage into the TO mode. The autopilot engages into the HDG HOLD or ATT (as installed) roll mode and the V/S pitch mode whenever the flight director TO roll and/or pitch mode is engaged. On airplanes with the “Autopilot Engagement into Takeoff Mode” option, the autopilot engages into the TO mode.

Noise Abatement - One Engine Inoperative

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



Engine Failure During Reduced Thrust Takeoff

Takeoff thrust reduction is based on a minimum climb gradient that clears all obstructions with an engine failure after V₁. If reduced thrust is used and an engine failure occurs, based on performance, it is not necessary to set maximum thrust on the remaining engine. However, if maximum thrust is desired, thrust on the operating engine may be increased to go-around thrust by manually setting the thrust levers.

Note: Pushing the GA switch cancels the derate and provides a target thrust setting, but the autothrottle does not come out of the THR HLD mode.

For reduced thrust takeoffs, resetting the operating engine to full thrust provides additional performance margin. This additional performance margin is not a requirement of the reduced thrust takeoff certification and its use is at the discretion of the flight crew. It should be noted the assumed temperature method of computing reduced thrust takeoff performance is always conservative and provides performance equal to or better than the performance obtained if actually operating at the assumed temperature.



Climb, Cruise, Descent and Holding
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Preface

This chapter outlines recommended operating practices and techniques used during climb, cruise, descent and holding. Loss of an engine during climb or cruise and engine inoperative cruise/driftdown is also addressed. The recommended operating practices and techniques discussed in this chapter improve crew coordination, enhance safety, and provide a basis for standardization.

Climb

Reduced Thrust Climb

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

The Thrust Management Computer (TMC) or the FMC THRUST LIM page (as installed) provides two reduced thrust climb selections.

- CLB 1 depends upon the specific derate thrust limit options selected by the customer.
- CLB 2 depends upon the specific derate thrust limit options selected by the customer.
- reduced thrust climb may also be automatically selected by the TMC depending upon the amount of thrust reduction made for takeoff by either the fixed derate or assumed temperature method.
- climb thrust reductions are gradually removed as the airplane climbs until full climb thrust is restored. If rate of climb should drop below approximately 500 feet per minute, the next higher climb rating should be selected.
- prior to takeoff the pilot may override the automatic reduction after the takeoff selection has been completed by selecting another option on the TMSP or THRUST LIMIT (as installed) page.

Note: Use of reduced thrust for climb increases total trip fuel and should be evaluated by each operator.

Climb Constraints

Climb constraints may be automatically entered in the route when selecting a procedure, or manually entered through CDU entry. When the airplane levels off at an MCP altitude, that altitude is treated as a climb constraint by the FMC.

All hard altitude climb restrictions should be set in the MCP altitude window including “at or below” constraints. The next altitude may be set when the restriction has been satisfied, or further clearance has been received. This procedure provides altitude alerting and assures compliance with altitude clearance limits.

When relieved of constraints by ATC, use of FLCH or VNAV with MCP altitude intervention (as installed) is recommended in congested areas, or during times of high workload. Altitude intervention (as installed) is accomplished by selecting the next desired altitude in the MCP altitude window, pushing the MCP altitude selector which deletes the altitude constraint and allows the airplane to climb to the MCP altitude.

Low Altitude Level Off

Occasionally a low altitude climb restriction is required after takeoff. This altitude restriction should be put in the MCP altitude window. When the airplane approaches this altitude prior to selection of a pitch mode, the pitch mode annunciation changes from TO to ALT CAP.

When the pitch flight mode annunciation changes from TO to ALT CAP, the autothrottle engages into the EPR/N1 mode to maintain the takeoff power setting. For proper speed control, either manually retard the thrust levers or set the desired target airspeed into the MCP IAS/Mach window and select the autothrottle SPD mode.

Note: For airplanes with manual climb thrust selection, the CLB switch must be selected prior to selecting the autothrottle SPD mode to preclude exceeding climb thrust limits.

Transition to Climb

Maintain flaps up maneuvering speed until clear of obstacles or above minimum crossing altitudes. If there are no altitude or airspeed restrictions, accelerate to the desired climb speed schedule. The sooner the airplane can be accelerated to the climb speed schedule, the more time and fuel efficient the flight.

Climb Speed Determination

Enroute climb speed is automatically computed by the FMC and displayed on the climb and progress pages. It is also displayed as command speed when VNAV is engaged. Below the speed transition altitude the FMC targets the transition speed limit stored in the navigation data base for the departure airport (250 knots below 10,000 feet MSL in FAA airspace), or flaps up maneuvering speed, whichever is higher. The FMC applies waypoint-related speed restrictions displayed on the LEGS pages, and altitude-related speed restrictions displayed on the climb page.

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The FMC provides optimum climb speed modes for economy (ECON) operation and engine out (ENG OUT) operation. These optimum speeds can be changed before or during the climb. Reference speeds are also provided for maximum angle climb (MAX ANGLE) operation.

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

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.

Engine Icing During Climb

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 airplane. 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.

Note: The engine anti-icing system should be turned on whenever icing conditions exist or are anticipated. Failure to follow the recommended anti-ice procedures can result in engine stall, overtemperature or engine damage.

Economy Climb

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

Economy climb speed normally exceeds 250 knots for all gross weights. FMC climb speed is limited to 250 knots or flaps up maneuvering speed, whichever is greater, below 10,000 feet (FAA Airspace). If ATC permits the use of a higher speed below 10,000 feet, the use of ECON speed may provide additional fuel savings.

Economy Climb Schedule - FMC Data Unavailable

- 250 knots/VREF 30 + 80, whichever is higher- Below 10,000 feet
- 290 knots/.78 Mach - Above 10,000 feet

Maximum Rate Climb

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

- flaps up Maneuver Speed + 50 knots until intercepting Mach 0.76

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

Maximum Angle Climb

The FMC provides maximum angle climb speeds. Maximum angle climb speed is normally used for obstacle clearance, minimum crossing altitude or to reach a specified altitude in a minimum distance. It varies with gross weight and provides approximately the same climb gradient as flaps up maneuvering speed.

Engine Inoperative Climb

The engine inoperative climb speed is approximately maximum angle climb speed and varies with gross weight and altitude. At high altitudes and weights, a fixed Mach is used as an upper limit on the engine out climb speed. Engine out climb speed is the FMC default used during climb when ENG OUT CLIMB is selected. Select ENG OUT CLIMB after flap retraction and all obstructions are cleared.

If a thrust loss occurs at other than takeoff thrust, set maximum continuous thrust on the operative engine and lower the nose slowly to maintain airspeed as the thrust loss occurs.

Note: Selecting CON on the TMSP or the FMC THRUST LIM page (as installed) moves the N1/EPR bug to maximum continuous thrust until another mode is selected or automatically engaged. Thrust must be manually set.

In the clean configuration, select the engine out prompt on the CDU climb page. The engine out mode provides VNAV commands to climb at engine out climb speed to cruise altitude, or maximum engine out altitude, whichever is lower. If the airplane is currently above maximum engine out altitude, driftdown information is available. Upon reaching level off altitude, the command speed changes to engine out LRC. Leave thrust set at maximum continuous thrust until airspeed increases to the commanded value.

Note: If computed climb speeds are not available, use flaps up maneuvering speed and maximum continuous thrust.

Cruise

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

Maximum Altitude

Maximum altitude is the highest altitude at which the airplane can be operated. It is determined by three basic characteristics, which are unique to each airplane model. The FMC predicted maximum altitude is the lowest of:

- maximum certified altitude - determined during certification and is usually set by the pressure load limits on the fuselage. The maximum certified altitude may not be exceeded.
- thrust limited altitude - the altitude at which sufficient thrust is available to provide a specific rate of climb. (Reference the Long Range Cruise Maximum Operating Altitude table in the PI chapter of the QRH). Depending on the thrust rating of the engines, the thrust limited altitude may be above or below the maneuver limited altitude capability.
- maneuver limited altitude - the altitude at which a specific maneuver margin exists prior to buffet onset (minimum 0.2g for FAA or 0.3g for CAA/JAA operation). These margins provide 33° (FAA) or 40° (CAA/JAA) of bank angle protection to buffet.

Although each of these limits are checked by the FMC, thrust limitations may limit the ability to accomplish anything other than relatively minor maneuvering. When at or near the FMC maximum altitude, it is possible for LNAV inputs to exceed the capability of the airplane. This could result in loss of altitude or airspeed. This risk may be reduced by changing the FMC parameters (maintenance action) to suit individual operator needs.

Fuel predictions may be inaccurate at or above the maximum altitude and are not displayed on the CDU. VNAV is not available above FMC maximum altitude. Fuel burn at or above maximum altitude increases. Flight above this altitude is not recommended.

The maneuver speed indication on the speed tape (as installed) does not guarantee the ability to fly at that speed. Decelerating the airplane to the amber band may create a situation where it is impossible to maintain speed and/or altitude because as speed decreases airplane drag may exceed available thrust, especially while turning.

Optimum Altitude

Optimum altitude is the cruise altitude for minimum cost when operating in the ECON mode, and for minimum fuel burn when in the LRC or pilot-selected speed modes. In ECON mode, optimum altitude increases as either airplane weight or cost index decreases. In LRC or selected speed modes, optimum altitude increases as either airplane weight or speed decreases. On each flight, optimum altitude continues to increase as weight decreases during the flight.

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

Flight plans not constrained by short trip distance are typically based on conducting the cruise portion of the flight within plus or minus 2000 feet of optimum altitude. Since the optimum altitude increases as fuel is consumed during the flight, it is necessary to climb to a higher cruise altitude every few hours to achieve the flight plan fuel burn. This technique, referred to as Step Climb Cruise, is typically accomplished by initially climbing 2000 feet above optimum altitude and then cruising at that flight level until 2000 feet below optimum. For most flights, one or more step climbs may be required before reaching TOD. It may be especially advantageous to request an initial cruise altitude above optimum if altitude changes are difficult to obtain on specific routes. This minimizes the possibility of being held at a low altitude/high fuel consumption condition for long periods of time. The requested/accepted initial cruise altitude should be compared to the thrust limited or the maneuver margin limited altitudes. Remember, a cruise thrust limited altitude is dependent upon the cruise level temperature. If the cruise level temperature increases above the chart value for gross weight, maximum cruise thrust will not maintain desired cruise speed.

The selected cruise altitude should normally be as close to optimum as possible. Optimum altitude is the altitude that gives the minimum trip cost for a given trip length, cost index, and gross weight. It provides approximately a 1.5 load factor (approximately 48° bank to buffet onset) or better buffet margin. As deviation from optimum cruise altitude increases, performance economy deteriorates.

Some loss of thrust limited maneuver margin can be expected above optimum altitude. Levels 2000 feet above optimum altitude normally allows approximately 45° bank prior to buffet onset. The higher the airplane 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.

On airplanes with higher thrust engines, the altitude selection is most likely limited by maneuver margin to initial buffet. 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.

Cruise Speed Determination

Cruise speed is automatically computed by the FMC and displayed on the CRZ and PROGRESS pages. It is also displayed by the command air speed when VNAV is engaged. The default cruise speed mode is economy (ECON) cruise. The pilot can also select LRC, engine out modes, or overwrite fixed Mach or CAS values on the CRZ page target speed line.

ECON cruise is a variable speed schedule that is a function of gross weight, cruise altitude, cost index, and headwind component. It is calculated to provide minimum operating cost for the entered cost index. Entry of zero for cost index results in maximum range cruise.

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

LRC is a variable speed schedule providing fuel mileage 1% less than the maximum available. The FMC does not apply wind corrections to LRC.

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

Step Climb

Step altitudes can be planned as step ups or step downs at waypoints or they can be optimum step points calculated by the FMC. Optimum step points are a function of the route length, flight conditions, speed mode, present aircraft altitude, STEP TO altitude (or adjacent STEP TO altitudes) and the gross weight.

The FMC computed step point provides for minimum trip cost for the flight, including allowances for climb fuel. Initiate a cruise climb to the new altitude as close as practicable to the step climb point.

Fuel for Enroute Climb

The additional fuel required for a 4,000 foot enroute climb varies from 550 to 1,300 lbs (250 to 600 kgs) depending on the airplane gross weight and air temperature. 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 FMC or the flight plan, provided the wind information used is reliable.

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 Former Soviet Union, 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. 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 3 consecutive refuelings with the 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, the 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 appropriate operations manual.

Maintaining a minimum fuel temperature should not be a concern unless the fuel temperature approaches the minimum temperature limit. The rate of cooling of the fuel is approximately 3°C per hour, with a maximum of 12°C per hour possible under the most extreme conditions.

Total air temperature can be raised in the following three ways, used individually or in combination:

- climb or descend to a warmer air mass
- deviate to a warmer air mass
- increase Mach number.

Note: In most situations warmer air can be reached by descending but there have been reports of warmer air at higher flight levels. Air temperature forecasts should be carefully evaluated when colder than normal temperatures are anticipated.

It takes from 15 minutes to an hour to stabilize the fuel temperature. In most cases, the required descent would be 3,000 feet to 5,000 feet below optimum altitude. In more severe cases a 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, wind enroute, and cruise speed.

Actual fuel burn should be compared with the flight plan fuel burn throughout the flight.

The planned fuel burn can increase due to:

- temperature above planned
- a lower cruise altitude than planned
- cruise altitude more than 2,000 feet above optimum altitude
- speed faster than planned or appreciably slower than long range cruise speed when long-range cruise was planned
- stronger headwind component
- fuel imbalance
- improperly trimmed airplane
- excessive thrust lever adjustments.

Cruise fuel penalties include:

- ISA + 10° C: 1% increase in trip fuel
- 2,000 feet above/below optimum altitude: 1% to 2% increase in trip fuel
- 4,000 feet below optimum altitude: 3% to 5% increase in trip fuel
- 8,000 feet below optimum altitude: 8% to 14% increase in trip fuel
- cruise speed M.01 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 M.80. Long range cruise also provides best buffet margin at all cruise altitudes.

Note: If a discrepancy is discovered between actual fuel burn and flight plan fuel burn that cannot be explained by one of the items above, a fuel leak should be considered. Accomplish the applicable non-normal checklist.

Engine Inoperative Cruise/Driftdown

Performance of a non-normal checklist or sudden engine failure may lead to the requirement to perform a single engine driftdown.

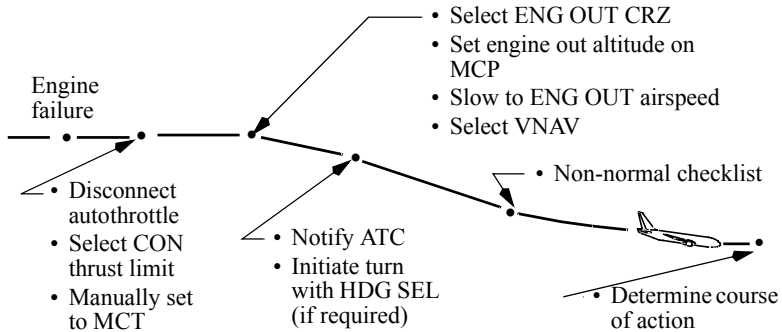
Engine inoperative cruise information is available from the FMC.

If an engine failure occurs while at cruise altitude, it may be necessary to descend. The autothrottle should be disconnected, thrust reference set to CON and the thrust manually set to MCT on the operative engine. On the FMC ACT CRZ page, select the ENG OUT. This displays MOD CRZ calculated on engine out MCT and maintaining the airspeed displayed on the EO SPD line.

Set the engine out cruise altitude in the MCP altitude window and execute the ENG OUT CRZ D/D page. The thrust reference mode on the EICAS display will display CON. The airplane descends in VNAV using the VNAV SPD pitch mode. Once the descent rate has decreased to 300 fpm during driftdown it is held constant by the FMC until altitude capture.

At altitude capture the ENG OUT CRZ page is displayed. Maintain MCT on the operative engine and driftdown altitude until the E/O SPD speed is established. Maintain this speed using manual thrust adjustments.

After level off at the target altitude, maintain MCT and allow the airplane to accelerate to the single engine long range cruise speed. Maintain this speed with manual thrust adjustments. Entering the new cruise altitude and airspeed on the ECON CRZ page updates the ETAs and Top of Descent predictions. When the ENG OUT VNAV mode is selected and an engine-out condition is detected, the FMC computes engine-out trip predictions, guidance parameters, and MAX ALT consistent with the detected engine-out conditions, the selected thrust rating using the actual bleeds. Refer to Engine Out Familiarization, chapter 7, for trim techniques.



Note: If the airplane is at or below maximum ENG OUT altitude when an engine becomes inoperative, select and execute the ENG OUT CRZ page. Maintain engine out cruise speed using manual thrust adjustments.

If required to cruise at maximum altitude, set MCT, establish a climb and decelerate slowly to ENG OUT CRZ speed. At level off select ENG OUT LRC for best fuel economy.

An alternate target driftdown speed can be selected using the MOD CRZ or ENG OUT D/D page. LRC speed would result in a lower driftdown altitude but better fuel performance. A company specified speed could be selected and provides for a higher driftdown speed and a shorter flight time to the alternate.

An ENG OUT ALT can be entered on the MOD CRZ or ENG OUT D/D page. If an engine out cruise altitude lower than the computed maximum altitude is entered, the FMC commands a cruise descent at approximately 1250 fpm rather than a driftdown schedule.

Unless altered by the pilot, the level off cruise mode will be the same as was used during driftdown. FMC fuel and ETA calculations for driftdown and the remainder of the trip will be consistent with the selected speed mode. For best fuel performance select the engine-out LRC mode following a minimum drag speed (E/O) driftdown.

When VNAV is not used during engine out, set MCT on the operative engine and maintain altitude until the airplane decelerates to the displayed appropriate engine out speed. Use engine out speed from the FMC while descending to the engine out cruise altitude. Remain at MCT until the airplane accelerates to LRC, then maintain LRC speed with manual thrust adjustments. If the FMC is inoperative use turbulence penetration airspeed to driftdown and the engine out long-range cruise tables in the QRH.

High Altitude High Speed Flight

The airplane exhibits excellent stability throughout the high altitude / high Mach range. Mach buffet is not normally encountered at high Mach cruise. The airplane does not have a Mach tuck tendency.

With Mach trim inoperative, the airplane exhibits a neutral trim change when accelerating to speeds approaching MMO. When the Mach trim system is operative, the airplane exhibits a nose up trim change that increases steadily as the airplane accelerates to speeds approaching MMO. The stabilizer motion associated with this nose up trim change is imperceptible without careful scrutiny of the aisle stand indicator.

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.

ETOPS

Extended Range Operation with Two Engine Airplanes (ETOPS) are those flights which include points at a flying distance greater than one hour (in still air) single engine cruise speed from an adequate airport. Improved technology and the increased reliability of two engine airplanes has prompted a re-examination of the rules governing their flights over oceans or desolate areas.

ETOPS Requirements and Approval

Operators conducting ETOPS are required to comply with the provisions of FAA Advisory Circular 120-42A or other applicable governing regulations. An airline must have an ETOPS configured airplane, and approved flight operations and maintenance programs in place to support ETOPS operations.

The Minimum Equipment List (MEL) and the Dispatch Deviation Guide (DDG) include dispatch relief levels appropriate to ETOPS.

The airline ensures that the ETOPS airplane is in compliance with the requirements of the appropriate Boeing Configuration, Maintenance and Procedures (CMP) documents. The airline's maintenance department must develop programs which monitor and report reliability of the engines, airframe and components. The Minimum Equipment List (MEL) and the Dispatch Deviation Guide (DDG) have been expanded to address the improved redundancy levels and the additional equipment unique to ETOPS configured airplanes.

Flight and Performance

Crews undertaking ETOPS flights must be familiar with the suitable enroute alternates listed in the flight plan. These airports must meet ETOPS weather minima which require an incremental increase above conventional alternate minimums, and be located so as to ensure that the airplane can divert and land in the event of a system failure requiring a diversion.

Planning an ETOPS flight requires an understanding of the area of operations, critical fuel reserves, altitude capability, cruise performance tables and icing penalties. The Operations Manual provides guidance to compute critical fuel reserves which are essential for the flight crew to satisfy the requirements of the ETOPS flight profile. Fuel corrections must be made for winds, non-standard atmospheric conditions, performance deterioration caused by engines or airframe, and (if applicable) flight through forecast icing conditions.

Procedures

Normal procedures on ETOPS flights do not differ from standard operation. However, during the last hour of ETOPS cruise, the FAA currently requires that a fuel crossfeed valve check be performed on aircraft with a single crossfeed valve. This verifies that the crossfeed valve is operating so that on the subsequent flight, if an engine fails, fuel feed is available from both main tanks through the crossfeed valve.

Non-normal procedures are performed using the standard non-normal checklist. ETOPS engine-out procedures may be different from standard non-normal procedures. Following engine failure the crew performs a modified “driftdown” procedure determined by the ETOPS route requirements. This procedure typically uses higher descent and cruise speeds, and a lower cruise altitude following engine failure. This permits the airplane to reach an alternate airport within the specific time limits authorized for that operator. These cruise speeds and altitudes are determined by the airline and approved by its regulatory agency and usually differ from the engine-out speeds provided by the FMC. The captain however, has the discretion to modify this speed if actual conditions following the diversion decision dictate such a change.

With an in-flight loss of both main AC busses, the hydraulic driven generator automatically powers essential electrical systems. In this case the total air temperature indicator is inoperative and Static Air Temperature (SAT) must be used to calculate performance. If the hydraulic driven generator is inoperative, the APU must be operating before entering the ETOPS phase of flight.

If an engine failure occurs and is accompanied by a loss of both main AC busses, the airplane may have to be retrimmed to compensate for the induced yaw. The rudder ratio changer is unpowered following a loss of both main AC busses.

A loss of main AC busses unpowers the fuel boost pumps. The system design normally precludes any fuel imbalance because fuel is drawn approximately equally from both wing tanks. In the unlikely event that an imbalance occurs, a deliberate sideslip may be used to raise the wing containing the heavier tank. This ensures that the fuel is drawn from the heavier tank to balance the load. This action may slightly decrease the range due to the increased sideslip drag.

Polar Operations

Refer to the FMC Polar Navigation section of the Operations Manual for specifics on FMC operation in polar regions and a description of the boundaries of the polar regions.

During preflight planning extremely cold air masses should be noted and cold fuel temperatures should be considered. See the Low Fuel Temperature section in this chapter for details regarding recommendations and crew actions.

Operators should establish a remote airport diversion plan to include supporting the airplane, passengers and crew. Airplane equipment and document needs to be considered:

- cold weather clothing to enable one or more crewmembers to exit the airplane at a diversion airport with extreme cold conditions
- comprehensive instructions on securing the airplane for cold weather to include draining water tanks, etc.
- diversion airport data to include airport diagrams, information on nearby terrain and photographs (if available), emergency equipment availability, etc.
- cold temperature altitude correction table.

Due to limited availability of alternate airports relative to other regions, special attention should be given to diversion planning including airport conditions and availability of compatible fuel. Crews should be prepared to operate in QFE and metric altitude where required. Expect changes in assigned cruising levels enroute since standard cruising levels vary by FIR. Some airports provide QNH upon request, even if their standard is QFE. Metric wind speed (m/sec) may be all that is available. A simple approximation: 1 m/sec = 2 knots. A feet to meters conversion chart may be useful for planning step climbs, converting minima, etc.

Use caution when using ADF and/or VOR raw data. ADF orientation (true or magnetic) is determined by the heading reference selected by the crew. VOR radials are displayed according to the orientation of the VOR station.

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Communications should be handled according to the applicable enroute charts. Above 82 degrees N, SATCOM is unavailable. HF frequencies and HF SELCAL must be arranged by the flight crew prior to the end of SATCOM coverage. Routine company communications procedures should include flight following to enable immediate assistance during a diversion or other emergency.

Note: To use SATCOM on the ground, the IRUs/ADIRUs (as installed) must be aligned.

When navigating in the polar regions, magnetic heading should be considered unreliable or totally useless for navigation. Magnetic variations typically are extreme, often are not constant at the same point and change rapidly as airplane position changes. Ensure the computer flight plan shows true tracks and true headings. Grid headings may also be used as a reference for those airplanes equipped with grid heading indicators although no airplane systems use grid heading. For some high latitude airports, grid headings are shown on the instrument approach procedures. Note that unmapped areas in the GPWS terrain data base display as magenta dots on the map, regardless of the airplane altitude.

The primary roll mode for polar operations should be LNAV, which may be used with the heading reference switch in the NORM position. HDG SEL/HOLD are functional but require the manual selection of TRUE heading reference. Deviations from planned route may be accomplished in HDG SEL.

Note: Operation should be limited to between N87 degrees and S87 degrees latitude since the FMC and displays may not provide accurate map, heading or track information closer than 3 degrees latitude to either pole.

Loss of both GPS units results in an increased ANP and possible display of the UNABLE RNP message but normally would not prevent polar operation.

Loss of one or two IRUs does not significantly affect navigation accuracy. Operation on one remaining IRU should be limited to diversion to the nearest suitable airport.

Descent

Descent Speed Determination

The default FMC descent speed schedule is an economy (ECON) descent from cruise altitude to the airport speed transition altitude followed by a descent at ten knots less than this speed. The speed schedule is adjusted to accommodate waypoint speed/altitude constraints displayed on the LEGS pages, and speed/altitude constraints displayed on the DES page. If desired, the ECON speed schedule can be modified by alternate Mach, Mach/IAS, or IAS values on the DES page target speed line. If the FMC information is not available, use target speeds from the Descent Rates table in this chapter.

Descent Path

An FMC path descent is the most economical descent method. At least one waypoint-related altitude constraint below cruise altitude on a LEGS page generates a descent guidance path. The path is built from the lowest constraint upward, assuming idle thrust, or approach idle below the anti-ice altitude entered on the DESCENT FORECAST page.

The path is based on the descent speed schedule, any entered speed/altitude constraints or forecast use of anti-ice. The path reflects descent wind values entered on the DESCENT FORECAST page.

Descent Constraints

Descent constraints may be automatically entered in the route when selecting an arrival procedure, or manually entered through the CDU.

Set all mandatory altitude restrictions and at or above constraints in the Mode Control Panel (MCP) altitude window. The next altitude may be set when the restriction has been assured, and further clearance has been received.

Note: Use of DES DIR deletes constraints from the LEGS page.

Shallow vertical path segments may result in the autothrottle supplying partial power 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.

Speed Intervention

VNAV speed intervention can be used to respond to ATC speed change requirements. VNAV SPD pitch mode responds to speed intervention by changing airplane pitch while the thrust remains at idle. VNAV PTH pitch mode may require the use of speedbrakes or increased thrust to maintain the desired airspeed.

Offpath Descent (as installed)

The LEGS pages should reflect the planned arrival procedure. If a published arrival procedure is required for reference while being radar vectored, or the arrival is momentarily interrupted by a heading vector from ATC, the offpath descent circles provide a good planning tool to determine drag and thrust requirements for the descent.

The outer circle is referenced to the end of descent point, using a clean configuration and a direct path from the airplane position to the end of descent waypoint constraint. The inner circle is referenced to the end of descent point using speedbrakes. A separate waypoint may be entered on the OFFPATH DES page as a reference for the descent circles.

Both circles assume normal descent speed schedules, including deceleration at transition altitude, but do not include waypoint speed and altitude constraints.

Descent Planning

Flight deck workload typically increases as the airplane descends into the terminal area. Distractions must be minimized and administrative and nonessential duties completed before descent or postponed until after landing. The earlier that essential duties can be performed, the more time will be available for the critical approach and landing phases.

Operational factors and/or terminal area procedures may not permit 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 meet the requirements.

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 3.5 NM/1000 feet altitude loss for no wind conditions using ECON speed. Rate of descent is dependent upon thrust, drag, airspeed schedule and gross weight.

Descent Rates

Descent Rates tables provide typical rates of descent below 20,000 feet with idle thrust and speedbrakes extended or retracted.

Target Speed	Rate of Descent (Typical)			
	Clean		With Speedbrake	
	757-200	757-300	757-200	757-300
M 0.78 / 290 knots	1800 fpm	2000 fpm	2700 fpm	3200 fpm
250 knots	1500 fpm	1500 fpm	2000 fpm	2400 fpm
VREF 30 + 80	1200 fpm	1300 fpm	1600 fpm	2000 fpm

Normally, descend with idle thrust and in clean configuration (no speedbrakes). Maintain cruise altitude until the proper distance or time out for the planned descent and then hold the selected airspeed schedule during descent. Deviations from this schedule may result in arriving too high at destination and require circling to descend, or arriving too low and far out requiring extra time and fuel to reach destination.

The speedbrake may be used to correct the descent profile if arriving too high or too fast. The Approach checklist is normally initiated during descent and should be completed passing 10,000 feet MSL or transition level, whichever is lower.

Plan the descent to arrive at traffic pattern altitude at flaps up maneuvering speed approximately 12 miles from the runway when proceeding straight-in or about 8 miles out when making an abeam approach. A good crosscheck is to be at 10,000 feet AGL, 40 miles from the airport, at 250 knots.

Losing airspeed can be difficult and may require a level flight segment. For planning purposes, it requires approximately 45 seconds and 3 NM to decelerate from 290 to 250 knots in level flight without speedbrakes. It requires an additional 45 seconds and 3 NM to decelerate to flaps up maneuvering speed at average gross weights. Using speedbrakes to aid in deceleration reduces these times and distances by approximately 30%.

Maintaining the desired descent profile and using the map mode to maintain awareness of position ensures a more efficient operation. Maintain awareness of the destination weather and traffic conditions, and consider the requirements of a potential diversion. Review the airport approach charts and discuss the plan for the approach, landing, and taxi routing to parking. Complete the approach briefing as soon as practical, preferably before arriving at top of descent. This allows full attention to be given to airplane control.

Speedbrakes

The pilot flying should keep a hand on the speedbrake lever when they are used in-flight. This precludes leaving the speedbrakes extended.

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Use of speedbrakes does not appreciably affect airplane roll response. While using the speedbrakes in descent, allow sufficient altitude and airspeed margin to level off smoothly. Lower the speedbrakes before adding thrust.

To avoid buffeting, use of speedbrakes with flaps greater than 5 should be avoided. If circumstances dictate the use of speedbrakes with flaps extended, high sink rates during the approach should be avoided. Speedbrakes should be retracted before reaching 1,000 feet AGL.

757-300

Note: With speedbrakes fully extended, flaps up maneuver margin to stick shaker is reduced. Additional airspeed (up to 5 knots) may be added to flaps up maneuvering speed to ensure full maneuver margin (40° bank capability).

The flaps are normally not used for increasing the descent rate. Normal descents are made in the clean configuration to pattern or instrument approach altitude.

When descending with the autopilot engaged and the speedbrakes extended at speeds near VMO/MMO, the airspeed may momentarily increase to above VMO/MMO if the speedbrakes are retracted quickly. 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.

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 selected speed and delay speedbrake retraction until after level off is complete.

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, the landing gear can be lowered to increase the rate of descent.

Extend the flaps when in the terminal area and conditions require a reduction in airspeed below flaps up maneuvering speed. Normally select flaps 5 prior to the approach fix going outbound, or just before entering downwind on a visual approach.

Note: Avoid using the landing gear for increased drag. This minimizes passenger discomfort and increases gear door life.

Speed Restrictions

Speed restrictions below specific altitudes/flight levels and in the vicinity of airports are common. At high gross weights, minimum maneuvering speed may exceed these limits. Consider extending the flaps to attain a lower maneuvering speed or obtain clearance for a higher airspeed from ATC.

Other speeds may be assigned by ATC. Pilots complying with speed adjustments are expected to maintain the speed within plus or minus 10 knots.

Engine Icing During Descent

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. The anticipated anti-ice use altitude should be entered on the DESCENT FORECASTS page to assist the FMC in computing a more accurate descent profile.

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 airplane. Once ice starts to form, accumulation can build very rapidly. Although one bank of clouds may not cause icing, another bank, which is similar, may induce icing.

Note: The engine anti-icing system should be turned on whenever icing conditions exist or are anticipated. Failure to follow the recommended anti-ice procedures can result in engine stall, overtemperature or engine damage.

Holding

Start reducing to holding airspeed 3 minutes before arrival time at the holding fix so that the airplane crosses the fix, initially, at or below the maximum holding airspeed.

If the FMC holding speed is greater than the ICAO or FAA maximum holding speed, holding may be conducted at flaps 1, using flaps 1 speed. Flaps 1 uses approximately 10% more fuel than flaps up. Holding speeds in the FMC provide an optimum holding speed based upon fuel burn and speed capability; but in no case are lower than flaps up maneuvering speed. If the holding speed is not available from the FMC, flaps up maneuvering speed approximates minimum fuel burn speed and may be used at low altitudes.

Note: Above FL250, use VREF 30 + 100 knots to provide adequate buffet margin.

Procedure Holding

When a procedure holding pattern is selected from the navigation data base and the FMC shows PROC HOLD on the legs page, the following is true when the PROC HOLD is the active leg:

- exiting the holding pattern is automatic; there is no need to select EXIT HOLD
- if the crew desires to remain in holding a new holding pattern must be entered.

ICAO Holding Airspeeds (Maximum)

Altitude	Speed
Through 14,000 feet	230 knots
Above 14,000 to 20,000 feet MSL	240 knots
Above 20,000 to 34,000 feet MSL	265 knots
Above 34,000 feet MSL	.83 Mach

FAA Holding Airspeeds (Maximum)

Altitude	Speed
Up to 6,000 feet MSL	200 knots
6,000 feet MSL through 14,000 feet MSL	230 knots (210 knots Washington D. C. & New York FIRs)
Above 14,000 feet MSL	265 knots / .83 Mach

Maintain clean configuration if holding in icing conditions or in turbulence.

If the holding pattern has not been programmed in the FMC, the initial outbound leg should be flown for 1 minute or 1 1/2 minutes as required by altitude. Timing for subsequent outbound legs should be adjusted as necessary to achieve proper inbound leg timing.

In extreme wind conditions or at high selected 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. Advise ATC if an increase in airspeed is necessary due to turbulence, if unable to accomplish any part of the holding procedure, or if unable to comply with speeds listed in the tables above.



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Approach and Missed Approach

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Preface

This chapter outlines recommended operating practices and techniques for ILS, non-ILS, circling and visual approaches, and the missed approach/go-around maneuver. Flight profile illustrations represent the recommended basic configuration for normal and non-normal flight maneuvers and provide a basis for standardization and crew coordination.

The maneuvers are normally accomplished as illustrated. However, due to conflicting traffic at training airports, air traffic separation requirements, and radar vectors, modifications may be necessary. Conditions beyond the control of the flight crew may preclude following an illustrated maneuver exactly. The maneuver profiles are not intended to replace good judgment and logic.

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.

The Approach Checklist is normally initiated during descent and should be completed passing 10,000 feet MSL or transition level, whichever is lower.

Complete the approach preparations before arrival in the terminal area. Set decision altitude/height DA(H) or minimum descent altitude/height MDA(H). Crosscheck radio and pressure altimeters whenever practical. Do not completely abandon enroute navigation procedures even though air traffic is providing radar vectors to the initial or final approach fix. Check ADF/VOR selector set to the proper position. Verify ILS, VOR and ADF are tuned and identified if required for the approach.

Check that the marker beacon is selected on the audio panel. The course and glide slope signals are reliable only when their warning flags are not displayed, localizer and glide slope pointers are in view, and the ILS identifier is received. Confirm the published approach inbound course is set or displayed.

Do not use radio navigation aid facilities that are out of service even though flight deck indications appear normal. Radio navigation aids that are out of service may have erroneous transmissions that are not detected by airplane receivers and no flight deck warning is provided to the crew.

Approach Briefing

Thorough planning and briefing are the keys to a safe, unhurried, professional approach. Prior to the start of an instrument approach, the pilot flying should brief the other pilot as to intentions in conducting the approach. Both pilots should review the approach procedure. All pertinent approach information, including minimums and missed approach procedures, should be reviewed and alternate courses of action considered.

As a guide, the approach briefing should include at least the following:

- weather and NOTAMS at destination and alternate, as applicable
- type of approach and the validity of the charts to be used
- navigation and communication frequencies to be used
- minimum safe sector altitudes for that airport
- approach procedure including courses and heading
- vertical profile including all minimum altitudes, crossing altitudes and approach minimums
- determination of the Missed Approach Point (MAP) and the missed approach procedure
- other related crew actions such as tuning of radios, setting of course information, or other special requirements
- taxi routing to parking
- any appropriate information related to a non-normal procedure
- management of AFDS.

Approach Category

FAA Category	Speed
C	121 knots or more but less than 141 knots
D	141 knots or more but less than 166 knots
Speed - based upon a factor of 1.3 or 1.23 (see note) times stall speed in the landing configuration at maximum certificated landing weight.	

Note: Factor is dependant upon airplane type certification basis.

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ICAO Category	Vat	Range of Speeds for Initial Approach	Range of Speeds for Final Approach	Max Speeds for Visual Maneuvering (Circling)	Max Speeds for Missed Approach	
					Inter-mediate	Final
C	121/140	160/240	115/160	180	160	240
D	141/165	185/250	130/185	205	185	265

Vat - Speed at threshold based upon a factor of 1.3 or 1.23 (see note) times stall speed in the landing configuration at maximum certified landing mass.

Note: Factor is dependant upon airplane type certification basis.

The 757 is classified as a Category “C” airplane for straight in approaches. For circling approaches use the minima associated with the anticipated circling speed.

Approach Clearance

When cleared for an approach and on a published segment of that approach, descend to the minimum altitude for that segment (or procedure turn altitude if in holding pattern at the final approach fix). In preparation for the instrument approach, cross the initial approach fix at the initial approach fix altitude. If not in the holding pattern at the final approach fix, descend to the procedure turn altitude as shown on the approach chart.

When conducting an instrument approach from the holding pattern, continue on the same pattern as holding, extend flaps to 5 on the outbound track parallel to final approach course. Turn inbound on the procedure turn heading. This type of approach is also referred to as a race track approach.

Procedure Turn

On some approaches the procedure turn must be completed within specified limits, such as within 10 NM of the procedure turn fix, beacon, or outer marker. Adjust time outbound for airspeed, wind effects, and/or location of the procedure turn fix, especially if the procedure turn fix is located on or very near the field. The published procedure turn altitudes are normally minimum altitudes.

Stabilized Approach Recommendations

Maintaining a stable speed, descent rate, and vertical/lateral flight path in landing configuration is commonly referred to as the stabilized approach concept.

Any significant deviation from planned flight path, airspeed, or descent rate should be announced. The decision to execute a go-around is no indication of poor performance.

Note: Do not attempt to land from an unstable approach.

Recommended Elements of a Stabilized Approach

The following recommendations are consistent with criteria developed by the Flight Safety Foundation.

All approaches should be stabilized by 1,000 feet above airport elevation in instrument meteorological conditions (IMC) and by 500 feet above airport elevation in visual meteorological conditions (VMC). An approach is considered stabilized when all of the following criteria are met:

- the aircraft is on the correct flight path
- only small changes in heading/pitch are required to maintain the correct flight path
- the aircraft speed is not more than VREF + 20 knots indicated airspeed and not less than VREF
- the aircraft is in the correct landing configuration
- sink rate is no greater than 1,000 fpm; if an approach requires a sink rate greater than 1,000 fpm, a special briefing should be conducted
- power setting is appropriate for the aircraft configuration
- all briefings and checklists have been conducted.

Specific types of approaches are stabilized if they also fulfill the following:

- ILS approaches should be flown within one dot of the glide slope and localizer
- a Category II or Category III ILS approach should be flown within the expanded localizer band
- during a circling approach, wings should be level on final when the aircraft reaches 300 feet above airport elevation.

Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.

Note: An approach that becomes unstabilized below 1,000 feet above airport elevation in IMC or below 500 feet above airport elevation in VMC requires an immediate go-around.

These conditions should be maintained throughout the rest of the approach for it to be considered a stabilized approach. If the above criteria cannot be established and maintained at and below 500 feet AFE, initiate a go-around.

At 100 feet HAT for all visual approaches, the aircraft should be positioned so the flight deck is within, and tracking so as to remain within, the lateral confines of the runway edges extended.

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As the aircraft crosses the runway threshold it should be:

- stabilized on target airspeed to within + 10 knots until arresting descent rate at flare
- on a stabilized flight path using normal maneuvering
- positioned to make a normal landing in the touchdown zone (the first 3,000 feet or first third of the runway, whichever is less).

Initiate a go-around if the above criteria cannot be maintained.

Maneuvering (including runway changes and circling)

When maneuvering below 500 feet, be cautious of the following:

- descent rate change to acquire glide path
- lateral displacement from the runway centerline
- tailwind/crosswind components
- runway length available.

Mandatory Missed Approach

On all instrument approaches, execute an immediate missed approach:

- if a navigation radio or flight instrument failure occurs which affects the ability to safely complete the approach in instrument conditions
- when on ILS final approach, in instrument conditions, and either the localizer and/or glide slope indicator shows full deflection
- when the navigation instruments show significant disagreement and visual contact with the runway has not been made
- when on an RNP based approach, and an FMC alerting message indicates that ANP exceeds RNP
- when on a radar approach and radio communication is lost.

Landing Minima

Most regulatory authorities require visibility for landing minima. Ceilings are not required. There are limits on how far an aircraft can descend without visual contact with the runway environment when making an approach. Descent limits are based on a decision altitude/height DA(H) for approaches using a glide slope or certain approaches using a VNAV path; or a MDA(H) for approaches that do not use vertical guidance, or where a DA(H) is not authorized for use. Most agencies do not require specific visual references below AH.

Approach charts use the abbreviation DA(H) or MDA(H). DA(H) applies to Category I, II, and certain fail passive Category III operations. A decision altitude “DA” or minimum descent altitude “MDA” is referenced to MSL and the parenthetical height “(H)” is referenced to TDZE or threshold elevation. Example: A DA(H) of 1,440’ (200’) is a DA of 1,440’ with a corresponding height above TDZ of 200’.

When RVR is reported for the landing runway, it typically is used in lieu of the reported meteorological visibility.

Radio Altimeter (RA)

A radio altimeter is normally used to determine DH when a DA(H) is specified for Category II or Category III approaches, or to determine alert height (AH) for Category III approaches. Procedures at airports with irregular terrain may use a marker beacon instead of a DH to determine the missed approach point. The radio altimeter may also be used to cross check the primary altimeter over known terrain in the terminal area. However, unless specifically authorized, the radio altimeter is not used for determining MDA(H) on instrument approaches. It should also 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.

Missed Approach Point (MAP)

A missed approach point is a point where a missed approach must be initiated if suitable visual references are not available to make a safe landing or the airplane is not in a position to make a safe landing.

Determination of a MAP

For approaches such as ILS or GLS, the DA(H) in conjunction with the glide slope is used to determine the MAP. For non-ILS or G/S out approaches, two methods for determining the MAP are acceptable in lieu of timing due to the accuracy of FMC positioning:

- when arriving at the MDA(H) or DA(H) in conjunction with a VNAV path
- if not using a VNAV path, use of the map display to determine when the airplane has reached the VDP or the MAP. The approach legs along with distance and time to the missed approach waypoint are displayed on the map.

Timing During Approaches

Since FMC use is appropriate for instrument approach navigation, timing is not the primary means to determine the missed approach point. The probability of multiple failures that would result in timing being the only method of determining the missed approach point is remote. However, some regulatory agencies may still require the use of timing for approaches. The timing table, when included, shows the distance from the final approach fix to the MAP.

For non-RNP capable FMCs, timing for instrument approaches is not necessary when DME-DME updating of FMC position is active.

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For RNP capable FMCs, timing for instrument approaches is not necessary as long as there is no unable RNP alert displayed.

Instrument Landing System (ILS)

Arrival at the MAP is determined by reference to an altimeter. DA is determined by reference to the barometric altimeter, while DH is determined by reference to the radio altimeter.

Precision Approach Radar (PAR)

The MAP for a PAR is the geographic point where the glide path intersects the DA(H). Arrival at the MAP is determined by the pilot using the altimeter or as observed by the radar controller, whichever occurs first.

Instrument Approach using VNAV

When specifically authorized by the instrument procedure and regulatory authority, approaches may be flown to the following minima:

- a published VNAV DA(H)
- a published MDA(H) used as a decision altitude.

When either of the above minima are not specifically authorized, use the MDA(H) specified for the instrument procedure.

Airport Surveillance Radar (ASR)

The radar controller is required to discontinue approach guidance when the airplane is at the MAP or one mile from the runway, whichever is greater. Perform the missed approach when instructed by the controller.

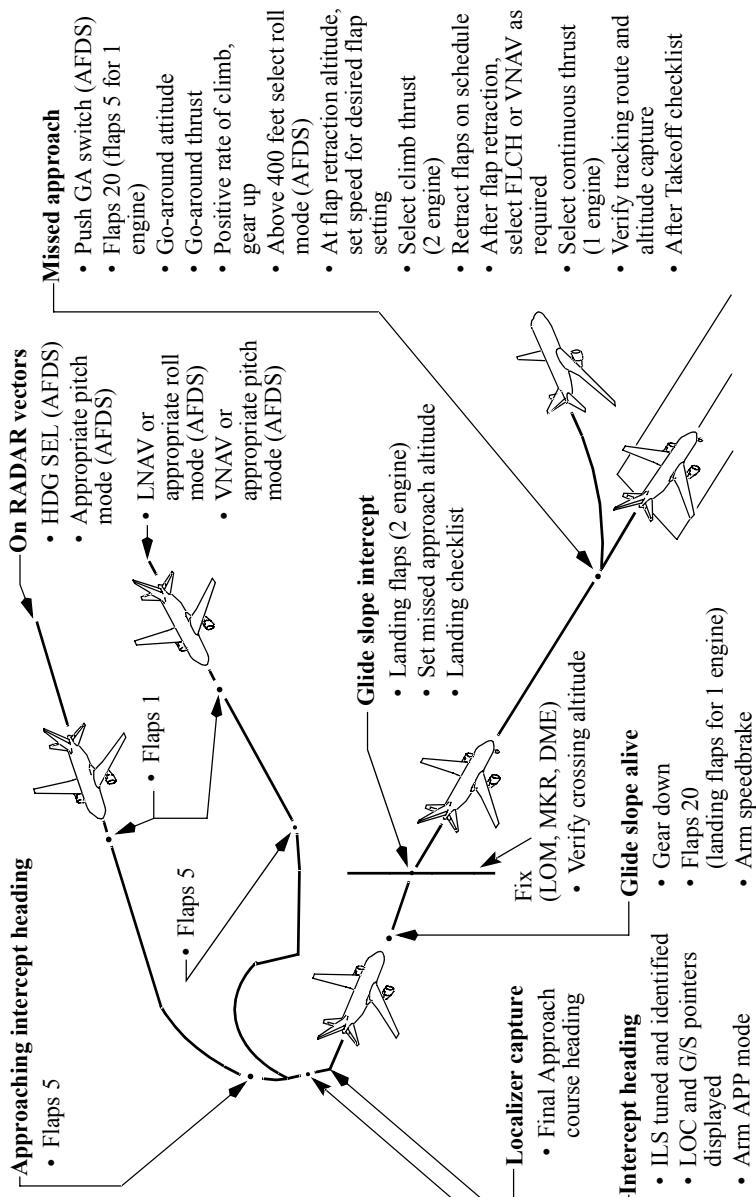
Localizer

The MAP for a localizer approach is not the same as for the corresponding ILS approach. For most approaches the MAP distance is to the threshold of the runway. Where authorized, a localizer approach may be flown in VNAV PTH using the missed approach criteria discussed above.

Other Non-ILS Approaches

The MAP for all other non-ILS approaches is depicted on the approach chart. If the procedure has a final approach fix, the MAP may be short of the runway threshold, at the runway threshold, or located over a radio facility on the field. For on airport facilities (VOR or NDB) which do not have a final approach fix, the facility itself is the MAP and in most cases is beyond the runway threshold. Do not assume the airplane will always be in a position to make a normal landing when reaching the MDA(H) prior to reaching the MAP. When the MAP is at or beyond the runway threshold, the airplane must reach MDA(H) prior to arrival at the MAP if a normal final approach is to be made.

ILS Approach



ILS Approach - General

The ILS approach illustrated 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 pattern may be modified to suit local traffic and air traffic requirements.

Decision Altitude/Height - DA(H)

A Decision Altitude/Height is a specified altitude or height in a precision approach where a missed approach must be initiated if the required visual reference to continue the approach has not been established. The “Altitude” value is typically measured by a barometric altimeter and is the determining factor for minima for Category I approaches (e.g. ILS, GLS, or RNAV with VNAV). The “Height” value specified in parenthesis, typically a RA height above the touchdown zone (HAT), is advisory. The RA may not reflect actual height above terrain.

For most Category II and Category III fail passive 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.

Alert Height - AH

Alert heights are normally used for fail operational Category III operations. Alert height is a height above the runway, above which a Category III approach must be discontinued and a missed approach initiated if a specified failure occurs. For a discussion on specified failures, see the AFDS Faults section, this chapter. Radio altimeters are set in accordance with the airline's policy or at alert height to assist in monitoring autoland status. Most regulatory agencies do not require visual references below alert height.

Fail Operational

Fail operational refers to an AFDS capable of completing an ILS approach, autoland, and rollout following the failure of any single system component after passing alert height.

Fail Passive

Fail passive refers to an AFDS which in the event of a failure, causes no significant deviation of airplane flight path or attitude. A DA(H) is used as approach minimums.

Procedure Turn

The procedure turn size is determined by the ground speed at which the procedure turn is flown. If the procedure turn is flown at an excessively high ground speed, the protected airspace may be exceeded. Cross the procedure turn fix at flaps 5 maneuvering airspeed. The procedure turn should be monitored using the map to assure the airplane remains within protected airspace.

Initial Approach

If a complete arrival procedure to the localizer and glide slope capture point has been selected via the CDU, the initial approach phase may be completed using LNAV and VNAV. Ensure the LEGS page sequence, altitude restrictions and the map display reflect the air traffic clearance. Last minute air traffic changes or constraints may be managed by appropriate use of the MCP heading selector and altitude window. Updating the LEGS sequencing should be accomplished only as time permits.

Approach

Both pilots should not be “heads-down” during the approach. In some cases, such as high density traffic, or when an arrival procedure is used only for reference, revising the FMS flight plan may not be appropriate. Displaying OFF PATH DESCENT circles on the map (if installed) provides vertical flight path guidance which may assist in planning the approach.

If displaying the arrival procedure is not desired, perform a “DIRECT TO” or “INTERCEPT LEG TO/INTERCEPT COURSE TO” the FAF, OM, or appropriate fix, to simplify the navigation display. This provides:

- a display of distance remaining to the FAF, OM, or appropriate fix
- a depiction of cross track error from the final approach course
- LNAV capability during the missed approach procedure.

The approach procedure may be flown using HDG SEL or LNAV for lateral tracking and VNAV, FLCH, or V/S for altitude changes. VNAV is the preferred descent mode when the FMS flight plan is programmed for the intended arrival. When VNAV is not available, use FLCH for altitude changes greater than 1,000 feet. For smaller altitude changes, V/S permits a more appropriate descent rate.

When maneuvering to intercept the localizer, decelerate and extend flaps to 5. Attempt to be at flaps 5 and flaps 5 maneuvering speed prior to localizer capture.

When operating in speed intervention or the autothrottle SPD mode, timely speed selections minimize thrust lever movement during the approach. This reduces cabin noise levels and increases fuel efficiency. When flaps are extended, select the next lower speed just as the additional configuration drag takes effect.

Delaying the speed selection causes an increase in thrust, while selecting the lower speed too quickly causes thrust to decrease, then increase.

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During the approach, adjust the map display and range to provide a scaled plan view of the area. When on an intercept heading and cleared for the approach, select the APP mode and observe the LOC and G/S mode annunciations are armed.

APP mode should not be selected until:

- the ILS is tuned and identified
- the airplane is on an inbound intercept heading
- both localizer and glide slope pointers appear on the attitude display in the proper position
- clearance for the approach has been received.

The glide slope may be captured before the localizer in some airplanes. The glide slope may be captured from either above or below. Glide slope capture does not occur if the intercept angle to the localizer is greater than 80°. The maximum intercept angle for the localizer is 120°. To avoid unwanted glide slope capture, LOC mode may be selected initially, followed by the APP mode.

CAUTION: When using LNAV to intercept the final approach course, ensure raw data indicates localizer interception to avoid descending on the glide slope with LOC not captured. If needed, use HDG SEL or HDG HOLD to establish an intercept heading to final approach course.

Final Approach

The pilots should monitor the quality of the approach, flare, landing and rollout, including speedbrake deployment and autobrake application.

At localizer capture, the heading bug automatically slews to the inbound course. For normal localizer intercept angles, very little overshoot occurs. Bank angles up to 30° may be commanded during the capture maneuver. For large intercept angles some overshoot can be expected.

Use the map display to maintain awareness of distance to go to the final approach fix. When the glide slope pointer begins to move (glide slope alive), extend the landing gear, select flaps 20, and decrease the speed to flaps 20 speed.

At glide slope capture, observe the flight mode annunciations for correct modes. At this time, select landing flaps and VREF + 5 knots or VREF + wind correction if landing manually, and complete the Landing checklist. When using the autothrottle to touchdown, no additional wind correction is required to the final approach speed. The pilot not flying should continue standard callouts during final approach and the pilot flying should acknowledge callouts.

When established on the glide slope, set the missed approach altitude in the altitude window of the MCP. Extension of landing flaps at speeds in excess of flaps 20 speed may cause flap load relief activation and large thrust changes.

Check for correct crossing altitude and begin timing, if required, when crossing the final approach fix (FAF or OM).

There have been incidents where airplanes have captured false glide slope signals and maintained continuous on glide slope indications as a result of an ILS ground transmitter erroneously left in the test mode. False glide slope signals can be detected by crosschecking the final approach fix crossing altitude and VNAV path information prior to glide slope capture. A normal pitch attitude and descent rate should also be indicated on final approach after glide slope capture. Further, if a glide slope 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° glide slope.

If a false glide slope capture is suspected, perform a missed approach if visual conditions cannot be maintained.

Below 1,500 feet radio altitude, the flare and rollout modes are armed. The autoland status annunciation should display LAND 3 or LAND 2. As the lowest weather minimums are directly related to the system status, both pilots must observe the autoland status annunciation.

If an autoland annunciation changes or system fault occurs above AH that requires higher weather minimums (reversion to LAND 2 or NO AUTOLAND), do not continue the approach below these higher minimums unless suitable visual reference with the runway environment is established.

Autopilots having fail operational capability are designed to safely continue an approach below AH after a single failure of an autopilot element. The autopilots protect against any probable system failure and safely land the airplane. AFDS design provides for an AH of at least 200 feet HAT but may be modified to a lower value by operators. The pilot should not interfere below AH unless it is clearly evident pilot action is required.

During an autoland with crosswind conditions, the runway alignment maneuver uses forward slip to reduce the crab angle of the airplane at touchdown. Alignment begins at 500 feet radio altitude or lower, depending on the strength of the crosswind. The amount of forward slip induced is limited to 5°. When a strong crosswind is present, the airplane does not fully align with the runway, but lands with a slight crab angle. In all cases, the upwind wing is low at touchdown.

The autopilot and autobrakes should remain engaged until a safe stop is assured and adequate visibility exists to control the airplane using visual references.

757 Flight Crew Training Manual**Delayed Flap Approach (Noise Abatement)**

If the approach is not being conducted in adverse conditions that would make it difficult to achieve a stabilized approach, the final flap selection may be delayed to conserve fuel or to accommodate speed requests by air traffic.

Intercept the glide slope with gear down and flaps 20 at flaps 20 speed. The thrust required to descend on the glide slope may be near idle. Approaching 1,000 feet AFE, select landing flaps, allow the speed to bleed off to the final approach speed, then adjust thrust to maintain it. Complete the Landing checklist.

Note: For particularly noise sensitive areas, use the technique above but delay extending the landing gear until 1,500 feet AFE.

Decision Altitude/Height - DA(H)

The pilot not flying should expand the instrument scan to include outside visual cues when approaching DA(H). Do not continue the approach below DA(H) unless the airplane 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, any of the above requirements are not met, immediately execute the missed approach procedure. When visual contact with the runway is established, maintain the glide path to the flare. Do not descend below the glide path.

Raw Data - (No Flight Director)

ILS deviation is displayed on the attitude display. ILS deviation may also be displayed on the navigation display by selecting an ILS mode on the EFIS Control Panel. The localizer course deviation scale on the attitude display remains normal scale during the approach and does not change to expanded scale at approximately 5/8 dot, as happens with F/D and/or autopilot engaged and localizer captured. Continue to cross-check the map display against the attitude display raw data.

The magnetic course/bearing information from the VOR/ADF 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 necessary 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 glide slope pointer begins to move (glide slope alive), lower the landing gear, extend flaps 20, and decelerate to flaps 20 speed. Intercepting the glide slope, extend landing flaps and establish the final approach speed. When established on the glide slope, preset the missed approach altitude in the altitude window. On final approach, maintain VREF + 5 knots or an appropriate correction for headwind component. Check altitude and time crossing the FAF. To stabilize on the final approach speed as early as possible, it is necessary to exercise precise speed control during the glide slope intercept phase of the approach. The rate of descent varies with the glide slope angle and groundspeed. Expeditious and smooth corrections should be made based on the ILS course and glide slope indications. Apply corrections at approximately the same rate and amount as the flight path deviations.

The missed approach procedure is the same as a normal missed approach. Flight Director guidance appears if GA is selected. Refer to Missed Approach/Go-Around - All Approaches, this chapter.

AFDS Autoland Capabilities

Refer to the applicable AFM for a description of demonstrated autoland capabilities.

Initiation of an approach based on using autoland with any hydraulic system inoperative is not appropriate. However, for fail operational airplanes, if a hydraulic system becomes inoperative below alert height, the automatic approach may be continued through landing and rollout unless a NO AUTOLAND is displayed. The pilot should not intervene unless it is clearly evident that pilot action is required.

Note: For autoland use flaps 25 or 30.

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 AFDS ROLLOUT mode may cause the airplane to depart the runway.

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 glide slope antenna. In the United States, these areas are restricted from all vehicle or aircraft operation any time the weather is reported less than 800 foot ceiling and/or visibility is less than 2 miles.

When the weather is less than 200 foot ceiling or the RVR is 2,000 or less, vehicle or aircraft operations in or over these critical areas are not authorized when an arriving aircraft is inside the Middle Marker (MM).

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During Category III operations, the entire length of the preceding aircraft must be 250 feet clear of the runway centerline before an aircraft on an ILS approach reaches the Middle Marker or 200 feet AGL.

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.

Flight crews must remember that the ILS critical areas are usually not protected when the weather is above 800 foot ceiling and/or 2 mile 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, flight crews should be alert for this possibility and guard the flight controls (control wheel, rudder pedals and thrust levers) throughout automatic approaches and landings. Be prepared to disengage the autopilot and manually land or go-around.

The AFDS includes a monitor to detect significant ILS signal interference. If localizer or glide slope signal interference is detected by the monitor, the autopilot disregards erroneous ILS signals and remains engaged in an attitude stabilizing mode based on inertial data. Most ILS signal interferences last only a short period of time, in which case there is no annunciation to the flight crew other than erratic movement of the ILS raw data during the time the interference is present. No immediate crew action is required unless erratic or inappropriate autopilot activity is observed.

If the condition persists, it is annunciated on the attitude display. If the autopilot is engaged, annunciations alert the flight crew that the autopilot is operating in a degraded mode and the airplane may no longer be tracking the localizer or glide slope. When the condition is no longer detected, the annunciations clear and the autopilot resumes using the ILS for guidance.

Autolands on Contaminated Runways

AFDS 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 airplane 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. Consideration should also be given to the Landing Crosswind Guidelines published in chapter 6 of this manual or operator guidelines.

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.

AFDS System Configuration

The system configurations listed in this section do not include all of the systems and equipment required for each type of operation. Regulations may prescribe additional systems such as autobrakes, autothrottle or rain removal.

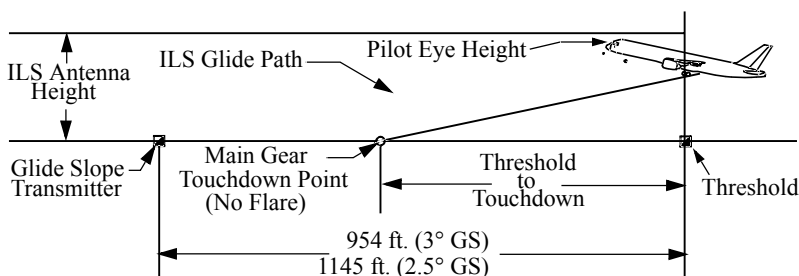
Compliance with the airworthiness performance standards for the autopilot and flight director does not constitute approval to conduct operations in lower weather minimums. The demonstrated conditions are not considered limiting. More detailed information concerning Category II and Category III operational requirements can be found in FAA advisory circulars or similar documents from other regulatory authorities.

ILS Approach/Landing Geometry

The following diagrams use these conditions:

- data is based on typical landing weight
- airplane body attitudes are based on Flaps 30, VREF 30 + 5 and should be reduced by 1° for each 5 knots above this speed
- pilot eye height measured at point when main gear crosses threshold
- airplane ILS antenna crosses threshold at 50 feet.

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Model	Glide Path (deg)	Airplane Body Attitude (deg)	Main Gear (feet)	Pilot Eye Height (feet)	Threshold to Main Gear Touchdown Point - No Flare (feet)
757 - 200	2.5	2.7	32	53	727
	3.0	2.2	32	53	605
757 - 300	2.5	2.2	31	53	717
	3.0	1.7	31	52	597

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 approaches. Touchdown RVR is normally controlling for Category I, II, and III approaches. For Category I and II approaches, mid and rollout RVR are normally advisory. For Category III operations mid and rollout RVR may be controlling. In some countries, visibility is used instead of RVR. Approval from the regulatory agency is required to use visibility rather than RVR.

During Category I approaches, visual reference requirements typically specify that either the approach lights or other aids be clearly visible to continue below DA(H). During Category I and II approaches, descent below 100 ft. above touchdown zone elevation requires the red terminating bars or red side row bars (ALSF or Calvert lighting systems, or ICAO equivalent, if installed) to be distinctly visible. If actual touchdown RVR is at or above the RVR required for the approach, the runway environment (threshold, threshold lights and markings, touchdown zone, touchdown lights and markings) should become clearly visible resulting in a successful approach. After acquiring the red terminating bars or red side row bars, if the runway environment does not become distinctly visible execute an immediate missed approach.

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Category III operations using fail passive autoland systems typically reach a DH of 50 ft. when approaching the threshold. In this instance, regulations require that the runway environment be clearly visible. If not, execute an immediate missed approach. Category III operations using fail operational autoland systems normally do not require specific visual references below AH.

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, expected runway exit, runway remaining lighting and expected taxi route during the approach briefing is recommended.

Regulatory agencies may require an additional 15% be added to the dry landing distance. Agencies may also require wind speed limitations less than maximum allowable autoland wind speeds found in the Operations Manual.

Category II Operations

Category II approaches may be conducted using single or multiple autopilots, or flight director only, with one or two engines. If an engine fails prior to final approach, the rudder must be trimmed for this condition. Autothrottles should be disconnected when the autopilot is disengaged. For single autopilot operation, the autopilot must be disengaged no lower than the minimum altitude listed in the Limitations Chapter of the Operations Manual.

Category II Approach Autopilot

The following equipment must be operative for an automatic approach requiring the use of Category II minima:

- 1 (or more) autopilots engaged
- 2 independent sources of electrical power. (The APU may be a substitute source of power for the left or right electrical system.)
- 2 attitude indicators supplied by different symbol generators including attitude, radio altitude, ILS deviation, DA(H) indication and AFDS status
757-200
- 2 (or 3) IRU's associated with the engaged autopilot(s) in Nav mode
757-300
- 2 (or 3) ADIRU's associated with the engaged autopilot(s) in Nav mode

Category II Approach Flight Director

The following equipment must be operative for a Flight Director (FD) approach requiring the use of Category II minima:

- 2 independent sources of electrical power. (The APU may be a substitute source of power for the left or right electrical system.)
- 2 separate flight directors, one of which must be the right FD
- 2 attitude indicators supplied by different symbol generators including attitude, radio altitude, ILS deviation, DA(H) indication and AFDS status

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757-200

- 2 (or 3) IRU's in Nav mode

757-300

- 2 (or 3) ADIRU's in Nav mode

Category III Operations

Category III operations are based on an approach to touchdown using the automatic landing system. Normal operations should not require pilot intervention. However, pilot intervention should be anticipated in the event inadequate airplane performance is suspected, or when an automatic landing cannot be safely accomplished in the touchdown zone. Guard the controls on approach through the landing roll and be prepared to take over manually, if required.

The airplane is certified for Category IIIB operations with two engines operating. The airplane is certified for Category IIIA operations with two engines operating or with one engine inoperative if the engine failure occurs during the final approach.

Note: Some airplanes are also certified for Category IIIA approach and autoland through rollout, with an engine inoperative prior to selecting landing flaps. See Engine Out Autoland tables in the ILS - One Engine Inoperative section.

Category IIIA/Autoland

For Category IIIA operations the following equipment must be operative and LAND 2 or LAND 3 annunciated:

- 2 independent sources of electrical power. (The APU generator may be a substitute source of power for the left or right electrical system.)
- 2 or 3 autopilots
- 3 hydraulic systems
- 2 attitude indicators supplied by different symbol generators including attitude, radio altitude, ILS deviation, DA(H) or AH indications, and AFDS status
- 2 (or 3) IRU's (associated with the engaged autopilots) in Nav mode
- autoland status annunciator for the pilot conducting the approach

Category IIIB/Autoland

For Category IIIB operations, visual reference is not normally a specific requirement for continuation of the approach to touchdown.

Category IIIB operations require the following equipment to be operative and LAND 3 annunciated:

- 3 autopilots
- 3 hydraulic systems

- autothrottle
 - 3 independent sources of electrical power. Normally the left generator, the right generator and the battery bus. (The APU generator may be a substitute source of power for the left or right engine driven generator.)
 - 2 autoland status annunciators
 - 2 attitude indicators supplied by different symbol generators including attitude, radio altitude, ILS deviation, AH or DA(H) indications, and AFDS status
- 757-200
- 3 IRU's in Nav mode
- 757-300
- 3 ADIRU's in Nav mode

AFDS Faults

Faults leading to non-normal operations can be divided into two categories:

- those occurring above AH
- those occurring at or below alert height.

Within these categories many non-normal situations or scenarios are possible. The flight deck is designed so that a quick analysis and decision can be made for virtually all non-normal or fault situations using the crew alerting system and autoland status annunciation.

If the flight crew is aware of the airplane equipment requirements for the approach, the following can be used for any AFDS fault indication:

| Above Alert Height

Immediately after recognizing the fault from the crew alerting system, instrument flags, or engine indications, check autoland status annunciation.

- if the autoland status annunciation has not changed, and the equipment is not required for the approach or can be switched, (e.g., flight director), continue the approach
- if the autoland status annunciation has changed, or the equipment is required for the approach, adjust to the appropriate higher minimums or go-around.

At or Below Alert Height

For any EICAS alert, continue the approach to an automatic landing and rollout unless NO AUTOLAND is displayed. The pilot should not intervene unless it is clearly evident that pilot action is required.

- |** A thorough fault analysis was included as a part of the fail operational certification. Below 200 feet AGL a safe landing and rollout can be made with any probable failure conditions.

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Flight crew alerts (messages, lights, or aural) may occur at any time during the approach. If a master caution or warning (amber or red light illuminated with the associated aural) occurs below alert height, do not disengage the autopilot unless the autopilot system is not controlling the airplane adequately. Below alert height, multiple autopilots protect against any probable system failure and will safely land the airplane. The pilot should not intervene below AH unless it is evident that pilot action is required. If a fault affects the autothrottle or autobrakes, assume manual control of thrust and braking. Accomplish related procedures for system faults after rollout is complete and manual control of the airplane is resumed.

If the autopilot is unintentionally disengaged below alert height, the landing may be completed if suitable visual reference is established. Be alert for the mistrim condition that may exist on some airplanes. With multiple autopilots engaged, 3 units of up trim may be introduced to prevent a hard landing if a flare fault occurs.

If a go-around is initiated with the autopilot disengaged, press the GA switch. If the GA switch is not pressed, the flight directors remain in the approach mode.



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Pilot Response to Approach, Landing, and Go-Around Alerts

Alert	Above 200 ft. AGL	Below 200 ft. AGL	During Rollout	During Go-Around
Master Warning/Caution Lights with EICAS Messages (see note)				
AUTOPILOT DISC (Warning)	*Execute manual go-around	**Execute manual go-around	Execute manual rollout	Execute manual go-around
AUTOPILOT (Caution)	*Execute go-around	**Execute go-around	Disengage autopilot and execute a manual rollout	Disengage autopilot and execute a manual go-around
AUTOTHROT DISC (Caution)	*Continue with manual throttle control (if Cat IIIb-go-around)	**Execute go-around	N/A	Continue with manual throttle control
SPEEDBRAKES EXT (Caution)	Retract speedbrakes	**Execute go-around	N/A	Retract speedbrakes
Autoland Status Annunciation				
NO LAND 3 or LAND 2	*Continue approach (if Cat IIIb-go-around)	N/A (message inhibited)	N/A	N/A
NO AUTOLAND	*Execute go-around	**Execute go-around	N/A	N/A
Flashing G/S or LOC Indicators (as installed)				
ILS Deviation Alert	*Execute go-around	**Execute go-around	N/A	N/A

* If suitable visual reference is not established.

** If suitable visual reference is established, land.

Note: All other EICAS messages are dealt with according to QRH procedures.

Non-Normal Operations (ILS or GLS)

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.

One Engine Inoperative

AFDS management and associated procedures are similar to those used during the normal ILS approach. Flight director (manual) or autopilot may be used. Weather minima for an ILS with one engine inoperative are specified in the applicable AFM and/or the operators Operational Specification or equivalent.

During a multiple autopilot approach, the pilot must use rudder pedal pressure to control yaw, followed by rudder trim to maintain an in-trim condition until descending below 1,500-foot radio altitude with localizer and glide slope captured. A centered control wheel indicates proper trim. When LAND 2 or LAND 3 annunciates, rudder inputs are controlled by the autopilots.

Some airplanes allow single autopilot use with APP mode engagement. During a single autopilot or flight director (manual) approach, the pilot must use rudder pedal pressure to control yaw, followed by rudder trim to maintain an in-trim condition. A centered control wheel indicates proper trim. During a single autopilot approaches, the pilot must control yaw during the entire approach. When accomplishing a single autopilot approach, disengage the autopilot at minimums.

Directional control (yaw) is not affected by rudder trim with the autopilot in the LOC or ROLLOUT modes. It may be desirable to center the rudder trim for taxi.

Note: Use of the autothrottle for an approach with an engine inoperative is not recommended.

Minimize thrust lever movements to reduce both asymmetry and speed changes. Airplane configuration changes require little thrust change until capturing the glide slope.

Intercept the localizer with flaps 5 at flaps 5 speed. When the glide slope is alive, lower the landing gear, extend flaps to 20, set final approach speed, and decelerate.

Be prepared to take over manually in the event system performance is not satisfactory.

Note: For airplanes with earlier FCCs, when the autopilots are disengaged prior to flare, be prepared to counter the UP trim bias used in some multiple autopilot approaches. Initial pitch force will be up to 30 pounds nose up. Maintain required rudder pedal pressure.

Autolands Not Allowed with Engine Inoperative Prior to Landing Flaps

The table below provides a tabulation of autopilot engine out operations for those airplanes which do not have the engine out autoland option activated. Note the areas in the table that are marked “not certified”.



Conditions		Engine Fails		
		Prior to landing flaps	After selecting landing flaps	Below Alert Height
Cat II	CMD or FD (fail safe approach only)	DISC A/T, flaps 20, no autoland	DISC A/T, flaps 20 or existing flaps if greater, no autoland	DISC A/T, no autoland
	LAND 2 (fail passive autoland)	Same as CMD or FD above	DISC A/T, flaps 25 or 30, normal autoland with manual throttle	DISC A/T, flaps 25 or 30, normal autoland with manual throttle
	LAND 3 (fail operational autoland)	Same as CMD or FD above	Same as LAND 2 above	Same as LAND 2 above
Cat IIIa	LAND 2 (fail passive autoland)	Not certified	Same as Cat II LAND 2 above	Same as Cat II LAND 2 above
	LAND 3 (fail operational autoland)	Not certified	Same as Cat II LAND 2 above	Same as Cat II LAND 2 above
Cat IIIb	LAND 3 (fail operational autoland)	Not certified	Not certified	Same as Cat II LAND 2 above
Note: Operation without engine inoperative autoland option.				

Autolands Allowed with Engine Inoperative Prior to Landing Flaps

Some airplanes have an engine out autoland option activated. This option provides the capability to conduct an automatic approach to Category IIIa minimums, with an engine initially inoperative, if the quality of the approach is satisfactory.

Additional engine-out logic is incorporated during runway alignment to ensure the downwind wing is not low at touchdown. If the crosswind is from the same side as the failed engine, then the airplane is crabbed by inducing a sideslip. This assures a wings-level approach. For moderate or strong crosswinds from the opposite side of the failed engine, no sideslip is induced as the failed engine high approach configuration guarantees an upwind wing low touchdown characteristic.

The table below provides a tabulation of autopilot engine out operations for those airplanes which have the engine out autoland option activated. Note the areas in the table that are marked “not certified.

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Conditions		Engine Fails		
		Prior to landing flaps	After selecting landing flaps	Below Alert Height
Cat II	CMD or FD (fail safe approach only)	DISC A/T, flaps 20, no autoland	DISC A/T, flaps 20 or existing flaps if greater, no autoland	DISC A/T, no autoland
	LAND 2 (fail passive autoland)	DISC A/T, flaps 25 or 30, normal autoland with manual throttle	DISC A/T, flaps 25 or 30, normal autoland with manual throttle	DISC A/T, flaps 25 or 30, normal autoland with manual throttle
	LAND 3 (fail operational autoland)	Same as LAND 2 above	Same as LAND 2 above	Same as LAND 2 above
Cat IIIa	LAND 2 (fail passive autoland)	Same as Cat II LAND 2 above	Same as Cat II LAND 2 above	Same as Cat II LAND 2 above
	LAND 3 (fail operational autoland)	Same as Cat II LAND 2 above	Same as Cat II LAND 2 above	Same as Cat II LAND 2 above
Cat IIIb	LAND 3 (fail operational autoland)	Not certified	Not certified	Same as Cat II LAND 2 above
Note: Operation with engine inoperative autoland option.				

Note: Approval to conduct Category II or Category III operations must be obtained by each operator from the appropriate authorities.

Engine Inoperative, Rudder Trim - All Instrument Approaches

Rudder trim may be set to zero to facilitate directional control during thrust reduction. This should be accomplished by 500 feet AFE to allow the PNF ample time to perform other duties and make appropriate altitude callouts.

Centering the rudder trim prior to 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.

However, 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.

Engine Failure On Final Approach

If an engine failure should occur on final approach with the flaps in the landing position, adequate thrust is available to maintain the approach profile using landing flaps, if desired.

A landing using flaps 25 or 30 might be preferable in some circumstances, especially if the failure occurs on short final or landing on runways where stopping distance is critical.

The ability to continue the approach with such a failure in Category III operations may also be a factor. If the approach is continued at flaps 25 or 30, advance the thrust to maintain the appropriate speed.

- If a go-around is required, follow the normal missed approach/go-around procedures, retracting the flaps to 20. Adequate performance is available at flaps 20. Subsequent flap retraction should be made at a safe altitude in level flight or a shallow climb.

It is usually preferable to continue the approach using flaps 20. This provides a better thrust margin, less thrust asymmetry and improved go-around capability. If the decision is made to reduce the flap setting, increase thrust to attain flaps 20 speed. Speed should be increased to 15 knots over the previously set flaps 25 or 30 VREF. This is equal to at least VREF for flaps 20.

If a go-around is required with flaps set at 20, maintain the additional 15 knots, select flaps 5 and continue the usual engine inoperative go-around. The decision to continue the approach at normal landing flaps, to retract the flaps to 20 or execute a go-around is a decision that should be made immediately.

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 on Boeing airplanes 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.
- GPS approach - an approach designed for use by airplanes using stand-alone GPS receivers as the primary means of navigation guidance. However, Boeing airplanes 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: A manual FMC entry of 0.3 RNP is required if not automatically provided.

- VOR approach
- NDB approach
- LOC, LOC-BC, LDA, SDF, IGS, TACAN, or similar approaches.

Non-ILS approaches are normally flown using VNAV or V/S pitch modes. Recommended roll modes are provided in the applicable Operations Manual procedure.

Non - ILS Instrument Approaches - General

Over the past several decades there have been a number of CFIT and unstabilized approach incidents and accidents associated with non-precision (non-ILS) approaches and landings. Many of these could be prevented by the use of constant angle approach methods. Traditional methods of flying non-ILS approaches involve setting a vertical speed on final approach, leveling off at step-down altitudes (if applicable) and at MDA(H), followed by a transition to a visual final approach segment and landing. These traditional methods involve changing the flight path at low altitudes and are not similar to methods for flying ILS approaches. Further, these traditional methods often require of the crew a higher level of skill, judgment and training than the typical ILS approach.

The following sections describe methods for flying non-ILS constant angle approaches. If used, 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 VNAV or V/S, as illustrated, assumes all preparations for the approach; such as review of the approach procedure and setting of minima and radio tuning have been completed. The procedures illustrated focuses generally on crew actions and avionics systems information. The flight pattern may be modified to suit local traffic and air traffic requirements.

The following discussions assume a straight-in instrument approach is being flown. A circling approach may be flown following an instrument approach using VNAV or V/S provided the MCP altitude is set in accordance with the circling approach procedure.

Types of Approaches

VNAV is the preferred method for accomplishing non-ILS approaches that have an appropriate vertical path defined on the FMC LEGS page. The section on Use of VNAV provides several methods for obtaining an appropriate path, to include published glide paths, and where necessary, a pilot constructed path. V/S may be used as an alternate method for accomplishing non-ILS approaches.

Use of the Autopilot during Approaches

Automatic flight is the preferred method of flying non-ILS approaches. Automatic flight minimizes flight crew workload and facilitates monitoring the procedure and flight path. During non-ILS approaches, autopilot use allows better course and vertical path tracking accuracy, reduces the probability of inadvertent deviations below path, and is therefore recommended until suitable visual reference is established on final approach.

Manually flying non-ILS approaches in IMC conditions increases workload without a significant increase in efficiency and protection provided by the automatic systems. However, to maintain flight crew proficiency, pilots may elect to use the flight director without the autopilot when in VMC conditions.

Note: Currently, the VNAV PTH mode contains no path deviation alerting. For this reason, the autopilot should remain engaged until suitable visual reference has been established.

Raw Data Monitoring Requirements

During localizer-based approaches; LOC, LOC-BC, LDA, SDF, and IGS, applicable raw data must be monitored throughout the approach.

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With a single operational FMC, during VOR approaches one pilot must have raw data from the VOR associated with the approach displayed on the RDMI or RMI (as installed) with separate DME display, or HSI in a VOR mode no later than the final approach fix. During other non-localizer based approaches where the FMC is used for course or path tracking (VOR, TACAN, NDB, RNAV, GPS, etc.), Boeing recommends monitoring raw data if it is available. For airplanes with two operational FMCs, two IRSs and two GPS receivers (or two DME receivers if GPS updating is not available), or if the FMC is RNP/ANP capable, raw data monitoring is not required.

Note: The FMC is RNP/ANP capable if RNP/ANP is displayed on the applicable FMC POS REF page.

During non-localizer based approaches where the FMC is used for course or path tracking (TACAN, NDB, RNAV etc.), if only one FMC or one IRS or one DME is operational, or the FMC is not RNP capable, raw data must be monitored or checked if available for correct navigation or the update mode should be checked no later than final approach.

During single FMC, single IRU, or single DME or single GPS operation, in the event the single operational FMC, IRU, DME, or GPS fails during the FMC approach, there must be a non-FMC means of navigation available for a missed approach such as VOR/NDB raw data and/or radar, and there must be a non - FMC approach available. Failure of the remaining single DME need not be considered if GPS updating is being used.

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.

When raw data VOR information is required, the manual tuning feature may be used to pretune the appropriate frequency and select the course prior to starting the approach. The frequency may then be returned to automatic control. When required for the approach, selection of the VOR mode restores the preset frequency. With a single operational FMC, monitoring of VOR raw data is required no later than the final approach fix. Use of the VOR course and DME information displayed on the RDMI or RMI (as installed) with DME display, or one EHSI in a VOR mode satisfies this requirement.

Note: When appropriate, compare airplane position on the map with ILS, VOR, DME, and ADF systems to detect possible map shift errors. Use of the VOR mode selectable on the EFIS control panel is the recommended method for making this comparison. If ADF pointers are available, they should be displayed on the map.

RNAV Approaches

RNAV approaches may be flown with any RNP alerting capable FMC (Pegasus) provided the RNP being used is equal to or less than the RNP specified for the approach and is consistent with the AFM demonstrated RNP capability.

FMCs that are not RNP alerting capable (prior to Pegasus) may be used for RNAV approaches provided the following requirements are met:

- the approach has an RNP no smaller than 0.5NM
- the pilot ensures that DME-DME updating is active prior to commencing the approach.

With non-RNP alerting capable FMCs, VNAV PTH may be used to fly final approach, however the MDA(H) published for the approach must be observed. As a technique, use MDA(H) + 50 feet as the decision altitude and use the same procedure as is published in the Operations Manual for Instrument Approach Using VNAV. Use of a VNAV DA(H) is not appropriate.

Approach Requirements Relating to RNP

With appropriate operational approval, approaches requiring RNP alerting may be conducted in accordance with the following provisions:

- AFM indicates that the airplane has been demonstrated for selected RNP
- at least one GPS or one DME is operational
- any additional GPS or DME requirements specified by Operations Specification or by the selected terminal area procedure must be satisfied
- when operating with the following RNP values, or smaller:

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Approach Type	RNP
NDB, NDB/DME	0.6 NM
VOR, VOR/DME	0.5 NM
RNAV	0.5 NM
GPS	0.3 NM

- no UNABLE RNP alert is displayed during the approach

Use of LNAV

To use LNAV for approaches and missed approaches, a proper series of legs/waypoints that describe the approach route (and missed approach) must appear on the LEGS page. There are two methods of loading these waypoints:

- Database Selection

This method is required for RNAV and GPS approaches. An approach procedure selected through the FMC ARRIVALS 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 the approach to be flown is not in the database, another approach having the same plan view may be selected. For example, an ILS procedure might be selected if the plan view (route) is identical to an NDB approach. In this case, waypoint altitudes must be checked and modified as required. When an approach is flown by this "overlay" method, raw data should be monitored throughout the approach to assure obstacle clearance.

Note: If an NDB approach for the desired runway is in the database, an overlay approach should not be used.

If a waypoint is added to or deleted from a database procedure, FMC "on approach" logic (as described in the Operations Manual) is partially or completely disabled and the VNAV obstacle clearance integrity of the procedure may be adversely affected. If an additional waypoint reference is desired, use the FIX page and do not modify waypoints on the LEGS page.

- Manual Waypoint Entry

Due to potentially inadequate terrain clearance, manual waypoint entry should not be accomplished for RNAV or GPS approaches, nor should this method be used with VNAV after the FAF.

When no procedure is available from the FMC ARRIVALS page, manual entry of a series of waypoints may be accomplished to define the approach routing. The waypoints may be conveniently defined by using names of waypoints or nav aids in the database, bearing/distance from such fixes, intersections of radials or latitude/longitude information.

Procedure turns and DME arcs cannot usually be manually entered (unless they can be defined by a series of waypoints). Deviation from the defined route may require use of “DIRECT TO” or “INTERCEPT LEG TO/INTERCEPT COURSE TO” when intercepting the inbound course. Constant monitoring of raw data during the approach is required.

Note: Procedure turns and DME arcs may require use of HDG SEL.

LNAV cannot be used to track fix or radial data displayed on the map. 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. A similar display may be created by manually tuning an appropriate VOR and selecting the desired course. These methods provide reference information on the map display only. They are not reflected on the LEGS page and cannot be tracked with LNAV. 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 FMC calculated course and is not raw data information.

Note: HDG SEL should be used to fly the approach ground track.

Note: VNAV PTH operation using speed intervention is not available with manually entered waypoints.

If the approach is not available in the NAV database, select the landing runway from the FMC ARRIVALS page. The runway and associated extended centerline then displays on the map to aid in maintaining position awareness.

Pilots should not become involved in excessive “heads down” FMC manipulation to build map displays while at low altitude. Raw data VOR, ILS, and ADF displays should be used to avoid distractions during higher workload phases of flight. Map building should be avoided below 10,000 feet AGL.

Use of VNAV

Approaches using VNAV may be accomplished using any of the recommended roll modes provided in the applicable Operations Manual procedure.

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A vertical path suitable for use of VNAV is one that approximates 3° and crosses the runway threshold at approximately 50 feet. To obtain such a VNAV path, maximum use of the navigation database is recommended. For approaches where an RNP is specified, or approaches where a DA(H) is used, the waypoints in the navigation database from the FAF onward may not be modified except to add a cold temperature correction, when appropriate, to the waypoint altitude constraints. With respect to the construction of a suitable final approach path, there are two types of approaches in the navigation database:

- approaches with a glide path (GP) angle displayed on the final approach segment of the LEGS page. The final approach segment is completely compatible with VNAV and complies with final approach step down altitudes (minimum altitude constraints).
- approaches where no GP angle is published and where the approach end of the runway is defined by a runway waypoint (RWxx) or a missed approach point fix (MXxx or a named waypoint) exists. Normally these waypoints display an approximate 50 foot threshold crossing altitude constraint and may be used “as is” for VNAV. If the RWxx waypoint altitude constraint does not coincide with approximately 50 feet, this waypoint may be modified with a threshold crossing altitude of approximately 50 feet.

Note: Threshold crossing altitude normally require entry of a four-digit number. Example: enter 80 feet as 0080.

VNAV may be used for approaches modified in this way; however, the approach should be flown by constant reference to raw data (VOR, NDB, DME, etc.) and compliance with each minimum altitude constraint is required. Use of a DA(H) is not appropriate when the final approach is manually constructed in this manner.

Note: ILS approaches are in the process of being coded with the appropriate threshold crossing height. When coded in this way, approaches may be used as an overlay for a LOC or NDB approach, for example, and the need for this waypoint altitude constraint modification by the crew is eliminated.

VNAV should not be used for approaches containing no waypoint (RWxx or MXxx) coincident with the approach end of the runway since the path does not provide a normal glide path. An example of such an approach is a VOR approach with a MAP beyond the runway threshold. These approaches are gradually being re-coded to permit VNAV path operation.

Note: Approaches designated for circling only are not VNAV compatible.

With the autopilot engaged, the EICAS alert message AUTOPILOT and VNAV mode fail indications are available to alert the flight crew of potential problems with the flight path.

When appropriate, crews should make cold temperature altitude corrections by adding a correction from an approved table to the waypoint altitude constraints. VNAV PTH operation and procedure tuning function normally; however, the airplane follows the higher of the glide path angle associated with the approach (if available) or the geometric path defined by the waypoint altitude constraints.

When on final approach, VNAV should be used with speed intervention active to reduce workload. Adding speed constraints to the final approach waypoints is not recommended because of the extra workload, no safety benefit, and reduced ability to make last minute approach changes.

To prevent unnecessary leveloffs while descending in VNAV prior to the final approach, reset the MCP altitude selector to the next lower constraint prior to altitude capture when the altitude restriction is assured.

Use of Altitude Intervention (As installed) during Approaches using VNAV

Altitude intervention is appropriate during approaches only if the AFDS enters VNAV ALT mode above the approach path and descent must be continued.

Entering VNAV ALT mode can occur if passing a waypoint on the approach and the crew has failed to reset the MCP altitude to a lower altitude. If this occurs, set the MCP altitude to the next lower altitude constraint or the DA(H) or MDA(H), as appropriate, and select altitude intervention. When VNAV altitude intervention is selected, VNAV path deviation indications on the map display disappear momentarily while the path is recalculated, but should reappear.

If altitude intervention is selected when on-approach logic is active, typically after the airplane has sequenced the first approach waypoint, level flight is commanded until reaching the VNAV path, then the airplane captures the VNAV path.

Note: When a PROC HOLD is active, VNAV altitude intervention functions normally by causing the next waypoint altitude constraint to be deleted and a descent to be initiated.

Non - ILS Approach - One Engine Inoperative

Engine out maneuvering prior to and after the final approach fix with one engine inoperative is the same as an all engine non-ILS approach.

Procedure Turn and Initial Approach

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

Cross the IAF at flaps 5 and flaps 5 maneuvering airspeed and monitor the procedure turn using the map to assure the airplane remains within protected airspace. The depicted procedure turn, or holding pattern in lieu of procedure turn, complies with approach airspace limits.

Note: If the fix is crossed at an excessively high ground speed, the procedure turn protected airspace may be exceeded.

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If a complete arrival procedure has been selected via the CDU, the initial approach phase may be completed using LNAV and VNAV path, or other appropriate modes. Ensure the LEGS page sequences, altitude restrictions and map display reflects the air traffic clearance. Last minute air traffic changes or constraints may be managed by appropriate use of the MCP heading and altitude selectors. Updating the LEGS page sequencing should be accomplished only as time permits.

Vertical Path Construction

This section describes typical final approach vertical profile (path) construction criteria as they relate to flying instrument approaches using VNAV. This information may also be useful to pilots who wish to fly the vertical path using V/S.

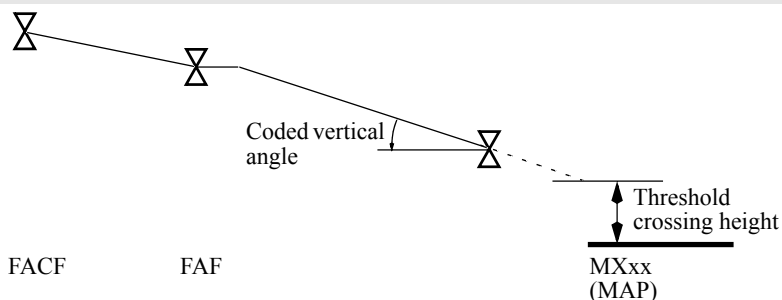
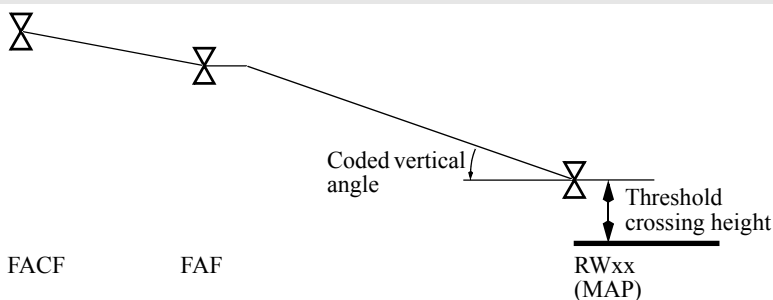
Where there is a glide path (GP) angle coded in the navigation database, the FMC builds the descent path upward and back in the direction of the FAF by starting at the location of the missed approach waypoint (MAP) and its associated altitude constraint. The FMC calculates this path using the coded GP angle, also called the vertical angle. The MAP is normally shown on the LEGS page as a RWxx or MXxx waypoint. In some cases a named waypoint is used as the MAP. A GP angle is coded in the navigation database for nearly all approach procedures. Approaches identified as circling only do not have a GP angle.

This GP angle is normally defined by the state authority responsible for the approach procedure and provides a continuous descent at a constant flight path angle for a final approach path that complies with minimum altitudes at intermediate step down fixes. The typical GP angle is approximately 3.00°, but can vary from 2.75° to 3.77°.

The projection of the vertical path upward and back toward the FAF along this coded GP angle stops at the next higher limiting altitude in the vertical profile. This limiting altitude is the more restrictive of the following:

- the “At” altitude on the constrained waypoint preceding the MAP
- the crossing altitude on the next “at or above” constrained waypoint preceding the MAP
- the speed transition or the speed restriction altitude, whichever is lower
- cruise altitude.

The following examples show typical VNAV final approach paths where there is a GP angle in the navigation database. The first example shows an RWxx missed approach waypoint. The second example below shows the VNAV final approach path where there is a missed approach waypoint prior to the runway. Note that in the second case the projected path crosses the runway threshold at approximately 50 feet. VNAV guidance is level flight, however, when the airplane passes the missed approach point. Both examples are for “At” altitude constraints at the FAF.



Note: The final approach course fix (FADF) is typically located on the final approach course approximately 7 NM prior to the FAF. The FAF referred to in the following procedures refers to the charted FAF and is intended to mean the point at which the final approach descent is begun.

For the non-ILS approach procedures with an “At” constraint altitude at the FAF, a short, level segment between the FAF and the final glide path (also called a “fly-off”) may result. For the ILS procedure, the constraint altitude at the FAF is computed to be the crossing altitude of the glide slope.

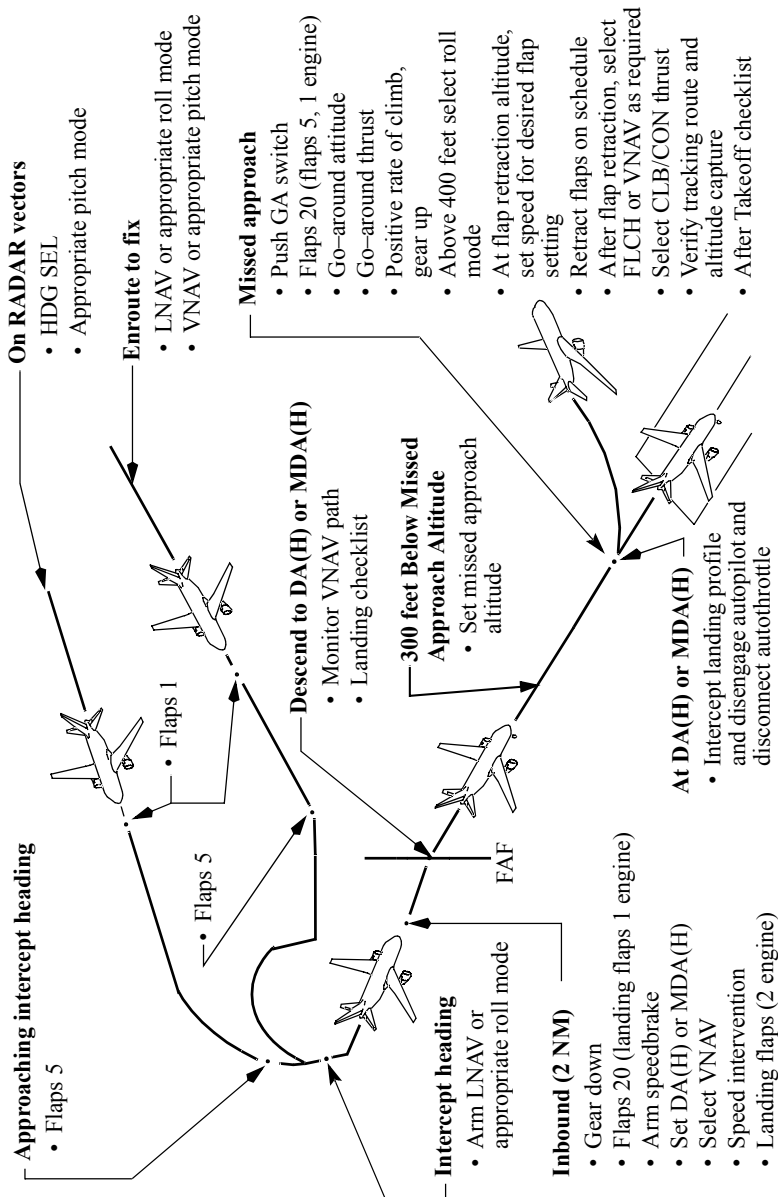
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Crews can expect to see several other variations of approach path construction:

- approaches where the FAF has an “at or above” waypoint altitude constraint. The GP angle normally terminates at the FACF altitude constraint or the cruise altitude, whichever is lower. When this type of path is flown, the airplane passes above the FAF.
- where there is more than one GP angle, such as for ILS approaches, the airplane uses the GP angle for the active leg to define the VNAV approach path. These types of paths are shown on the LEGS page as having two GP angle values, one approaching the FAF, the second approaching the runway (missed approach point).

Note: The coded GP angle is steeper than normal in temperatures warmer than ISA standard and is shallower than normal in temperatures colder than ISA standard.

Instrument Approach Using VNAV



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Approach Preparations for using VNAV

Select the approach procedure from the ARRIVALS page of the FMC. Tune and identify appropriate navaids. Do not manually build the approach or add waypoints to the procedure. If additional waypoint references are desired, use the FIX page. To enable proper LNAV waypoint sequencing, select a straight-in intercept course to the FAF when being radar vectored to final approach. Verify/enter the appropriate RNP and set the DA(H) or MDA(H) using the baro minimums selector. If required to use MDA(H) for the approach minimum altitude, the barometric minimums selector should be set at MDA + 50 feet to ensure that if a missed approach is initiated, descent below the MDA(H) does not occur during the missed approach.

Note: The approach RNP is not displayed until the first waypoint of the approach is sequenced unless the pilot manually enters an RNP.

Final Approach using VNAV

Approaching intercept heading, select flaps 5 and ensure LNAV or other appropriate roll mode is armed or engaged. Approaching the FAF (approximately 2 NM), select gear down and flaps 20 and adjust speed. Set the DA(H) or MDA(H) in the MCP altitude window, select VNAV, and ensure VNAV PTH and appropriate roll mode is annunciated. Use VNAV speed intervention to control speed.

Note: If desired altitude is not at an even 100 foot increment, set the MCP altitude to the nearest 100 ft. increment below the altitude constraint or MDA(H).

Just prior to FAF, select landing flaps, reduce to final approach speed and complete the Landing checklist. If the charted FAF is too close to the runway to permit a stabilized approach, consider establishing final approach pitch mode and configuring for approach and landing earlier than specified in the Operations Manual procedure.

With the MCP altitude set to DA(H) or MDA(H) and the airplane stabilized on the final approach path, the map altitude range arc assists in determining the visual descent point (VDP). As soon as the airplane is at least 300 feet below the missed approach altitude and stabilized on final approach in VNAV PTH, set the MCP altitude to the missed approach altitude. VNAV path deviation indications on the map display assist in monitoring the vertical profile. The autopilot tracks the path in VNAV PTH resulting in arrival at, or near, the visual descent point by the DA(H) or MDA(H).

Minimum Descent Altitude (MDA(H))/Decision Altitude (DA(H))

When specifically authorized by the instrument procedure and regulatory authority, approaches may be flown to the following minima:

- a published VNAV DA(H)
- a published MDA(H) used as a decision altitude

When either of the above minima are not specifically authorized, use the MDA(H) specified for the instrument procedure.

When reaching the DA(H) or MDA(H), be prepared to disengage the autopilot, disconnect the autothrottle and land or execute an immediate go-around.

Note: If using an MDA(H), initiating a missed approach approximately 50 feet above MDA(H) may be necessary to avoid descending below the MDA(H) during the missed approach, if required for the procedure or by the regulatory authority.

The pilot not flying should expand the instrument scan to include outside visual cues when approaching DA(H) or MDA(H). Do not continue the approach below DA(H) or MDA(H) unless the airplane 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 MDA(H) or any time thereafter, if any of the above requirements are not met, immediately execute the missed approach procedure.

When suitable visual reference is established, maintain the descent path to the flare. Do not descend below the visual glide path. While VNAV PTH guidance may still be used as a reference once the airplane is below DA(H) or MDA(H), the primary means of approach guidance is visual.

Note: VNAV path guidance transitions to level flight once the missed approach fix is passed.

Simulated Instrument Approach Using VNAV

To maintain proficiency, crews may practice instrument approach using VNAV procedures while flying ILS approaches as follows:

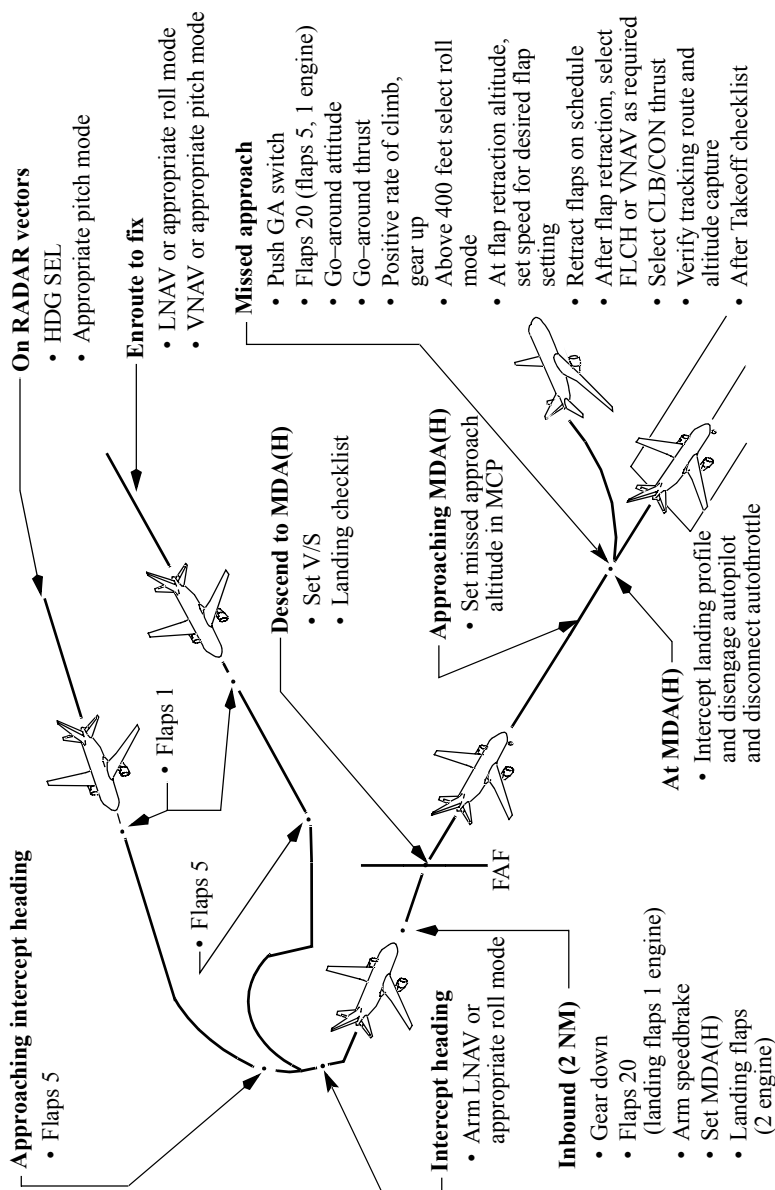
- ensure the ILS is tuned and identified and the ILS raw data is monitored throughout the approach
- track the localizer using LOC or LNAV as the roll mode
- use VNAV as the pitch mode to track the GP angle. The charted GP angle normally coincides with the ILS glide slope angle
- disengage autopilot by the minimum altitude specified in the limitations chapter of the Operations Manual.

Note: Limit the use of the above technique to VMC weather conditions.

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In ambient temperature conditions warmer than ISA standard, the airplane may remain slightly high relative to the ILS glide slope, and in temperatures colder than ISA standard, the airplane may remain slightly lower than the ILS glide slope. Discontinue use of this technique and manually track the localizer and glide slope if localizer or glide slope deviations become unacceptable.

Instrument Approach Using V/S



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Approach Preparations for using V/S

Select the approach procedure from the ARRIVALS page of the FMC. Tune and identify appropriate nav aids. If additional waypoint references are desired, use the FIX page. To enable proper LNAV waypoint sequencing, select a straight-in intercept course to the FAF when being radar vectored to final approach.

Verify/enter the appropriate RNP and set the MDA(H) using the baro minimums selector. If required to use MDA(H) for the approach minimum altitude, the barometric minimums selector should be set at MDA + 50 feet to ensure that if a missed approach is initiated, descent below the MDA(H) does not occur during the missed approach.

Final Approach using V/S

Approaching intercept heading, select flaps 5 and ensure LNAV or other appropriate roll mode is armed or engaged. Approaching the FAF (approximately 2 NM), select gear down and flaps 20 and adjust speed. Set the MCP altitude window to the first intermediate altitude constraint, or MDA(H) if no altitude constraint exists.

Note: If desired altitude is not at an even 100 foot increment, set the MCP altitude to the nearest 100 ft. increment below the altitude constraint or MDA(H).

Just prior to FAF, select landing flaps, reduce to final approach speed and complete the Landing checklist. If the charted FAF is too close to the runway to permit a stabilized approach, consider establishing final approach pitch mode and configuring for approach and landing earlier than specified in the Operations Manual procedure.

At or after the FAF, select V/S mode and descend at appropriate vertical speed to arrive at the MDA(H) at a distance from the runway (VDP) to allow a normal landing profile. Initial selection of an appropriate V/S should be made considering the recommended vertical speeds that are published on the approach chart, if available. These recommended vertical speeds vary with the airplane's ground speed on final approach. If no recommended vertical speeds are available, set approximately -700 to -800 fpm.

When stabilized in a descent on final approach, use one of the following techniques to make small incremental changes to the resulting vertical speed to achieve a constant angle descent to minimums. There should be no level flight segment at minimums.

Several techniques may be used to achieve a constant angle path that arrives at MDA(H) at or near the VDP:

- the most accurate technique is to monitor the VNAV path deviation indication on the map display and adjust descent rate to maintain the airplane on the appropriate path. This technique requires the path to be defined appropriately on the LEGS page and that the header GPx.xx is displayed for the missed approach point or there is a RWxx, MXxx, or named waypoint on the legs page with an altitude constraint which corresponds to approximately 50 ft. threshold crossing height. When this method is used, crews must ensure compliance with each minimum altitude constraint on the final approach segment (step down fixes).
- select a descent rate that places the altitude range arc at or near the stepdown fix or visual descent point (VDP). This technique requires the stepdown fix or MDA(H) to be set in the MCP and may be difficult to use in turbulent conditions. See the Visual Descent Point section for more details on determining the VDP.
- using 300 feet per mile for a 3° path, determine the desired HAA which corresponds to the distance in NM from the runway end. The PNF can then call out recommended altitudes as the distance to the runway changes (Example: 900 feet - 3 NM, 600 feet - 2NM, etc.). The descent rate should be adjusted in small increments for significant deviations from the nominal path.

Be prepared to land or go-around from the MDA(H) at the VDP. Note that a normal landing cannot be completed from the published missed approach point on many instrument approaches.

Approximately 300 feet above the MDA(H), select the missed approach altitude. Leaving the MDA(H), disengage the autopilot and disconnect the autothrottle. Turn both F/Ds OFF, then place the PNF's F/D ON. This eliminates unwanted commands for the PF and allows continued F/D guidance for the PNF in the event of a go-around when pitch or roll mode is changed. Complete the landing.

Minimum Descent Altitude/Height (MDA(H))

The pilot not flying should expand the instrument scan to include outside visual cues when approaching MDA(H). Do not continue the approach below MDA(H) unless the airplane 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 MDA(H) or any time thereafter, if any of the above requirements are not met, immediately execute the missed approach procedure.

When suitable visual reference is established, maintain the descent path to the flare. Do not descend below the visual glide path.

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Minimum Descent Altitude (MDA (H))/ Decision Altitude (DA(H))

Non-ILS approach using VNAV

When specifically authorized by the instrument procedure and regulatory authority, approaches may be flown to the following minima:

- a published VNAV DA(H)
- a published MDA(H) used as a decision altitude.

When either of the above minima are not specifically authorized, use the MDA(H) specified for the instrument procedure.

The diagram below illustrates an approach procedure containing DA(H) and MDA(H) minimums for approaches using LNAV/VNAV or LNAV only.

STRAIGHT-IN LANDING RWY 28R				CIRCLE - TO - LAND	
LNAV/VNAV DA(H) 720' (709')		LNAV MDA(H) 1000' (989')			
	ALS out		ALS out	Max Kts	MDA(H)
A	2	2 1/2	RVR 40 or 3/4	90	1000' (989') - 2 1/2
B			RVR 50 or 1	120	
C			2 1/2	140	
D				160	
	2 1/4		3		1000' (989') - 3

Note: Some non-ILS approaches specify a VNAV DA(H). Regulations may require use of the autopilot in the VNAV PTH mode to permit use of the DA(H).

When reaching the DA(H) or MDA(H), be prepared to continue the approach to landing or execute an immediate go-around. If continuing to landing, disengage the autopilot and disconnect the autothrottle no later than the single autopilot minimum use height.

Note: If using an MDA(H), initiating a missed approach approximately 50 feet above MDA(H) may be necessary to avoid descending below the MDA(H) during the missed approach, if required for the procedure or by the regulatory authority.

The pilot not flying should expand the instrument scan to include outside visual cues when approaching DA(H) or MDA(H). Do not continue the approach below DA(H) or MDA(H) unless the airplane 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 MDA(H) or any time thereafter, if any of the above requirements are not met, immediately execute the missed approach procedure.

When suitable visual reference is established, maintain the descent path to the flare. Do not descend below the visual glide path. While VNAV PTH guidance may still be used as a reference once the airplane is below DA(H) or MDA(H), the primary means of approach guidance is visual.

Note: VNAV path guidance transitions to level flight once the missed approach fix is passed.

Vertical Speed Approach

Use the MDA(H) specified for the instrument procedure.

The pilot not flying should expand the instrument scan to include outside visual cues when approaching MDA(H). Do not continue the approach below MDA(H) unless the airplane 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 MDA(H) or any time thereafter, if any of the above requirements are not met, immediately execute the missed approach procedure.

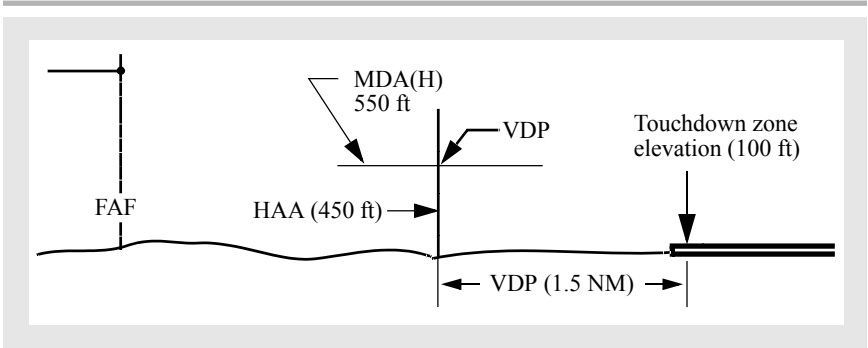
When suitable visual reference is established, maintain the descent path to the flare. Do not descend below the visual glide path.

Visual Descent Point

For a non-ILS approach, the VDP is defined as the position on final approach from which a normal descent from the MDA(H) to the runway touchdown point may be initiated when suitable visual reference is established. If the airplane arrives at the VDP, a stabilized visual segment is much easier to achieve since little or no flight path adjustment is required to continue to a normal touchdown.

VDPs are indicated on some non-ILS approach charts by a "V" symbol. The distance to the runway is shown below the "V" symbol. If no VDP is given, the crew can determine the point where to begin the visual descent by determining the height above the airport (HAA) of the MDA(H) and use 300 feet per NM distance to the runway.

In the following example, an MDA(H) of 550 feet MSL with a 100 feet touchdown zone elevation results in a HAA of 450 feet. At 300 feet per NM, the point to begin the visual descent is 1 ½ NM distance from the runway.

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Most VDPs are between 1 and 2 NM from the runway. The following table provides more examples.

HAA (feet)	300	400	450	500	600	700
VDP Distance, NM	1.0	1.3	1.5	1.7	2.0	2.3

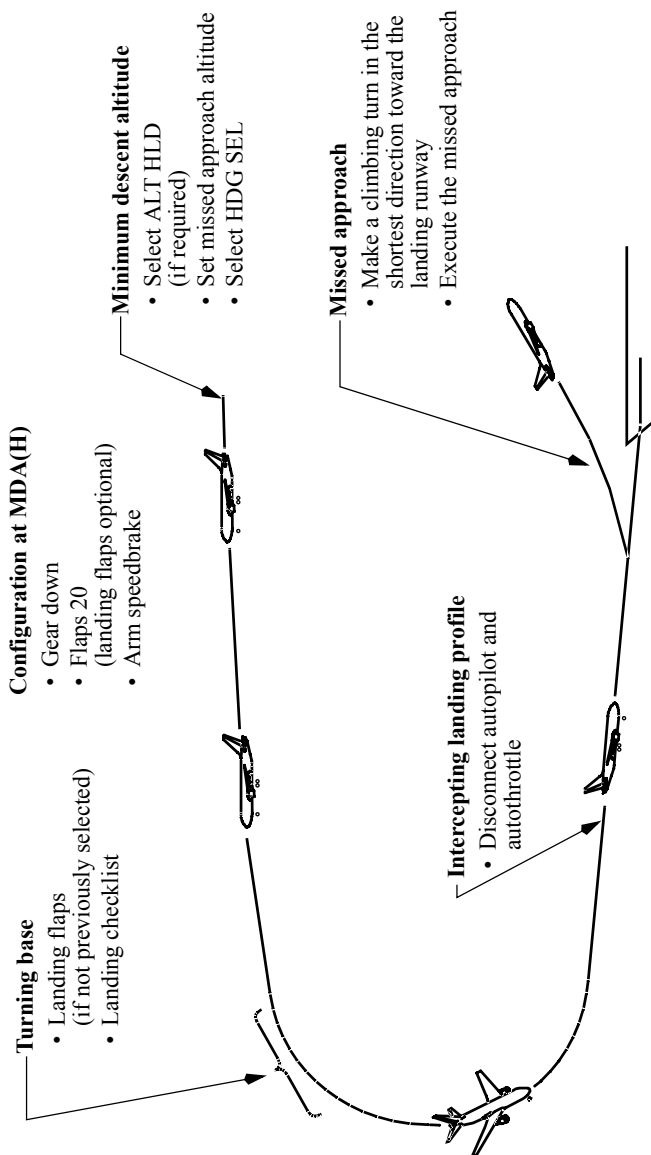
Note: If flying a VNAV path approach and the airplane remains on the published path, then the VDP is automatically complied with when the airplane arrives at the DA(H) or MDA(H). It is not necessary to determine the point to begin the visual descent for VNAV path approaches for this reason.

When flying an instrument approach using V/S, if the pilot adjusts the altitude range arc to approximately the VDP distance in front of the runway by varying the vertical speed, the airplane will remain close to or on the proper path for typical non-ILS approaches.

Missed Approach - Non-ILS

Refer to Missed Approach/Go-Around - All Approaches, this chapter.

Circling Approach



Circling Approach - General

The circling approach should be flown with landing gear down, flaps 20, and at flaps 20 maneuvering speed. Use the weather minima associated with the anticipated circling speed. As an option the approach may be flown with flaps 25 or 30. Maintain MDA(H) using ALT HOLD mode and use HDG SEL or HDG HOLD for the maneuvering portion of the circling approach. If circling from an ILS approach, fly the ILS in LOC and VNAV or V/S modes.

Note: If the MDA(H) does not end in “00”, select ALT HOLD when the airplane reaches MDA(H).

Use of the APP mode for descent to a circling approach is not recommended for several reasons:

- the AFDS does not level off at MCP altitude
- exiting the APP mode requires initiating a go-around or disconnecting the autopilot and turning off the flight directors.

When in altitude hold at MDA(H) and prior to commencing the circling maneuver, set the missed approach altitude.

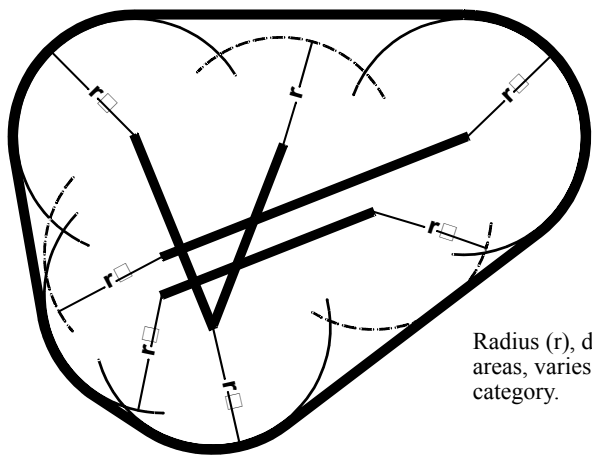
Initiating the turn to base leg, select landing flaps and begin decelerating to the approach speed plus wind correction. To avoid overshooting final approach course, adjust the turn to final to initially aim at the inside edge of the runway threshold. Timely speed reduction also reduces turning radius to the runway. Complete the landing checklist. Do not descend below MDA(H) until intercepting the visual profile to the landing runway.

Leaving MDA(H), disengage the autopilot and disconnect the autothrottle. After intercepting the visual profile, cycle both F/D to OFF, and select the PNF F/D to ON. This eliminates unwanted commands for the PF and allows continued F/D guidance for the PNF in the event of a go-around when pitch or roll mode is changed. Complete the landing.

Note: If a go-around is selected with F/D switches off, the F/D commands disappear when the first pitch or roll mode is selected or engaged.

Obstruction Clearance

Obstruction clearance areas during the circling approach are depicted in the following figure. Distances are determined by aircraft approach category. Adjust airplane heading and timing so that the airplane ground track does not exceed the obstruction clearance distance from the runway at any time during the circling approach.



Radius (r), defining size of areas, varies with airplane category.

Aircraft Category	FAA Obstruction Clearance Radius (r)	ICAO Obstruction Clearance Radius (r)
C	1.7 NM	4.2 NM
D	2.3 NM	5.28 NM

Circling Approach - One Engine Inoperative

If a circling approach is anticipated, maintain gear down, flaps 20 and a minimum of VREF 20 + wind correction while circling. Do not descend below MDA(H) until intercepting the visual profile.

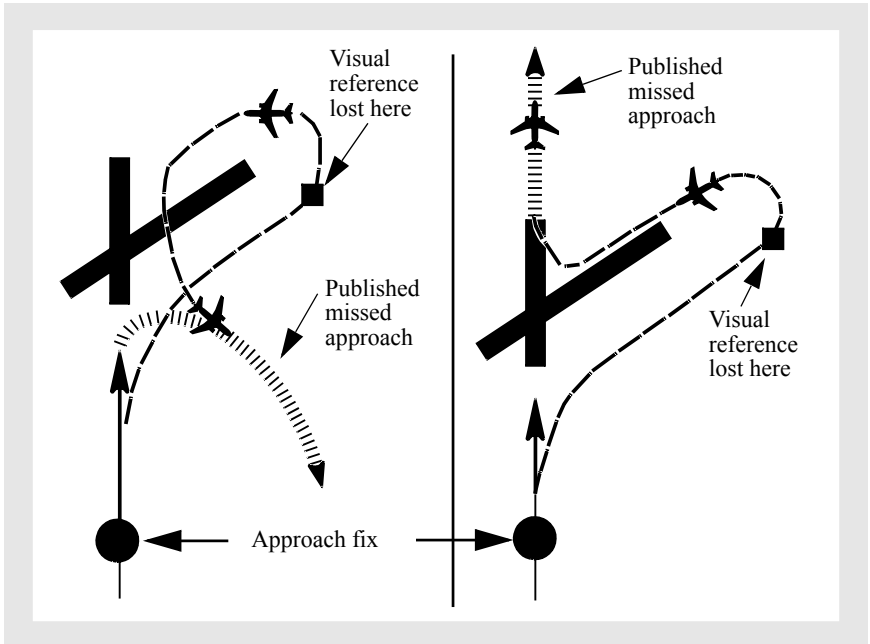
Under some flight conditions such as high temperatures, high pressure altitudes, and high airplane weight, limit thrust may be required to maintain level flight with the gear down and flaps 20. When these conditions are encountered consider retracting the landing gear for the circling portion of the approach after the descent to MDA(H). The GPWS gear override switch may be used to prevent nuisance warnings.

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. 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.

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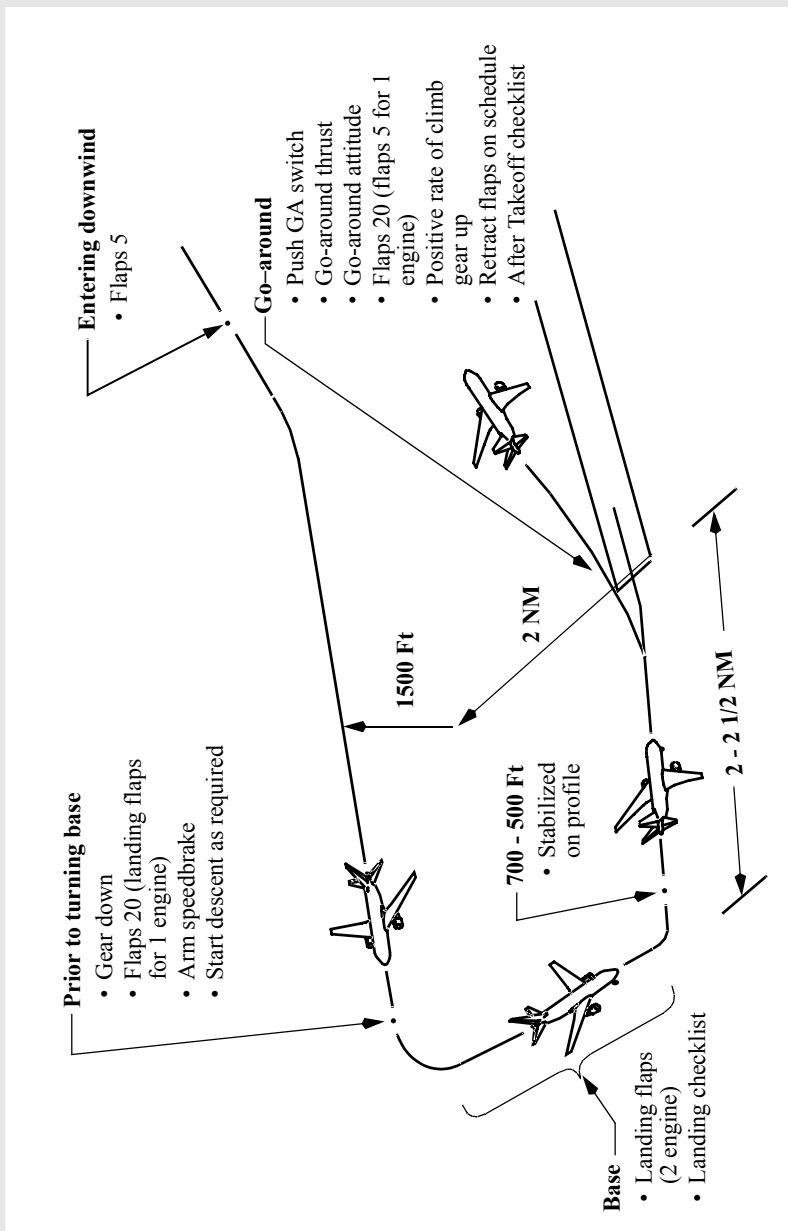
Different patterns may be required to become established on the prescribed missed approach course. This depends on airplane position at the time the missed approach is started. The following figure illustrates the maneuvering that may be required. This ensures the airplane remains within the circling and missed approach obstruction clearance areas.



In the event that a missed approach must be accomplished from below the MDA(H), consideration should be given to selecting a flight path which assures safe obstacle clearance until reaching an appropriate altitude on the specified missed approach path.

Refer to Missed Approach/Go-Around - All Approaches, this chapter.

Visual Traffic Pattern



Visual Approach - General

The recommended landing approach path is approximately $2\frac{1}{2}^{\circ}$ to 3° . Once the final approach is established, the airplane 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.

Thrust

Engine thrust and elevators are the primary means to control attitude and rate of descent. Adjust thrust slowly using small increments. Sudden large thrust changes make airplane control more difficult and are indicative of an unstable approach. No large changes should be necessary except when performing a go-around. Large thrust changes are not required when extending landing gear or flaps on downwind and base leg. A thrust increase may be required when stabilizing on speed on final approach.

Downwind and Base Leg

Fly at an altitude of 1500 feet above the runway elevation and enter downwind with flaps 5 at flaps 5 maneuvering speed. Maintain a track parallel to the landing runway approximately 2 NM abeam.

Prior to turning base leg, extend the landing gear, select flaps 20, arm the speedbrake, and slow to flaps 20 maneuvering speed or approach speed plus wind correction if landing at flaps 20. If the approach pattern must be extended, delay lowering gear and selecting flaps 20 until approaching the normal visual approach profile. Turning base leg, adjust thrust as required while descending at approximately 600-700 fpm.

Extend landing flaps prior to turning final. Allow the speed to decrease to the proper final approach speed and trim the airplane. Complete the Landing checklist. When established in the landing configuration, maneuvering to final approach may be accomplished at final approach speed (VREF + wind correction).

Final Approach

Roll out of the turn to final on the extended runway centerline and maintain the appropriate approach speed. An altitude of approximately 300 feet above airport elevation for each mile from the runway provides a normal approach profile. Attempt to keep thrust changes small to avoid large trim changes. With the airplane in trim and at target airspeed, pitch attitude should be approximately the normal approach body attitude. At speeds above approach speed, pitch attitude is less. At speeds below approach speed, pitch attitude is higher. Slower speed reduces aft body clearance at touchdown. Stabilize the airplane on the selected approach airspeed with an approximate rate of descent between 700 and 900 feet per minute on the desired glide path, in trim. Stabilize on the profile by 500 feet above touchdown.

Note: Descent rates greater than 1,000 fpm should be avoided.

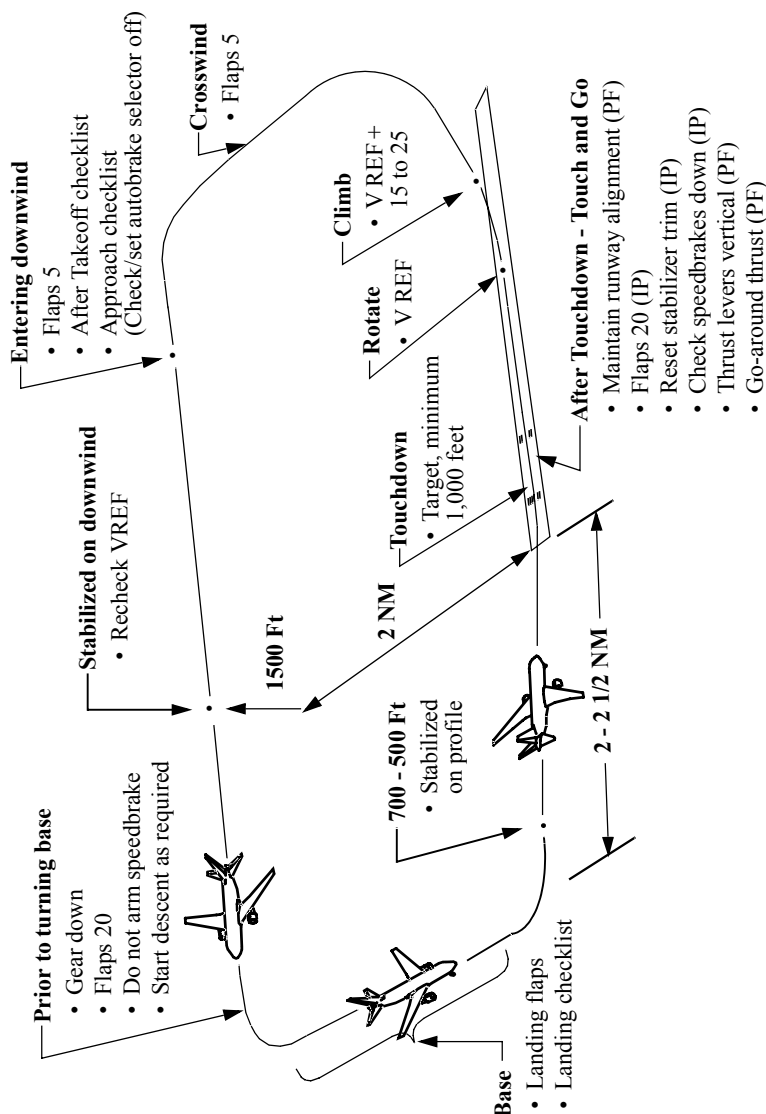
With one engine inoperative, the rudder trim may be centered prior to landing. This allows most of the rudder pedal pressure to be removed when the thrust of the operating engine is retarded to idle at touchdown.

Full rudder authority and rudder pedal steering capability are not affected by rudder trim. Because of crew workload and the possibility of a missed approach, it may not be advisable to zero the 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.

Engine Failure On Final Approach

In case of engine failure on visual final approach, use the procedure described in the ILS approach section, this chapter.

Touch and Go Landings



Touch and Go Landing - General

The primary objective of touch and go landings is approach and landing practice. It is not intended for landing roll and takeoff procedure training.

Approach

Accomplish the pattern and approach procedures as illustrated. The landing gear may remain extended throughout the maneuver for brake cooling, but be prepared to retract the landing gear if an actual engine failure occurs during go-around. Do not arm the speedbrakes. Select the autobrakes OFF.

Landing

The trainee should accomplish a normal final approach and landing. After touchdown, the instructor selects flaps 20, sets stabilizer trim, ensures speedbrakes are down and at the appropriate time instructs the trainee to move the thrust levers to approximately the vertical position (so engines stabilize before applying go-around thrust). When the engines are stabilized, the instructor instructs the trainee to set thrust.

Note: Flaps 20 is recommended after touchdown to minimize the possibility of a tailstrike during the takeoff.

WARNING: After reverse thrust is initiated, a full stop landing must be made.

At VREF, the instructor calls "ROTATE" and the trainee rotates smoothly to approximately 15° pitch and climb at VREF + 15 to 25 knots. The takeoff warning horn may sound momentarily if the flaps have not retracted to flaps 20 and the thrust levers are advanced to approximately the vertical position.

Stop and Go Landings

The objective of stop and go landings is to include landing roll, braking, and takeoff procedure practice in the training profile.

Note: At high altitude airports, or on extremely hot days, stop and go landings are not recommended.

After performing a normal full-stop landing, a straight ahead takeoff may be performed if adequate runway is available (FAR field length must be available). After stopping, and prior to initiating the takeoff, accomplish the following:

- set takeoff flaps
- trim the stabilizer for takeoff
- place speedbrake lever in the down detent
- place autobrake to RTO

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- check the rudder trim
- set airspeed bugs for the flap setting to be used.

Perform a normal takeoff.

CAUTION: Do not make repeated full stop landings without allowing time for brake cooling. Brake heating is cumulative and brake energy limits may be exceeded. Flat tires may result. Flying the pattern with gear extended assists in brake cooling.

Missed Approach/Go-Around - All Approaches

The missed approach/go-around is generally performed in the same manner whether an instrument or visual approach was flown. The missed approach/go-around is flown using the go-around procedure described in the Operations Manual. The discussion in this section supplements those procedures.

Missed Approach/Go-Around - All Engines Operating

If a missed approach is required following an autopilot approach, leave the autopilots engaged. Push either GA switch, call for flaps 20, 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.

At typical landing weights, actual thrust required for a normal go-around is usually considerably less than maximum go-around thrust. This provides a thrust margin for windshear or other situations requiring maximum thrust. If full thrust is desired after thrust for the nominal climb rate has been established, advance thrust levers manually to maximum go-around thrust.

If a missed approach is required following a manual instrument approach or visual approach, push either GA switch, call for flaps 20, ensure/set go-around thrust, and rotate smoothly toward 15° pitch attitude. Then follow flight director commands and retract the landing gear after a positive rate of climb is indicated on the altimeter.

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 airplane rotates to the go-around attitude.

Note: An automatic go-around cannot be initiated after touchdown or if the airplane is below 5 feet radio altitude for more than 2 seconds.

The GA pitch mode initially commands a go-around attitude and then transitions to speed as the rate of climb increases. This speed is normally between command speed and command speed + 25 knots. The GA roll mode maintains existing ground track. Above 400 feet AGL, select a roll mode as appropriate.

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. During training, use 1,000 feet AGL to initiate flap retraction, as during the takeoff procedure.

Note: Selection of pitch and roll modes below 400 feet AGL does not change the autopilot and flight director modes.

Note: When accomplishing a missed approach from a multi-autopilot approach, initial selection of a roll mode, pitch mode, or when altitude capture occurs above 400 feet AGL the autopilot reverts to single autopilot operation.

If initial maneuvering is required during the missed approach, accomplish 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.

Command speed should not be increased until a safe altitude or flap retraction altitude is attained. Accelerate to flap retraction speed by repositioning the command speed to the maneuvering speed for the desired flap setting. Retract flaps on the normal flap/speed schedule. When the flaps are retracted and the airspeed approaches maneuvering speed, select FLCH and ensure CLB thrust is set. Verify the airplane levels off at selected altitude and proper speed is maintained.

If VNAV is used during go-around, the FMC missed approach profile should contain the appropriate holding speeds and altitudes. Speed intervention may be used to further modify airspeed as desired. If VNAV ALT (as installed) is displayed, a premature level off may occur and selection of FLCH may be required to complete the climb to the missed approach altitude.

If a diversion to an alternate airport is required, delay use of VNAV until appropriate FMC entries are completed.

Note: FMC speeds may not comply with speed/altitude restrictions when using VNAV at low altitudes.

Engine Failure During Missed Approach/Go-Around

If an engine fails during go-around, perform normal go-around procedures. Verify maximum go-around thrust is set. Maintain flaps 20, VREF 30 + wind correction (5 knots minimum) speed until initial maneuvering is complete and a safe altitude is reached. Accelerate to flap retraction speed by repositioning the command speed to the maneuvering speed for the desired flap setting. Retract flaps on the normal flap/speed schedule.

Missed Approach/Go-around - One Engine Inoperative

The missed approach with an engine inoperative should be accomplished in the same manner as a normal missed approach except use Flaps 5 for the go-around flap setting for a Flaps 20 approach or use Flaps 20 as the go-around flap setting for a Flaps 25 or 30 approach. After GA is engaged, the AFDS commands a speed that is normally between command speed and command speed + 15 knots. If accomplishing a manual go-around, the pilot must control yaw with rudder and trim. Some rudder pedal pressure may be required even with full rudder trim. Select maximum continuous thrust when flaps are retracted.

For a multi-autopilot go-around, yaw is initially controlled by the autopilots. Be prepared to immediately apply rudder input when selecting another roll mode, pitch mode, or when altitude capture occurs above 400 feet AGL because the autopilot reverts to single autopilot operation. The system reverts to normal autopilot operation and automatic control of rudder is discontinued.



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Landing

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Preface

This chapter outlines recommended operating practices and techniques for landing, rejected landings and landing roll. Techniques are provided to help the pilot effectively utilize approach lighting, control the airplane during crosswind landings and maintain directional control after landing. Additionally, information on factors affecting landing distance and landing geometry is provided.

Landing Configurations and Speeds

For normal landings use flaps 30. This provides additional aft body clearance from the runway compared to a flaps 25 landing.

Maneuver Margin

Flight profiles should be flown at, or slightly above, the recommended maneuvering speed for the existing flap configuration. These speeds approximate maximum fuel economy and allow full maneuvering capability (25° bank with a 15° overshoot).

Full maneuver margin exists for all normal and non-normal landing procedures whenever speed is at or above the maneuver speed for the current flap setting. Full maneuver margin exists with flaps 20 at VREF 30 + 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. It is necessary to apply wind correction to the VREF speeds. See the Command Speed section in chapter 1 for an explanation of wind corrections.

Non-Normal Landing Configurations and Speeds

The Non-Normal Configuration Landing Distance table in the Performance Inflight chapter of the QRH shows speeds and landing distances for various non-normal landing configurations and runway conditions. The target speed for the approach is the appropriate approach VREF plus the wind and gust additives.

Non-Normal Landing Distance

Because of higher approach speeds associated with the non-normal landing condition the actual landing distance is increased. The flight crew should review the non-normal landing distance information in the QRH.

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 low approach with marginal threshold height. Therefore, the two-bar VASI system should not be used to determine proper approach profile. It may provide 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 airplane is on the glide path, the pilot sees the two white bars and one red bar. Three-bar VASI may be safely used with respect to threshold height, but may result in landing further down the runway.

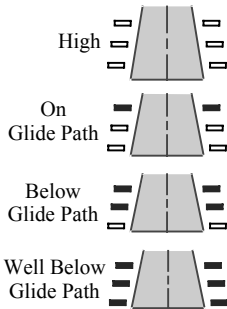
For a T-VASI, flying the approach with one additional white fly down light visible provides additional wheel clearance.

Three Bar VASI/T - VASI

Visual Approach Slope Indicator (VASI)

■ Red VASI Lights
□ White VASI Lights

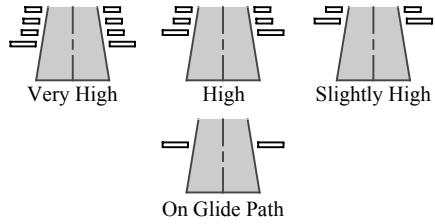
High Cockpit Airplanes (3-bar)



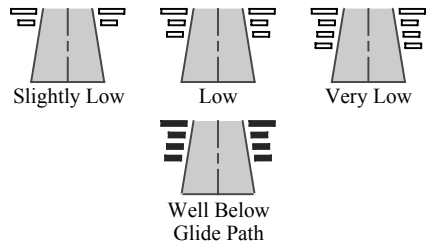
Visual Approach Slope Indicator (T-VASI)

■ 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) airplanes to provide a sufficient threshold crossing height.

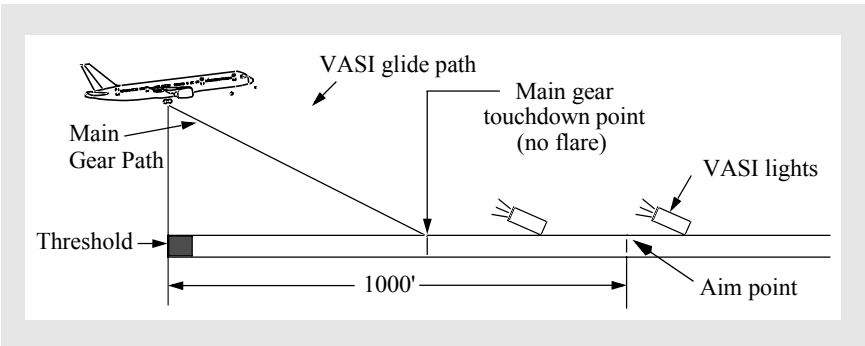
CAUTION: Use of a two bar VASI system results in main landing gear touchdown at, or very near, the end of the runway threshold. Use of a two bar VASI system is not recommended.

Two Bar/Three Bar VASI Landing Geometry

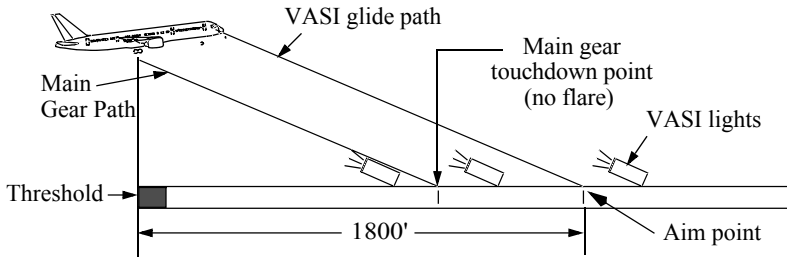
The following diagrams use these conditions:

- data is based upon typical landing weight
- airplane body attitudes are based on Flaps 30, VREF 30 + 5 and should be reduced by 1° for each 5 knots above this speed.
- eye height is calculated at the moment the main gear is over the threshold.

Two Bar VASI Landing Geometry



Flaps 30			AIM Point at 1,000 Feet		
757 Model	Visual Glide Path (degrees)	Airplane Body Attitude (degrees)	Threshold Height		Main Gear Touchdown Point - no flare (feet)
			Pilot Eye Height (feet)	Main Gear Height (feet)	
-200	3.0	2.2	48	28	526
-300	3.0	1.7	48	27	518

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Three Bar (Upper Glide Path) VASI Landing Geometry


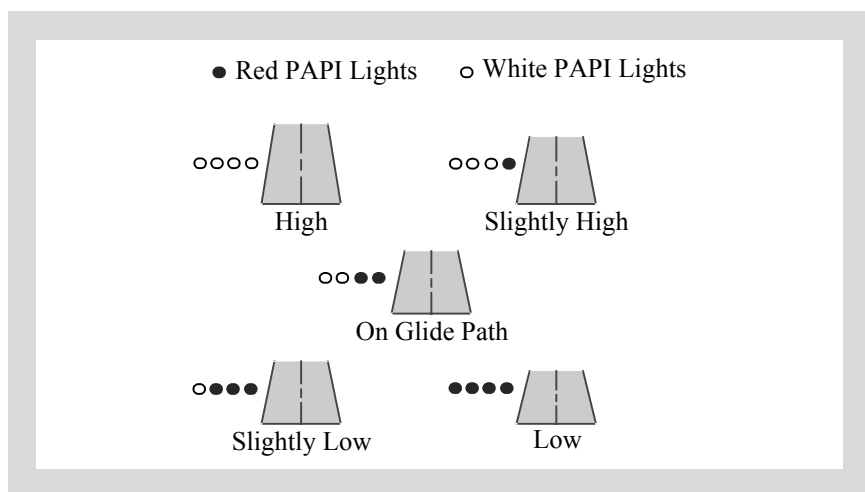
Flaps 30			AIM Point at 1,800 Feet		
757 Model	Visual Glide Path (degrees)	Airplane Body Attitude (degrees)	Threshold Height		Main Gear Touchdown Point - no flare (feet)
			Pilot Eye Height (feet)	Main Gear Height (feet)	
-200	3.3	1.95	98	77	1363
-300	3.3	1.45	97	77	1356

Precision Approach Path Indicator (PAPI)

The 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 airplane 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 down the runway.

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 airplane (the point does not move up or down in the pilot's field of view during the approach).

In first generation jet transports (e.g. B-707, DC-8), this method is acceptable 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 today's larger aircraft, 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 touchdown on the runway at the selected visual aim point.

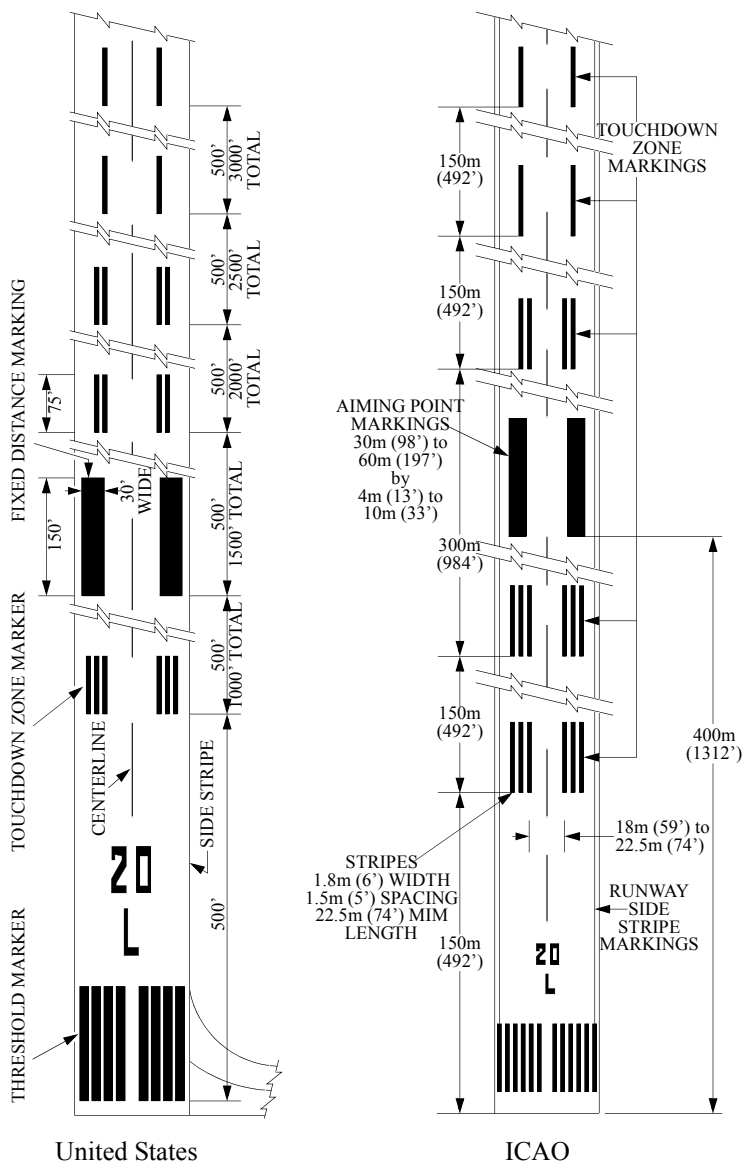
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Visual aim points versus gear touchdown point differences increase as glide path angle decreases as in a flat approach. For a particular visual approach, the difference between gear path and eye level path must be accounted for by the pilot.

Landing Runway Markings (Typical)

The following runway markings are for runways served by a precision approach.



Threshold Height

Threshold height is a function of glide path angle and landing gear touchdown target. Threshold height for main gear and pilot eye level is shown in the Two Bar/Three Bar VASI Landing Geometry tables on a previous page. 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.

Flare and Touchdown

These techniques discussed are applicable to all landings including crosswind landings and slippery runway conditions. 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.

When the threshold passes under the airplane 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.

After the flare is initiated, smoothly retard the thrust levers to idle, and make small pitch attitude adjustments to maintain the desired descent rate to the runway. Ideally, main gear touchdown should occur simultaneously with thrust levers reaching idle. A smooth power reduction to idle also assists in controlling the natural nose-down pitch change associated with thrust reduction. Hold sufficient back pressure on the control column to keep the pitch attitude constant. A touchdown attitude as depicted in the figure below is normal with an airspeed of approximately VREF plus any gust correction.

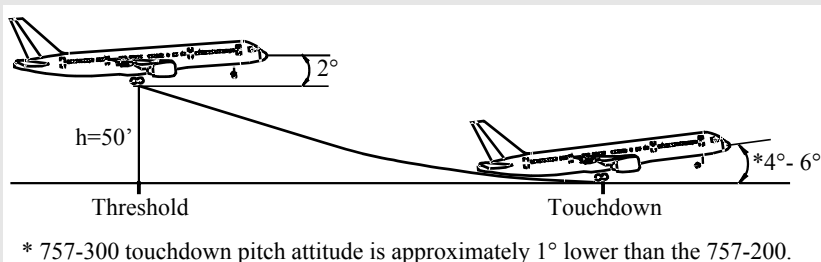
Note: Do not trim during the flare or after touchdown. Trimming in the flare increases the possibility of a tailstrike.

Landing Flare Profile

The following diagrams use 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
- airplane body attitudes are based upon typical landing weights, flaps 30, VREF 30 + 5 (approach) and VREF 30 + 0 (landing), and should be reduced by 1° for each 5 knots above this speed.



Typically, the pitch attitude increases slightly during the actual landing, but avoid over-rotating. Do not increase the pitch attitude after touchdown; this could lead to a tail strike.

Shifting the visual sighting point down the runway assists in controlling the pitch attitude during the flare. A smooth power reduction to idle also assists in controlling the natural nose down pitch change associated with thrust reduction. Hold sufficient back pressure on the control column to keep the pitch attitude constant.

Avoid rapid control column movements during the flare. Do not use pitch trim during flare or after touchdown. Such actions are likely to cause the pitch attitude to increase at touchdown and increase the potential for a tailstrike. Do not allow the airplane to float; fly the airplane onto the runway. Do not attempt to extend the flare by increasing pitch attitude in an attempt to achieve a perfectly smooth touchdown. Do not attempt to hold the nose wheel off the runway.

Bounced Landing Recovery

If the airplane 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.

Bounced landings can occur because higher than idle power is maintained through initial touchdown, disabling the automatic speedbrake deployment even when the speedbrakes are armed.

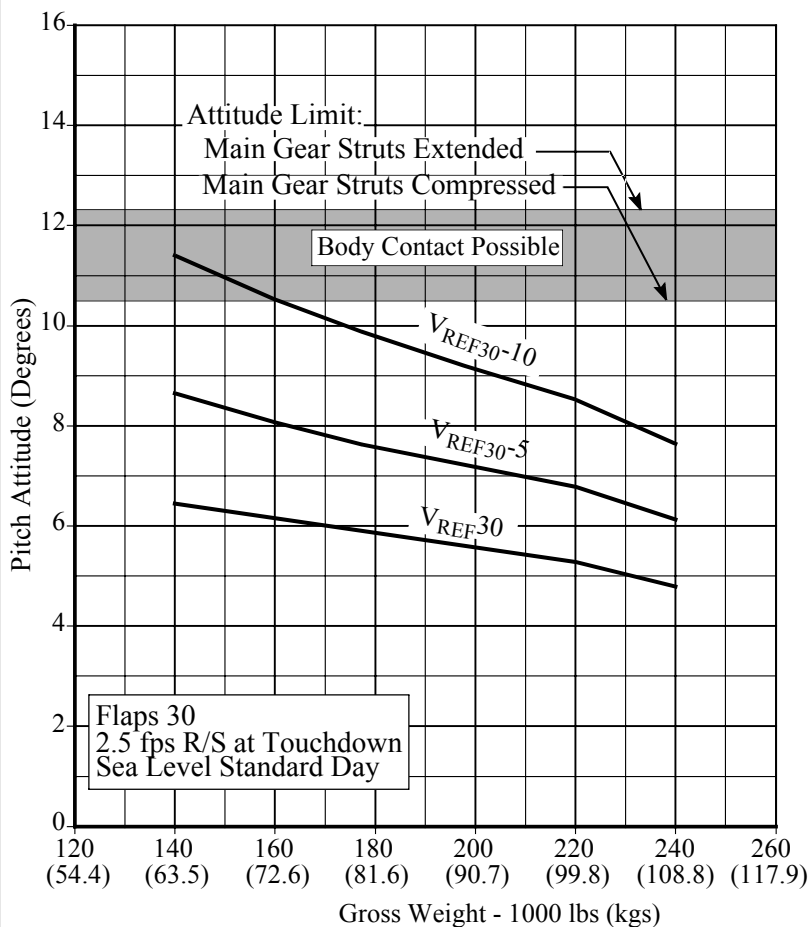
Normal Touchdown Attitude

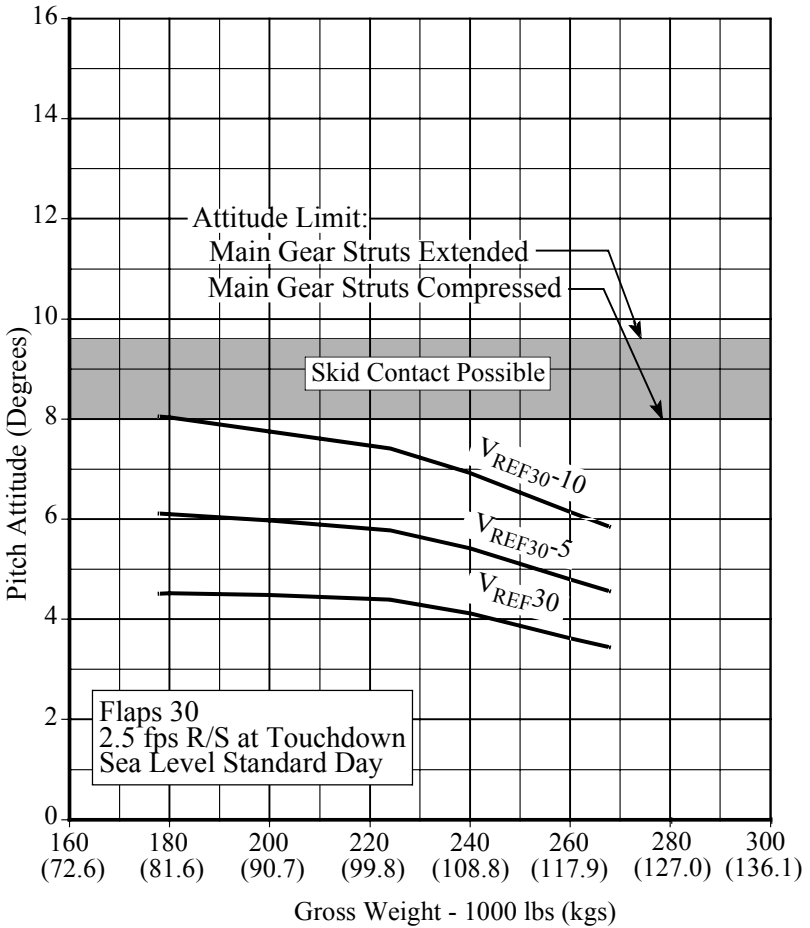
The following figures illustrate the effect of airspeed on body attitude on touchdown. It shows normal touchdown attitude for flaps 30. If flare control and thrust are excessive near touchdown, the airplane tends to float in ground effect.

With proper airspeed control and thrust management, touchdown occurs at no less than $V_{REF} - 5$. The illustration shows that touchdown at a speed significantly below V_{REF} seriously reduces aft fuselage-runway clearance.

Touchdown Body Attitudes

757-200



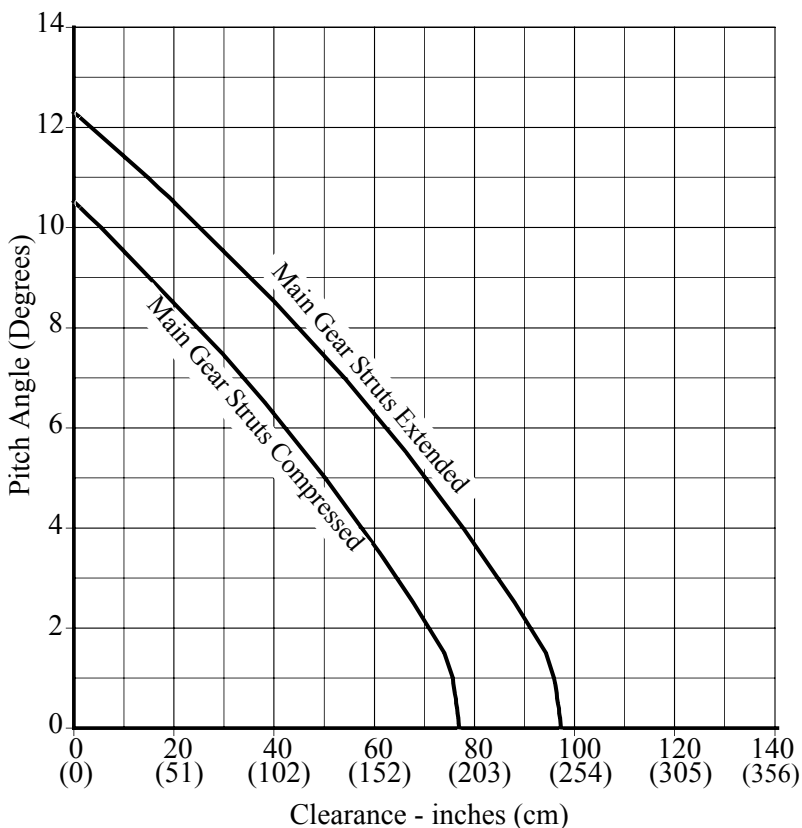
757 Flight Crew Training Manual
757-300


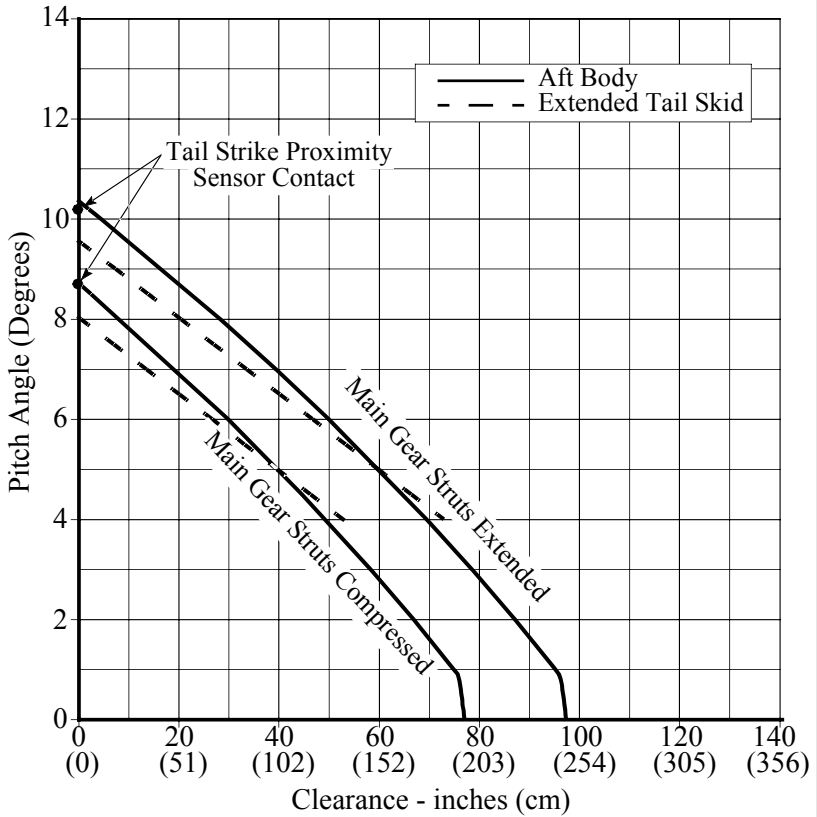
Body Clearance at Touchdown

The following figures show aft fuselage-runway clearance in relation to pitch angle with all main gear tires on the runway.

Body Clearance above Ground

757-200



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757-300




Pitch and Roll Limit Conditions

The Ground Contact Angles - Normal Landing figure illustrates body roll angle/pitch angles at which the airplane structure contacts the runway. 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.

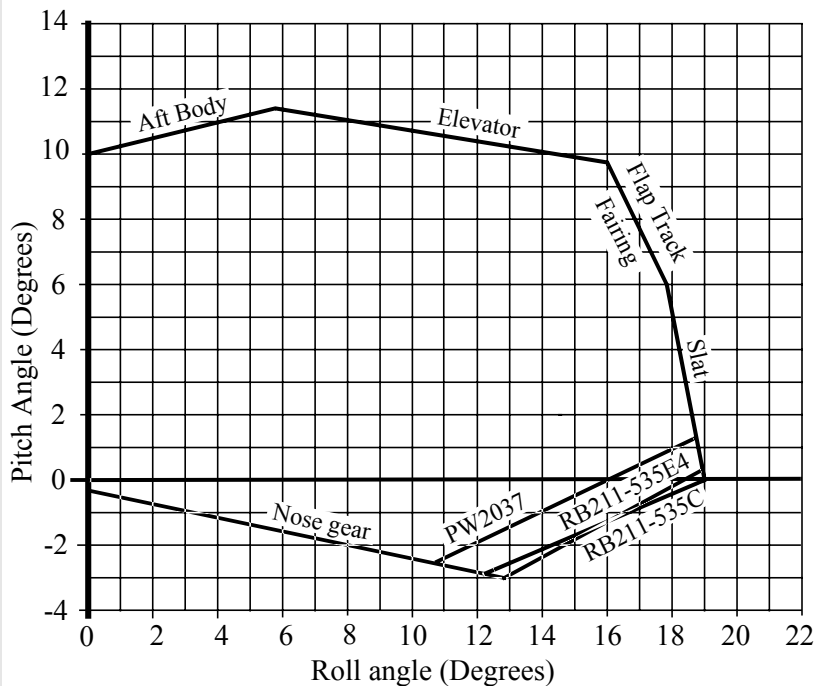
Fly the airplane onto the runway at the desired touchdown point and at the desired airspeed. Do not hold it off and risk the possibility of a tailstrike.

Note: A smooth touchdown is not the criterion for a safe landing.

757 Flight Crew Training Manual
Ground Contact Angles - Normal Landing
Conditions

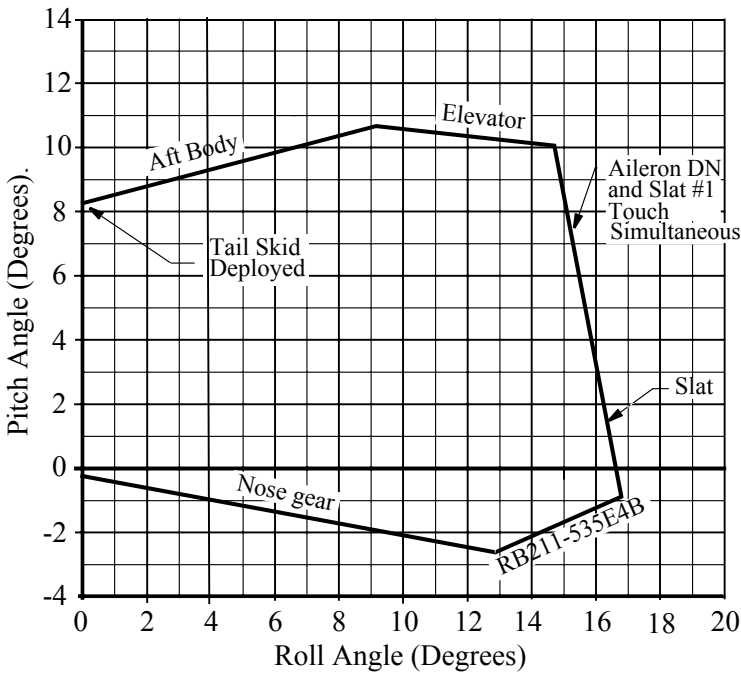
- Pitch about main gear centerline
- Slats fully extended
- Aileron full down
- Roll about outer tire centerline
- Stabilizer full nose up
- Elevator full down
- Struts compressed
- Flaps 30

757-200





757-300



After Touchdown and Landing Roll

Avoid touching down with thrust above idle since this may establish an airplane nose up pitch tendency and increases landing roll.

After main gear touchdown, initiate the landing roll procedure. If the speedbrakes do not extend automatically move the speedbrake lever to the UP position without delay. Fly the nosewheel onto the runway smoothly by relaxing aft control column pressure. Control column movement forward of neutral should not be required. Do not attempt to hold the nosewheel off the runway. Holding the nose up after touchdown for aerodynamic braking is not an effective braking technique.

CAUTION: Pitch rates sufficient to cause airplane structural damage can occur if large nose down control column movement is made prior to nose wheel touchdown.

To avoid the risk of tailstrike, 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. Use an appropriate autobrake setting or manually apply wheel brakes smoothly with steadily increasing pedal pressure as required for runway condition and runway length available. Maintain deceleration rate with constant or increasing brake pressure as required until stopped or desired taxi speed is reached.

Speedbrakes

The speedbrake system is controlled with the SPEEDBRAKE lever (which is moved UP and DOWN). The speedbrake system consists of individual spoiler panels which the pilot can extend and retract by moving the SPEEDBRAKE lever.

The speedbrakes can be fully raised after touchdown while the nose wheel is lowered to the runway, with no adverse pitch effects. The speedbrakes spoil the lift from the wings, which places the airplane weight on the main landing gear, providing excellent brake effectiveness.

Unless speedbrakes 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 anti-skid modulation.

Normally, speedbrakes are armed to extend automatically. Both pilots should monitor speedbrake extension after touchdown. In the event auto extension fails, the speedbrake should be manually extended immediately.

Pilot awareness of the position of the speedbrake lever during the landing phase is important in the prevention of over-run. The position of the speedbrakes should be announced during the landing phase by the PNF. 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 after Touchdown

If the nose wheel is not promptly lowered to the runway, braking and steering capability 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 tiller 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 PI section of the QRH. 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, speedbrakes, wheel brakes and surface conditions of the runway.

Note: Reverse thrust and speedbrake drag are most effective during the high speed portion of the landing. Deploy the speedbrake lever and activate reverse thrust with as little time delay as possible.

Note: Speedbrakes fully deployed, in conjunction with maximum reverse thrust and maximum manual anti-skid 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 airplane 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 airplane 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 length of runway used up before the airplane actually touches down.

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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.

Slippery Runway Landing Performance

When landing on slippery runways contaminated with ice, snow, slush or standing water, the reported braking action must be considered. Advisory information for reported braking actions of good, medium and poor is contained in the PI section of the QRH. The performance level associated with good is representative of a wet runway. The performance level associated with poor is representative of a wet ice covered runway. Also provided in the QRH are stopping distances for the various autobrake settings and for non-normal configurations. Pilots should use extreme caution to ensure adequate runway length is available when poor braking action is reported.

Pilots should keep in mind slippery/contaminated runway advisory information 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. With these caveats in mind, it is up to the airline to determine operating policies based on the training and operating experience of their flight crews.

One of the commonly used runway descriptors is coefficient of friction. Ground friction measuring vehicles typically measure this coefficient of friction. Much work has been done in the aviation industry to correlate the friction reading from these ground friction measuring vehicles to airplane performance. Use of ground friction vehicles raises the following concerns:

- the measured coefficient of friction depends on the type of ground friction measuring vehicle used. There is not a method, accepted worldwide, for correlating the friction measurements from the different friction measuring vehicles to each other, or to the airplane's braking capability.
- most testing to date, which compares ground friction vehicle performance to airplane performance, has been done at relatively low speeds (100 knots or less). The critical part of the airplane's deceleration characteristics is typically at higher speeds (120 to 150 knots).

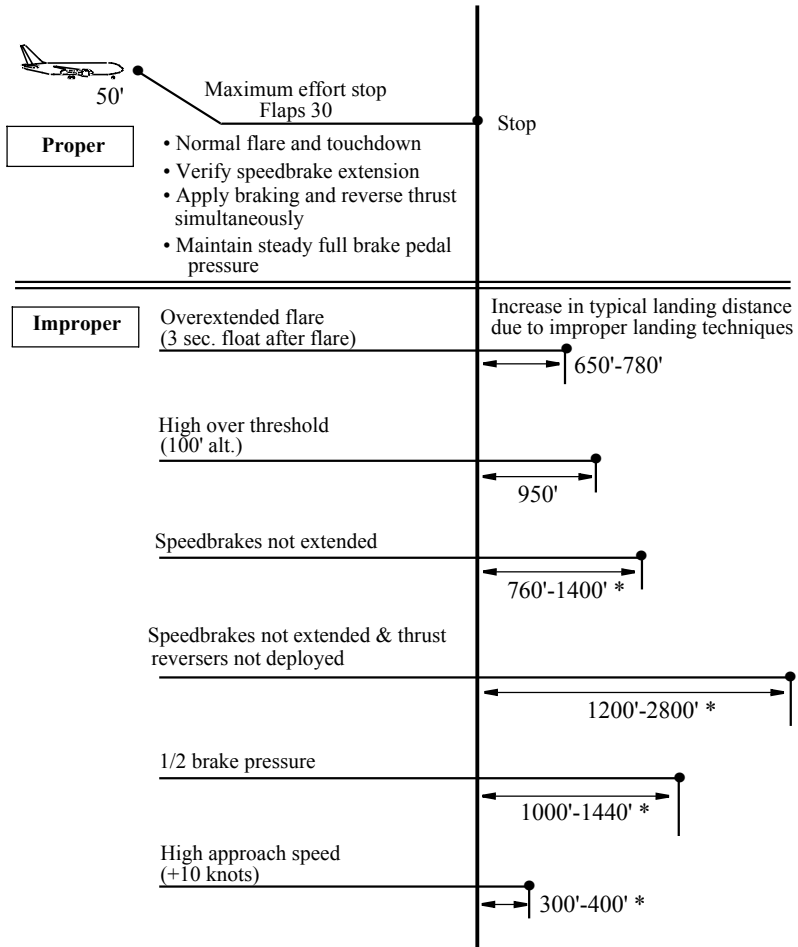
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- ground friction vehicles often provide unreliable readings when measurements are taken with standing water, slush or snow on the runway. Ground friction vehicles might not hydroplane (aquaplane) when taking a measurement while the airplane may hydroplane (aquaplane). In this case, the ground friction vehicles would provide an optimistic reading of the runway's friction capability. The other possibility is the ground friction vehicles might hydroplane (aquaplane) when the airplane would not, this would provide an overly pessimistic reading of the runway's friction capability. Accordingly, friction readings from the ground friction vehicles may not be representative of the airplane's capability in hydroplaning conditions.
- ground friction vehicles measure the friction of the runway at a specific time and location. The actual runway coefficient of friction may change with changing atmospheric conditions such as temperature variations, precipitation etc. Also, the runway condition changes as more operations are performed.

The friction readings from ground friction measuring vehicles do supply an additional piece of information for the pilot to evaluate when considering runway conditions for landing. Crews should evaluate these readings in conjunction with the PIREPS (pilot reports) and the physical description of the runway (snow, slush, ice etc.) when planning the landing. Special care should be taken in evaluating all the information available when braking action is reported as POOR or if slush/standing water is present on the runway.

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Factors Affecting Landing Distance (Typical)



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 airplane weight and any downward aerodynamic force such as speedbrakes.

The coefficient of friction depends on the tire condition and runway surface, (e.g. concrete, asphalt, dry, wet or icy).

Automatic Brakes

Boeing recommends that whenever runway limited, using higher than normal approach speeds, landing on slippery runways or landing in a crosswind, the autobrake system be used.

For normal operation of the autobrake system select a deceleration setting.

Settings include:

- **MAX AUTO:** Used when minimum stopping distance is required.
Deceleration rate is less than that produced by full manual braking
- **3 or 4:** Should be used for wet or slippery runways or when landing rollout distance is limited
- **1 or 2:** These settings provide a moderate deceleration effect suitable for all routine operations.

Note: Autobrakes 2 or greater results in a continuous brake application, which can increase carbon brake life.

Flight crew/airline experience with airplane characteristics relative to the various runway conditions routinely encountered provide initial guidance as to the desirable level of deceleration selected.

Immediate initiation of reverse thrust at main gear touchdown and full reverse thrust allow the autobrake system to reduce brake pressure to the minimum level. Since the autobrake system senses deceleration and modulates brake pressure accordingly, the proper application of reverse thrust results in reduced braking for a large portion of the landing roll.

The importance of establishing the desired reverse thrust level as soon as possible after touchdown cannot be overemphasized. This minimizes brake temperatures and tire and brake wear and reduces stopping distance on very slippery runways.

The use of minimum reverse thrust almost doubles the brake energy requirements and can result in brake temperatures much higher than normal.

During the landing roll, use manual braking if the deceleration is not suitable for the desired stopping distance.

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The autobrakes should be released by smoothly applying brake pedal force, as in a normal stop, until the autobrake system disarms. Following disarming of the autobrakes, smoothly release brake pedal pressure.

Disarming the autobrakes before coming out of reverse thrust provides a smooth transition to manual braking.

All crewmembers should be alert for autobrake disarm annunciations during the landing roll so that manual braking can be initiated if required.

The airplane speed at which the transition from autobrakes to manual braking is made varies with airplane deceleration and stopping requirements. For runway conditions that produce good deceleration, the transition from autobrakes to manual brakes should be made at about 60 knots. The transition speed should be closer to a safe taxi speed on very slippery runways or when runway length is limited.

A table in the Performance Inflight section of the QRH shows the relative stopping capabilities of the available autobrake selections.

Manual Braking

The following technique for manual braking provides optimum braking for all runway conditions:

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

Immediately after main gear touchdown, smoothly apply a constant brake pedal pressure for the desired braking. For short or slippery runways, use full brake pedal pressure.

- do not attempt to modulate, pump or improve the braking by any other special techniques
- do not release the brake pedal pressure until the airplane speed has been reduced to a safe taxi speed
- the antiskid system stops the airplane 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 effort. 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 or turning off the antiskid degrades braking effectiveness. Maintain steadily increasing brake pressure, allowing the antiskid system to function at its optimum.

Although immediate braking is desired, 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.

Braking with Antiskid Inoperative

When the antiskid system is inoperative, the following techniques apply:

- ensure that the nose wheel is on the ground and the speedbrakes 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.

Antiskid-off braking requires even greater care during lightweight landings.

Carbon Brake Life

Brake wear is primarily dependent upon the number of brake applications. For example, one firm brake application causes less wear than several light applications. Continuous light applications of the brakes to keep the airplane from accelerating over a long period of time (riding the brakes) to maintain a constant taxi speed produces more wear than proper brake application.

During taxi, proper braking should involve applying brakes to decelerate the airplane, releasing the brakes when the lower speed is attained and allowing the airplane to accelerate, then repeating.

During landing, one hard, high energy, long-duration brake application produces the same amount of wear as a light, low-energy, short application. This is different from steel brakes that wear as a function of the energy input during the stop.

Brake Cooling

A series of taxi-back or stop and go landings without additional in-flight brake cooling can cause excessive brake temperatures. The energy absorbed by the brakes from each landing is cumulative.

Extending the gear a few minutes early in the approach normally provides sufficient cooling for a landing. Total in-flight cooling time can be determined from the Performance Inflight section of the QRH.

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The optional 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 QRH should be used to identify potential overheat situations.

To minimize brake temperature build-up:

- for airplanes without operative brake temperature monitoring systems:
If the last ground time plus present flight time is less than 90 minutes, extend the landing gear 5 minutes early or 7 minutes prior to landing
- for airplanes with operating brake temperature monitoring systems:
Extend the landing gear approximately one minute early for each unit of brake temperature above normal.

Close adherence to recommended landing rollout procedures ensures minimum brake temperature build up.

Reverse Thrust Operation

Awareness of the position of the forward and reverse thrust levers must be maintained during the landing phase. Improper seat position as well as long sleeved apparel may cause inadvertent advancement of the forward thrust levers, preventing movement of the reverse thrust levers.

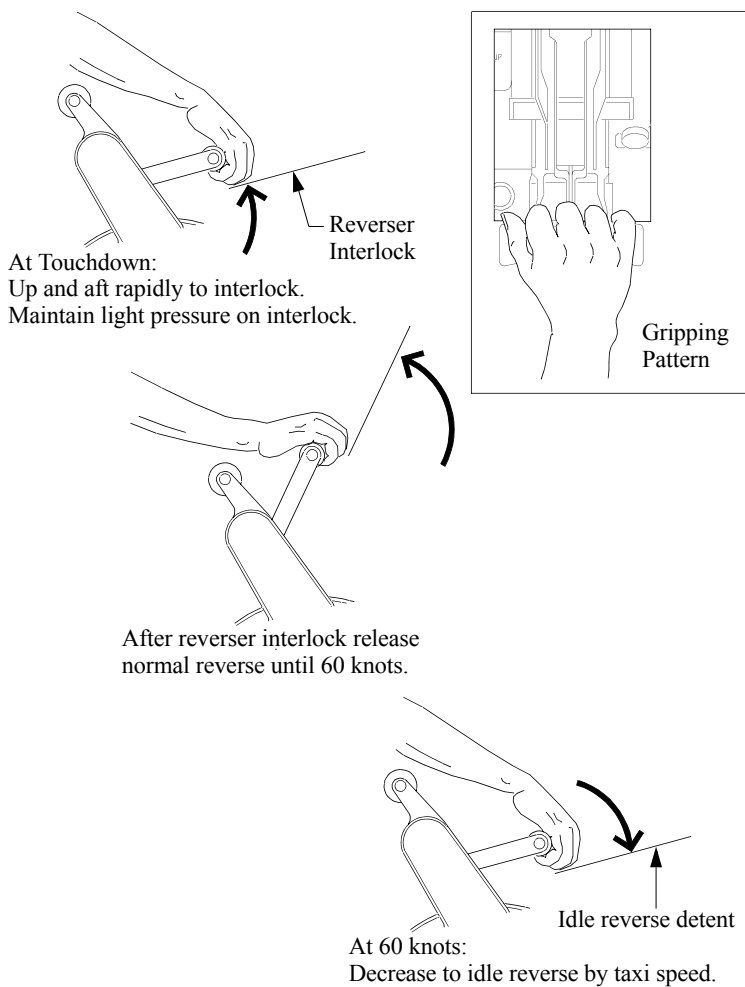
The position of the hand should be comfortable, permit easy access to the autothrottle disconnect switch, and allow control of all thrust levers, forward and reverse, through full range of motion.

Note: Reverse thrust always reduces the “brake only” stopping distance, brake and tire wear. Reverse thrust is most effective at high speeds.

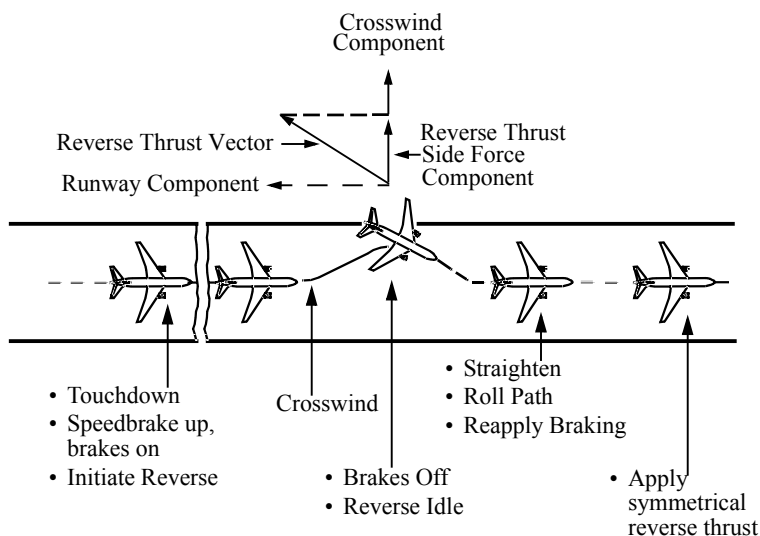
After touchdown, with the thrust levers at idle, rapidly raise the reverse thrust levers up and aft to the interlock position, then apply reverse thrust as required. The PNF should monitor engine operating limits and call out any engine operational limits being approached or exceeded, any thrust reverser failure, or any other abnormalities.

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Maintain reverse thrust as required, up to maximum, until the airspeed approaches 60 knots. At this point start reducing the reverse thrust so that the reverse thrust levers are moving down at a rate commensurate with the deceleration rate of the airplane. The thrust levers should be positioned to reverse idle by taxi speed, then to full down after the engines have decelerated to idle. The PNF should call out 60 knots to assist the pilot flying in scheduling the reverse thrust. The PNF should also call out any inadvertent selection of forward thrust as reverse thrust is cancelled. If an engine surges during reverse thrust operation, quickly select reverse idle on all engines.

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Reverse Thrust Operations


Reverse Thrust and Crosswind (All Engines)



This figure shows a directional control problem during a landing rollout on a slippery runway with a crosswind. As the airplane starts to weathervane into the wind, the reverse thrust side force component adds to the crosswind component and drifts the airplane to the downwind side of the runway. Main gear tire cornering forces available to counteract this drift are at a minimum when the antiskid system is operating at maximum braking effectiveness for the existing conditions.

To correct back to the centerline, reduce reverse thrust to reverse idle and release the brakes. This minimizes the reverse thrust side force component without the requirement to go through a full reverser actuation cycle, and improve tire cornering forces for realignment with the runway centerline. Use rudder pedal steering and differential braking as required, to prevent over correcting past the runway centerline. When re-established near the runway centerline, apply maximum braking and symmetrical reverse thrust to stop the airplane.

Reverse Thrust - EEC in the Alternate Mode (as installed)

Use normal reverse thrust techniques, modulating reverse levers as required to remain within maximum EPR/N1 limits computed by the Thrust Management Computer (TMC) and displayed on the engine instruments.

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 thrust lever to reverse idle detent.

Crosswind Landings

The crosswind guidelines shown below were derived through flight test data, engineering analysis and piloted simulation 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.

Landing Crosswind Guidelines

Crosswind guidelines are not considered limitations. Crosswind guidelines are provided to assist operators in establishing their own crosswind policies.

On slippery runways, crosswind guidelines are a function of runway surface condition, airplane loading, and assume proper pilot technique.

Runway Condition	Crosswind - Knots *
Dry	40 ***
Wet	40 ***
Standing Water/Slush	20
Snow - No Melting **	35 ***
Ice - No Melting **	17

Note: Reduce crosswind guidelines by 5 knots on wet or contaminated runways whenever asymmetric reverse thrust is used.

*Winds measured at 33 feet (10 m) tower height and apply for runways 148 feet (45m) or greater in width.

** Landing on untreated ice or snow should only be attempted when no melting is present.

*** Sideslip only (zero crab) landings are not recommended in crosswinds in excess of 28 knots (757-200) or 25 knots (757-300). This recommendation ensures adequate ground clearance and is based on maintaining adequate control margin.

Crosswind Landing Techniques

Three methods of performing crosswind landings are presented. They are the touchdown in a crab, 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 airplane, downwind rudder is applied to eliminate the crab and align the airplane 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.

Touchdown In Crab

The airplane can land using crab only (zero side slip) up to the landing crosswind guideline speeds. (See the landing crosswind guidelines table, this chapter).

On dry runways, upon touchdown the airplane tracks toward the upwind edge of the runway while de-crabbing to align with the runway. Immediate upwind aileron is needed to ensure the wings remain level while rudder is needed to track the runway centerline. The greater the amount of crab at touchdown, the larger the lateral deviation from the point of touchdown. For this reason, touchdown in a crab only condition is not recommended when landing on a dry runway in strong crosswinds.

On very slippery runways, landing the airplane using crab only reduces drift toward the downwind side at touchdown, permits rapid operation of spoilers and autobrakes because all main gears touchdown simultaneously, and may reduce pilot workload since the aircraft does not have to be de-crabbed before touchdown. However, proper rudder and upwind aileron must be applied after touchdown to ensure directional control is maintained.

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.

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The initial phase of the approach to landing is flown using the crab method to correct for drift. Prior to the flare the airplane 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 engine nacelle or outboard wing flap to contact the runway. (See Ground Clearance Angles - Normal Landing charts, this chapter.)

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. (See the landing crosswind guidelines table, this chapter). 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 airplane with the runway centerline. At touchdown, increased application of upwind aileron should be applied to maintain wings level.

Rejected Landing

The rejected landing procedure is identical to the go-around procedure. Press GA and ensure go-around thrust is set or manually apply go-around thrust and select flaps 20 while rotating to go-around attitude. Retract the landing gear after a positive rate of climb is established. At a safe altitude, set command speed to flaps up maneuvering speed, or other speed as desired, and retract flaps on schedule. Auto speedbrakes retract and autobrakes disarm as thrust levers are advanced for a rejected landing initiated after touchdown.

WARNING: After reverse thrust is initiated, a full stop landing must be made.

Factors dictating this are:

- five seconds are required for a reverser to transition to the forward thrust position
- a possibility exists that a reverser may not stow in the forward thrust position.

Overweight Landing

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 30 landings at all gross weights. However, wet or slippery runway field length requirements should be verified from the landing distance charts in the Performance Inflight chapter of the Operations Manual. Brake energy limits will not be exceeded for flaps 25 or 30 landings at all gross weights.

Note: If flaps 30 approach speed (VREF 30 + additives for wind and gusts) is within 10 knots of the Flap 30 placard speed, use flaps 25 and VREF 25 for landing.

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.

Analysis has determined that, when landing at high gross weights at speeds associated with non-normal procedures requiring flaps set at 20 or less, maximum effort stops may exceed the brake energy limits. The gross weights where this condition can occur are well above maximum landing weights. For these non-normal landings, maximize use of the available runway for stopping.

Observe 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. During flap extension, airspeed can be reduced by as much as 20 knots below normal maneuver speeds before extending to the next flap position. These lower speeds result in larger margins to the flap placards, while still providing normal bank angle maneuvering capability, but do not allow for a 15° overshoot margin in all cases.

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. At weights above the maximum landing weight, the final approach maximum wind correction may be limited by the flap placards and load relief system.

Fly a normal profile. Ensure that a higher than normal rate of descent does not develop. Do not hold the airplane off waiting for a smooth landing. Fly the airplane 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.

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Autobrake stopping distance guidance is contained in the Performance Inflight section of the QRH. If adequate stopping distance is available based upon approach speed, runway conditions, and runway length, the recommended autobrake setting should be used.

Overweight Autolands Policy

Boeing does not recommend overweight autolands. Autopilots on Boeing airplanes 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 airplane touches down after initiation of the go-around.



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Maneuvers

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Preface

This chapter provides a quick reference summary of operating procedures and training maneuvers. The discussion portion of each illustration highlights important information. The flight profile illustrations represent the Boeing recommended basic configuration during the accomplishment of the flight maneuvers, and provides a basis for standardization and crew coordination.

The procedures recommended are based on minimizing crew workload, crew coordination and operational safety and provide a basis for standardization.

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 airplane. This maneuver is performed in the full flight simulator 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 disconnected. Set command speed to VMO. As speed increases observe:

- nose down trim required to keep airplane 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 thrust levers to idle, set command speed to 250 knots, and decelerate to command speed. Since the airplane is aerodynamically clean, any residual thrust results in a longer deceleration time. As airspeed decreases observe that nose up trim is required to keep airplane 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 maneuvering speed and decelerate to command speed, again noting the distance traveled during deceleration. Observe the handling qualities of the airplane 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 airplane with one engine inoperative and gain familiarization with rudder control requirements.

	Condition One	Condition Two
Airspeed	Flaps up maneuvering speed	V2
Landing Gear	Up	Down
Flaps	Up	20
Thrust	As Required	MCT
When In Trim - Retard one thrust lever 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 (VMCA) is below VR and VREF.

Rudder and Lateral Control

This familiarization is performed to develop proficiency in handling the airplane 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.

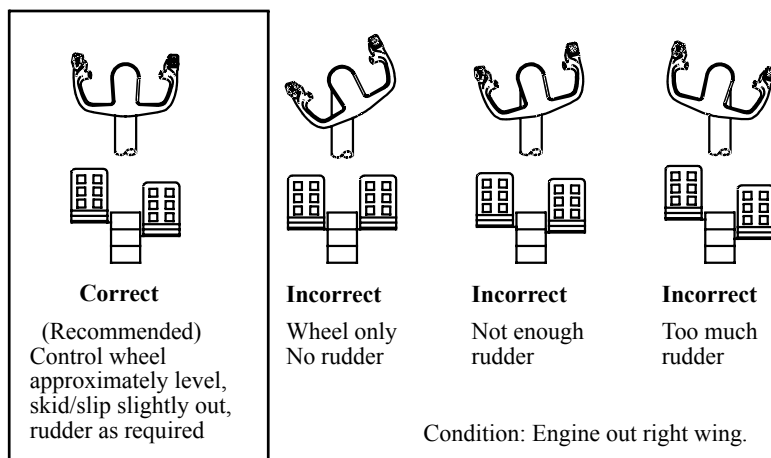
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When the rudder is trimmed to level the control wheel, the airplane maintains heading. A small amount of bank toward the operating engine may be noticeable on the bank indicator. The slip/skid indicator is displaced slightly toward the operating engine.

If the airplane is trimmed with too much control wheel displacement, full lateral control is not available and spoilers on one wing may be raised, increasing drag. 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.



Thrust and Airspeed

If not thrust limited, apply additional thrust, if required, to control the airspeed. The total two engine fuel flow existing at the time of engine failure may be used initially to establish a thrust setting at low altitude. If performance limited (high altitude), adjust airplane attitude to maintain airspeed while setting maximum continuous thrust.

Note: Autothrottle should not be used with an engine inoperative.



High Altitude Maneuvering, “G” Buffet

Airplane buffet reached as a result of aircraft maneuvering is commonly referred to as “g” buffet. During turbulent flight conditions, it is possible to experience high altitude “g” buffet at speeds less than MMO. In training, buffet is induced to demonstrate the airplane's response to control inputs during flight in buffet.

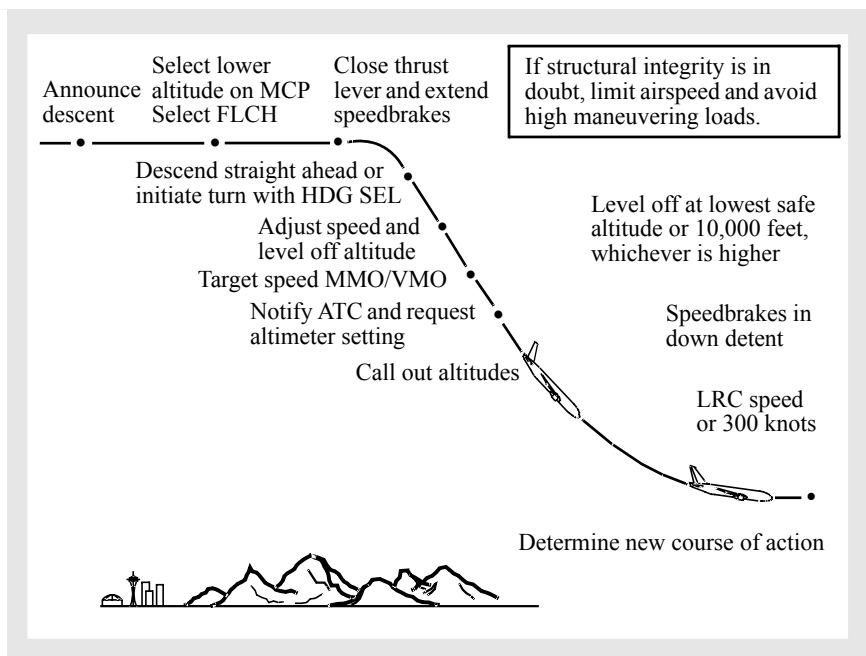
Establish an airspeed of Mach .85. Induce “g” buffet by smoothly increasing the bank angle until the buffet is noticeable. Increase the rate of descent while increasing the bank angle to maintain airspeed. Do not exceed 45° of bank. If buffet does not occur by 45° of bank, increase control column back 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.

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Rapid Descent

This maneuver is designed to bring the airplane down smoothly to a safe altitude, in the minimum time, with the least possible passenger discomfort.

Note: Use of the autopilot is recommended.



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 procedure deliberately and methodically. Do not be distracted from flying the airplane. If icing conditions are entered, use anti-ice and thrust as required.

Note: Rapid descent is made with the landing gear up.

The PNF checks the lowest safe altitude, notifies ATC, and obtains an altimeter setting (QNH). Both pilots should verify that all recall items have been accomplished and call out any items not completed. The pilot not flying calls out 2,000 feet and 1,000 feet above the level off altitude.



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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 turbulent air is encountered or expected, reduce to turbulent air penetration speed.

Autopilot Entry and Level Off

Flight Level Change (FLCH)

Because of airspeed and altitude protection and reduced crew workload, use of the autopilot with FLCH mode is the recommended technique for rapid descents. Use of the V/S mode is not recommended.

First set a lower altitude in the altitude window. Select FLCH, close the thrust lever and smoothly extend the speedbrakes. Fly straight ahead or initiate a turn using HDG SEL. 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 airplane pitches down smoothly while the thrust levers retard to idle. Adjust the speed as necessary and ensure the altitude window is correctly set for the level off. During descent, the IAS/MACH speed window changes from MACH to IAS at approximately 300 KIAS.

Manually reset to VMO as desired.

When approaching the target altitude, ensure the altitude is set in the MCP altitude select window. Altitude capture engages automatically. Adjusting the command speed to approximately LRC or 300 knots prior to level-off aids in smoothly transitioning to level flight. The pitch mode then controls altitude and the thrust levers increase to hold speed. Smoothly return the speedbrake lever to the down detent during the level off maneuver.

When descending with the autopilot engaged and the speedbrakes extended at speeds near VMO/MMO, the airspeed may momentarily increase to above VMO/MMO if the speedbrakes are retracted quickly. 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.

When the speedbrakes are retracted during altitude capture near VMO/MMO, a momentary overspeed condition may also 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 selected speed and delay speedbrake retraction until after level off is complete.

Control Wheel Steering (CWS)

If installed, CWS may be used to reduce pilot workload. Follow the manually flown procedure but instead of disengaging the autopilot, engage CWS.

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, it is recommended that turns not be initiated until the airplane is established in the descent.

To manually fly the maneuver, disconnect the autothrottles and retard thrust levers to idle. Smoothly extend the speedbrakes, disconnect the autopilot and smoothly lower the nose to initial descent attitude (approximately 10 degrees nose down).

About 10 knots before reaching target speed, slowly raise the pitch attitude to maintain target speed. Keep the airplane 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 returned to the down detent when approaching the desired level off altitude. After reaching level flight add thrust to maintain long range cruise or 300 knots.

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. Determine the new course of action based on weather, oxygen, fuel remaining, medical condition of crew and passengers, and available airports. Obtain a new ATC clearance.

Stall Recovery

The objective of the approach to stall recovery maneuver is to familiarize the pilot with the stall warning and correct recovery techniques. Recovery from a fully developed stall is discussed later in this section.

Approach to Stall Recovery

The following discussion and maneuvers are for an approach to a stall as opposed to a fully developed stall. An approach to a stall is a controlled flight maneuver; a stall is an out-of-control, but recoverable, condition.

Approach to Stall Recovery

Initial Conditions			Approach		Recovery
Flaps	Gear	Bank	Target% N1*		If ground contact is not a factor At buffet or stick shaker • Apply maximum thrust • Smoothly decrease pitch attitude to approximately 5° above the horizon • Level wings • Accelerate to maneuvering speed for flap position • Stop descent and return to target altitude • At altitudes above 20,000 feet, pitch attitudes less than 5° may be necessary to achieve
			757	767	
Up	Up	0°	40-45	45-50	*Approximate power settings to achieve a 1 kt/sec deceleration
20	Up	25°	40-45	45-50	
30	Dn	0°	45-50	50-55	
 Maintain airplane in trim until stick shaker or buffet			 Note pitch attitude at trim speed		  Maneuver complete
					If ground contact is a factor At buffet or stick shaker • Apply maximum thrust • Smoothly adjust attitude as necessary to avoid terrain • Level wings • Accelerate to maneuvering speed for flap position • Level off at target altitude

Command Speed

As the airplane is decelerated to the desired initial condition for the approach to stall, set command speed to the maneuver speed for each selected flap setting. For the approach to stall in the landing configuration, set command speed to VREF 30 + 5 knots.

Initial Buffet-Stall Warning-Stall Buffet

Approach to stalls are entered with thrust set appropriate for an airspeed decrease of 1 knot per second.

During the initial stages of a stall, local airflow separation results in initial buffet giving natural warning of an approach to stall. A stall warning is considered to be any warning readily identifiable by the pilot, either artificial (stick shaker) or initial buffet. Recovery from an approach to stall is initiated at the earliest recognizable stall warning, initial buffet or stick shaker.

Lateral and Directional Control

Lateral control is maintained with ailerons. Rudder control should not be used because it causes yaw and the resultant roll is undesirable.

Effect of Flaps

Flaps are used to increase low speed performance capability. The leading edge devices ensure that the inboard wing stalls prior to the outboard wing. This causes the nose of the airplane to pitch down at the onset of the stall.

Effect of Speedbrakes

For any airspeed, the angle of attack is higher with speedbrakes up. This increases initial buffet speed and stick shaker speed but has a lesser effect on actual stall speed.

Entry

To save time, thrust levers may be closed to allow a more rapid deceleration. Target thrust for the configuration should be set approaching selected speed.

Some thrust is used during entry to provide positive engine acceleration for the recovery. The airplane is maintained in trim while decelerating. Level flight or a slight rate of climb is desired.

Landing Gear

If the entry has been made with the landing gear extended, do not retract it until after the recovery.

**Flaps**

Do not retract flaps during the recovery. Retracting the flaps from the landing position, especially when near the ground, causes an altitude loss during the recovery.

Recovery

Recover from approach to a stall with one of the following recommended recovery techniques.

Ground Contact Not a Factor

At the first indication of stall (buffet or stick shaker) smoothly apply maximum thrust, smoothly decrease the pitch attitude to approximately 5 degrees above the horizon and level the wings. As the engines accelerate, counteract the nose up pitch tendency with positive forward control column pressure and nose down trim. (At altitudes above 20,000 feet, pitch attitudes of less than 5 degrees may be necessary to achieve acceptable acceleration.)

Accelerate to maneuvering speed and stop the rate of descent. Correct back to the target altitude.

Ground Contact a Factor

At the first indication of stall (buffet or stick-shaker) smoothly advance the thrust levers to maximum thrust and adjust the pitch attitude as necessary to avoid the ground. Simultaneously level the wings. Control pitch as smoothly as possible. As the engines accelerate, the airplane nose pitches up. To assist in pitch control, add more nose down trim as the thrust increases. Avoid abrupt control inputs that may induce a secondary stall. Use intermittent stick shaker as the upper limit for pitch attitude for recovery when ground contact is a factor.

When ground contact is no longer a factor, continue to adjust pitch as required to maintain level flight or a slight climb while accelerating to maneuvering speed for the existing flap position.

Autopilot Engaged

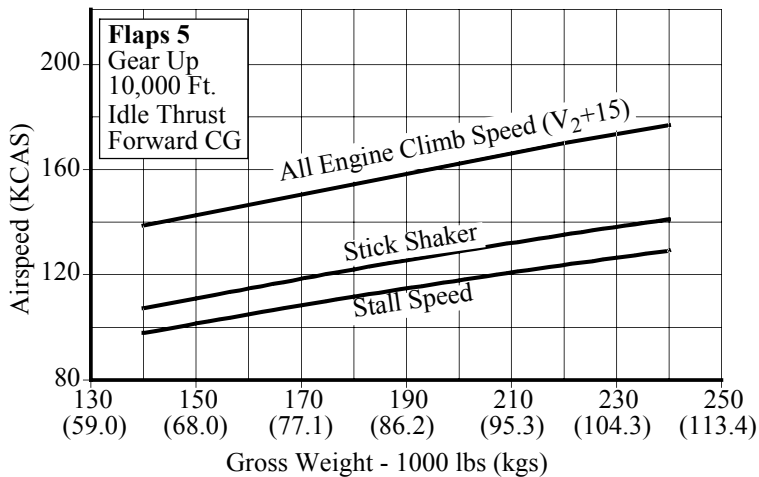
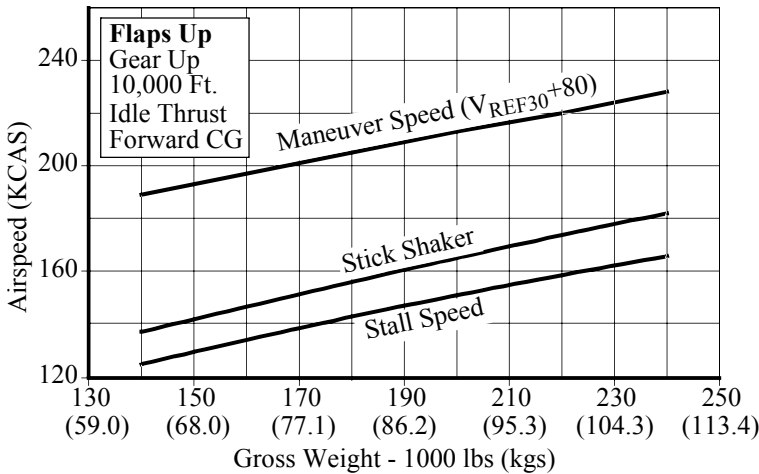
If an approach to a stall is encountered with the autopilot engaged, apply limit thrust and allow the airplane to return to the normal speed. At high altitude, it may be necessary to initiate a descent to regain maneuvering speed. If autopilot response is not acceptable, it should be disengaged.

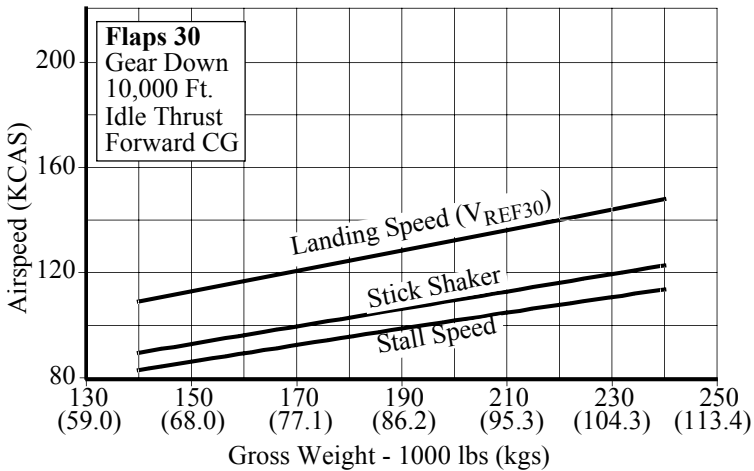
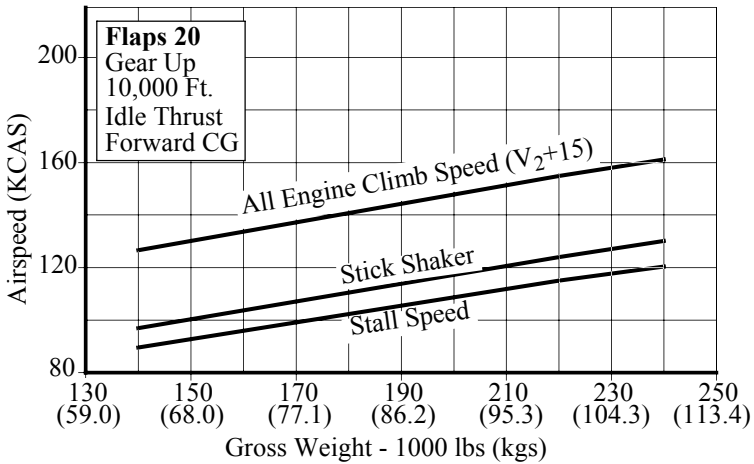
Stick Shaker and Stall Speeds

The following figures depict stick shaker and stall speeds at various gross weights and flap settings. This data is presented for training purposes only.



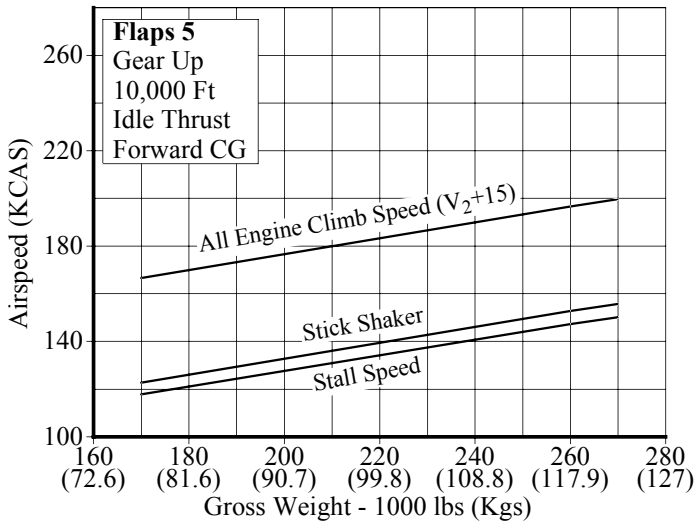
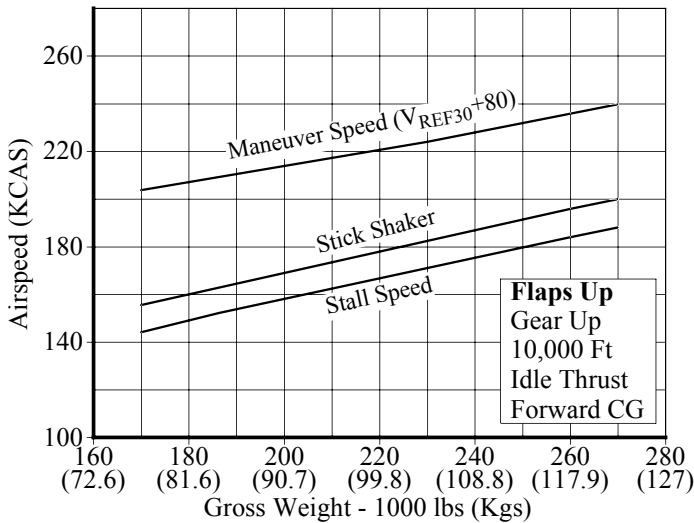
Stick Shaker and Stall Speed
757-200

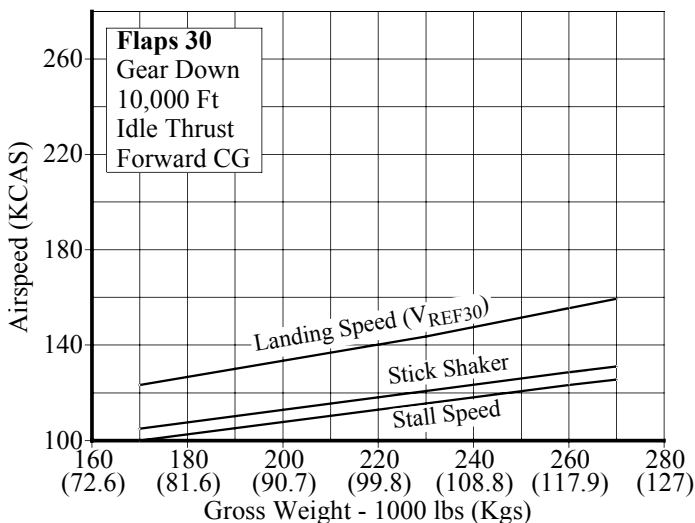
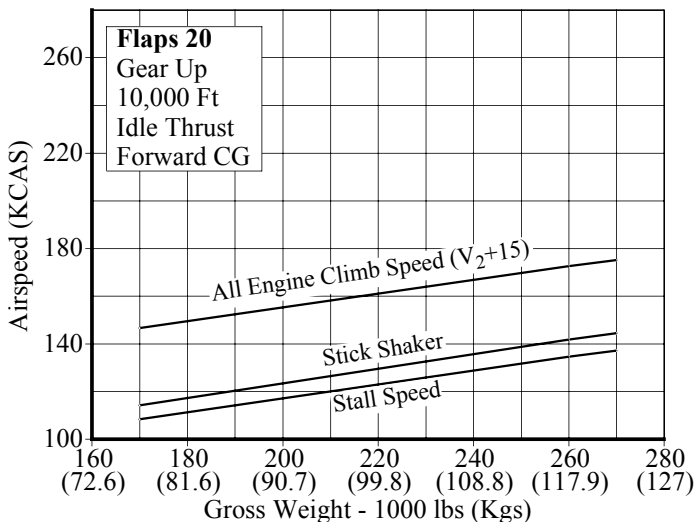


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Stick Shaker and Stall Speed
757-200




Stick Shaker and Stall Speed
757-300



757 Flight Crew Training Manual
Stick Shaker and Stall Speed
757-300


Recovery from a Fully Developed Stall

An airplane may be stalled in any attitude (nose high, nose low, high angle of bank) or any airspeed (turning, accelerated stall). It is not always intuitively obvious that the airplane is stalled.

An airplane stall is characterized by any one (or a combination) of the following conditions:

- buffeting, which could be heavy
- lack of pitch authority
- lack of roll control
- inability to arrest descent rate.

These conditions are usually accompanied by a continuous stall warning. A stall must not be confused with the stall warning that alerts the pilot to an approaching stall. Recovery from an approach to a stall is not the same as recovery from an actual stall. An approach to a stall is a controlled flight maneuver; a stall is an out-of-control, but recoverable, condition.

Note: Anytime the airplane enters a fully developed stall, the autopilot and autothrottle should be disconnected.

To recover from a stall, angle of attack must be reduced below the stalling angle. Nose down pitch control must be applied and maintained until the wings are unstalled. Application of down elevator (as much as full nose-down elevator may be required) and the use of some nose-down stabilizer 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 airplane using stabilizer trim, and should stop trimming nose down when they feel the g force on the airplane lessen or the required elevator force lessen. Under certain conditions, on airplanes with underwing-mounted engines, it may be necessary to reduce thrust in order to prevent the angle of attack from continuing to increase. Once the wing is unstalled, upset recovery actions may be taken and thrust reapplied as necessary.

If normal pitch control inputs do not stop an increasing pitch rate in a nose high situation, rolling the airplane to a bank angle that starts the nose down may be effective. Bank angles of about 45°, up to a maximum of 60°, could be needed. Normal roll controls - up to full deflection of ailerons and spoilers - may be used. Unloading the wing by maintaining continuous nose-down elevator pressure keeps the wing angle of attack as low as possible, making the normal roll controls as effective as possible.

Finally, if normal pitch control then roll control is ineffective, careful rudder input in the direction of the desired roll may be required to initiate a rolling maneuver recovery.

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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.

Steep Turns

The objective of the steep turn maneuver is to familiarize the pilot with airplane handling characteristics and improve the instrument cross check.

During training, 45° of bank is used. It is not intended that the pilot should bank greater than 25° to 30° for normal, or non-normal procedures. If so equipped, the GPWS gives momentary bank angle alerts up to 45°.

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. Trimming during the maneuver is not recommended. Varying the angle of bank while turning makes pitch control more difficult. If altitude loss becomes excessive, reduce the angle of bank as necessary 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.

Vertical Speed Indicator

IRS vertical speed indications are reliable during the turn.

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.

Note: If the command speed is set to target speed on the MCP, the airspeed fast/slow indicator (as installed) on the attitude display indicates thrust change required.

Rollout

Higher than normal pitch attitude and thrust is used during the turn. Roll out at the same rate as used with normal turns. Normally rollout should begin 15° to 20° prior to the desired heading.

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 airplane. The Look-ahead terrain alerting (as installed) also provides an aural warning when an unsafe distance is detected from terrain ahead of the airplane. Immediately accomplish the Terrain Avoidance maneuver found in the non-normal maneuvers section in the QRH.

Do not attempt to engage the autopilot and/or autothrottle until terrain clearance is assured.

Traffic Alert and Collision Avoidance System (TCAS)

TCAS is designed to enhance crew awareness of nearby traffic and issue advisories for timely visual acquisition or appropriate vertical flight path maneuvers to avoid potential collisions. It is intended as a backup to visual collision avoidance, application of right-of-way rules and ATC separation.

Use of TA/RA, TA Only, and Transponder Only Modes

TCAS operation should be initiated just before takeoff and continued until just after landing. Whenever practical, the system should be operated in the TA/RA mode to maximize system benefits. Operations in the Traffic Advisory (TA) Only or TCAS Off (Transponder Only) modes, to prevent nuisance advisories and display clutter, should be in accordance with operator policy.

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The responsibility for avoiding collisions still remains with the flight crew and ATC. Pilots should not become preoccupied with TCAS advisories and displays at the expense of basic airplane control, normal visual lookout and other crew duties.

Traffic Advisory (TA)

A Traffic Advisory (TA) occurs when nearby traffic meets system minimum separation criteria, and is indicated aurally and visually on the TCAS traffic display. If a TA is received, immediately accomplish the Traffic Avoidance recall procedure in the QRH.

Maneuvers based solely on a TA may result in reduced separation and are not recommended.

The TA ONLY mode may be appropriate under the following circumstances:

- during takeoff toward known nearby traffic (in visual contact) which would cause an unwanted RA during initial climb
- during closely spaced parallel runway approaches
- when flying in known close proximity to other airplanes
- in circumstances identified by the operator as having a verified and significant potential for unwanted or undesirable RAs
- engine out operation.

Resolution Advisory (RA)

When TCAS determines that separation from approaching traffic may not be sufficient, TCAS issues a Resolution Advisory (RA) aural warning and a pitch command. Maneuvering is required if any portion of the airplane 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). Flight crews should follow RA commands using established procedures unless doing so would jeopardize the safe operation of the airplane or positive visual contact confirms that there is a safer course of action. If a RA is received, immediately accomplish the Traffic Avoidance maneuver in the QRH.

RA maneuvers require only small pitch attitude changes which should be accomplished smoothly and without delay. Properly executed, the RA maneuver is mild and does not require large or abrupt control movements. Remember that the passengers and flight attendants may not all be seated during this maneuver. The flight director is not affected by TCAS guidance. Therefore, when complying with an RA, flight director commands may be followed only if they result in a vertical speed that satisfies the RA command.



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During the RA maneuver, the aircrew attempts to establish visual contact with the target. However, visual perception of the encounter can be misleading. The traffic acquired visually may not be the same traffic causing the RA.

Note: Unless it is confirmed that the target acquired visually is the one generating the RA, the pilot should always comply with the displayed RA commands.

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, GPWS, and stall warnings take precedence over TCAS advisories. Stick shaker must be respected at all times. 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 airplane. Smoothly and expeditiously return to appropriate altitudes and speeds when clear of conflict. Maneuvering opposite to an RA command is not recommended since TCAS may be coordinating maneuvers with other airplanes.

Upset Recovery

For detailed information regarding the nature of upsets, aerodynamic principles, recommended training and other related information, refer to the Airplane Upset Recovery Training Aid available through your operator.

An upset can generally be defined as unintentionally exceeding the following conditions:

- pitch attitude greater than 25 degrees nose up, or
- pitch attitude greater than 10 degrees nose down, or
- bank angle greater than 45 degrees, or
- within above parameters but flying at airspeeds inappropriate for the conditions.

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 airplane. 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:

- stall recovery
- nose high, wings level
- nose low, wings level

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- high bank angles
- nose high, high bank angles
- nose low, high bank angles

Stall Recovery

In all upset situations, it is necessary to recover from a stall before applying any other recovery actions. A stall may 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. Under certain conditions, it may be necessary to reduce some thrust in order to prevent the angle of attack from continuing to increase. Once stall recovery is complete, upset recovery actions may be taken and thrust reapplied as needed.

Nose High, Wings Level

In a situation where the airplane pitch attitude is unintentionally more than 25 degrees nose high and increasing, the airspeed is decreasing rapidly. As airspeed decreases, the pilot's ability to maneuver the airplane 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 airplane'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 airplane using stabilizer trim, and should stop trimming nose down when they feel the g force on the airplane lessen or the required elevator force lessen. This use of stabilizer trim may correct an out-of-trim airplane 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 to 1 g. If altitude permits, flight tests have determined that an effective way to achieve a nose-down pitch rate is to reduce some thrust.



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If normal pitch control inputs do not stop an increasing pitch rate, rolling the airplane to a bank angle that starts the nose down should work. Bank angles of about 45 degrees, up to a maximum of 60 degrees, 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 airplane to normal flight.

Nose Low, Wings Level

In a situation where the airplane pitch attitude is unintentionally more than 10 degrees 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 airplane'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 degrees, it is possible to experience bank angles greater than 90 degrees.

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Any time the airplane 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 degrees, level flight cannot be maintained within flight manual limits for a 2.5 g load factor. In high bank angle increasing airspeed situations, the primary objective is to maneuver the lift of the airplane 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 degrees 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 airplane.

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 airplane 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 airplane is at a high enough altitude that ground impact is not an immediate concern, airspeed can rapidly increase beyond airplane 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 degrees. 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 necessary.

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 airplane.

If an upset situation is recognized, immediately accomplish the Upset Recovery maneuver found in the non-normal maneuvers section in the QRH.

Windshear

General

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 airplane. 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.

Airplane Performance in Windshear

Knowledge of how windshear affects airplane 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 airplane is accelerating. As the airspeed decreases, the airplane 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.

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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 airplane 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.

Avoidance, Precautions and Recovery

Crew actions are divided into three areas: Avoidance, Precautions and Recovery. For more information on avoidance and precautions, see the Windshear Supplementary Procedure in Volume 1 of the Operations Manual. For specific crew actions for recovery, see the non-normal maneuvers section in the QRH.



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Non-Normal Operations

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Preface

This chapter describes pilot techniques associated with accomplishing selected Non-Normal Checklists (NNCs). Aircrews are expected to accomplish NNCs listed in the QRH. These checklists ensure maximum safety until appropriate actions are completed and a safe landing is accomplished. Techniques discussed in this chapter minimize workload, improve crew coordination, enhance safety, and provide a basis for standardization. A thorough review of the QRH section CI.2, (Checklist Introduction), is an important prerequisite to understanding this chapter.

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 AIRPLANE CONTROL:** It is mandatory for one pilot to fly the airplane while the non-flying pilot accomplishes the non-normal checklist. 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

Note: Pilots should don oxygen masks and establish communications anytime oxygen deprivation or air contamination is suspected, even though an associated warning has not occurred.

- **TAKE THE PROPER ACTION:** Although many in-flight non-normal situations require immediate corrective action, difficulties can be compounded by the rate the pilot flying issues commands and speed of execution by the non-flying pilot. Commands must be clear and concise, allowing time for acknowledgment of each command prior to issuing further instructions. The pilot flying must exercise positive control by allowing time for acknowledgment and execution. The other crewmembers must be certain their reports to the pilot flying 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 land at the nearest suitable airport, diversion to the nearest airport where a safe landing can be accomplished is required. If the NNC does not direct landing at the nearest suitable airport, the pilot must determine if continued flight to destination is a compromise to safety.

Landing at the Nearest Suitable Airport

“Plan to land at the nearest suitable airport” is a phrase used in Boeing Operations Manuals. 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 rule to meet the emergency. In all cases the pilot-in-command is expected to take a safe course of action.

Boeing assists flight crews in the decision making process by indicating in the Quick Reference Handbook (QRH) the situations where “landing at the nearest suitable airport” is required. These situations are indicated in the Checklist Introduction or the individual checklists.

The rules regarding an engine failure are specific. The FARs specify that the pilot-in-command of a twin engine airplane that has an engine failure or engine shutdown shall land at the nearest suitable airport at which a safe landing can be made.

Note: If the pilot-in-command lands at an airport other than the nearest suitable airport, in point of time, the FARs require a written report from the airline stating the reasons for determining that the selection of an airport, other than the nearest airport, was as safe a course of action as landing at the nearest suitable airport.

A suitable airport is defined by the operating authority for the operator by guidance material, but in general must have adequate facilities and meet certain minimum weather and field conditions. If required to divert to the nearest suitable airport (twin engine airplane with engine failure), the guidance material also typically specifies 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 airplane 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 airplane'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.

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 passenger evacuation. This may dictate landing at the nearest airport appropriate for the airplane type, rather than the nearest suitable airport normally used for the route segment where the incident occurs.

Ditching

Send Distress Signals

Transmit Mayday, establish 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 landfill.

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 aircraft secured. Put on life vests, shoulder harness, and seat belts. Do not inflate life vest until after exiting the airplane.

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 power available improves ability to properly control touchdown.

Passenger Cabin Preparation

Confer with cabin personnel either by interphone or by personally reporting to the flight deck to assure passenger cabin preparations for ditching are complete.

Ditching Final

Transmit final position. Extend flaps 30 or appropriate landing flaps for the existing condition.

Advise the cabin crew of imminent touchdown. On final approach announce ditching is imminent, advise crew and passengers to brace for impact. Maintain airspeed at VREF. Maintain 200 to 300 fpm rate of descent. Plan to touchdown 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 airplane has come to rest, proceed to assigned ditching stations and evacuate as soon as possible, assuring all passengers are out of the airplane.

Deploy slides/rafts. Be careful not to rip or puncture the slides/rafts. Avoid drifting into or under parts of the airplane. Remain clear of fuel saturated water.

Electrical

Approach and Landing on Standby Power

The probability of a total and unrecoverable AC power failure is remote. Because of system design, a checklist for accomplishing an approach and landing on standby power is not required. However, some regulatory agencies require pilots to train to this condition. During training, or in the unlikely event that a landing must be made on standby power, the following guidelines should be considered.

Fly the approach on speed. Anti-skid is not available, and with the higher approach speed, any excess speed is undesirable. Auto speedbrakes are not available. Thrust reversers are available on many, but not all airplanes. Verify thrust reverser availability with the appropriate operations manual.

Engines, APU

Engine Failure vs Engine Fire After Takeoff

In case of an engine failure, there are no recall checklist items. The non-normal checklist for an engine failure is normally accomplished after the flaps have been retracted and conditions permit.

In case of an engine fire, when the airplane is under control, the gear has been retracted, and a safe altitude has been attained (minimum 400 feet AGL) accomplish the non-normal checklist recall action items. Due to asymmetric thrust considerations, Boeing recommends that the PF retard the thrust lever after the PNF confirms that the PF has the correct engine. Reference items should be accomplished on a non-interfering basis with other normal duties after the flaps have been retracted and conditions permit.

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 to the flight crew when responding to this malfunction is recognizing the condition and determining which engine has malfunctioned. This condition can occur during any phase of flight.

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Failure of engine or fuel control system components, or loss of thrust lever 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 thrust lever condition. This fixed RPM or thrust lever condition may be very near the commanded thrust level and therefore difficult to recognize until the flight crew attempts to change thrust with the thrust lever. Other engine responses include: shutdown, operation at low RPM, or thrust at the last valid thrust lever setting (in the case of a thrust lever feedback fault) depending on altitude or air/ground logic. In all cases, the affected engine does not respond to thrust lever movement.

The Engine Limit/Surge/Stall non-normal checklist is written to include this malfunction. 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 Engine Limit/Surge/Stall checklist can be accomplished. This helps with directional control and may preclude an inadvertent shutdown of the wrong engine. In some conditions such as during low speed ground operations, immediate engine shutdown may be necessary to maintain directional control.

Dual Engine Failure

Dual engine failure is a situation that demands prompt action regardless of altitude or airspeed. Accomplish recall items and establish the appropriate airspeed to immediately attempt windmill restart. There is a higher probability that a windmill start will succeed if the restart attempt is made as early as possible (or immediately after recognizing 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 driftdown to lower altitude to improve windmill starting capability.

The inflight 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 dual engine failure checklist is written to ensure flight crews take advantage of the high RPM at engine failure regardless of altitude or airspeed. A subsequent APU start may be initiated as soon as practical for electrical power and starter assist start attempted if the rapid restart does not succeed. Initiate the rapid relight recall procedure before attempting an APU start for the reasons identified above.



EGT during rapid restart may exceed the limit displayed by EICAS for one-engine starts. During relight attempts with both engines failed, use the Standby Engine Indicator takeoff EGT placard limit even if EICAS remains powered. A hung or stalled in-flight start is normally indicated by stagnant RPM and/or increasing EGT. During start, engines may accelerate to idle slowly but action should not be taken if RPM is increasing and EGT is not near or rapidly approaching the SEI limit.

Note: When electrical power is restored, do not confuse the establishment of APU generator power with airplane engine generator power at idle RPM and advance the thrust lever prematurely.

Engine Severe Damage Accompanied by High Vibration

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 airplane 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 airplane 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 thus 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 backwards, 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.

Flight Controls

For any flight control problem, consider the possibility of higher airspeed on approach, longer landing distance, and a different flare picture and landing technique.

For non-normal landings, position two white reference airspeed bugs at VREF and single white reference airspeed bugs at the flap 5 maneuvering speed and the flap up maneuvering speed.

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.

All Flaps and Slats Up 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 airplane gross weight (burn off fuel) to reduce touchdown speed.

Fly a wide pattern to allow for the increased turning radius required for the higher maneuvering speed. Establish final approximately 10 miles 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. Maintain no slower than flaps up maneuvering speed until established on final. Maneuver with normal bank angles until on final.

Final Approach

Use an ILS glide slope if available. Do not reduce the airspeed to the final approach speed until aligned with the final approach. Prior to intercepting descent profile, decrease airspeed to command speed and maintain this speed until the landing is assured.

The rate of descent on final approach is approximately 1,000 fpm due to the higher ground speed. Final approach body attitude is approximately 4° higher than normal. Do not make a flat approach (shallow glide path angle) or aim for the threshold of the runway. This may result in main gear touching down short of the runway. Plan touchdown at the 1,800 foot point.



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Use manual control of thrust levers. Due to automatic speed protection, autothrottle use may result in higher than desired speed on final. Engines will be at low idle speed due to no flap extension. When engines are near idle RPM, time required for engines to accelerate is longer than normal.

Note: Use of the autopilot during approach phase is acceptable. Do not autoland.

Speedbrakes are not recommended for airspeed reduction below 800 feet. If landing is anticipated beyond the normal touch down zone, go around.

Landing

Fly the airplane onto the runway at the recommended touchdown point. Flare only enough to achieve acceptable reduction in the rate of descent. Do not allow the airplane 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 required to achieve touchdown at the desired point and to lower the nosewheel to the runway. After lowering the nosewheel to the runway, hold forward control column pressure and expeditiously accomplish the landing roll procedure. Full reverse thrust is required for a longer period of time.

Use of autobrakes is recommended. Autobrake setting should be consistent with runway length. (See Autobrakes Landing distance in the Performance Inflight section of the QRH). Use manual braking if deceleration is not suitable for the desired stopping distance.

Immediate initiation of reverse thrust at main gear touchdown (reverse thrust is more effective at high speeds) and full reverse thrust allows the autobrake system to reduce brake pressure to the minimum level. Less than maximum reverse thrust increases brake energy requirements and may result in excessive brake temperatures.

Leading Edge Slat Asymmetry - Landing

If a leading edge asymmetry/no leading edge device condition occurs, the adjusted VREF provides normal bank angle maneuvering capability but does not allow for 15° overshoot protection in all cases.

Do not hold the airplane off during landing flare. Floating just above the runway surface to deplete the additional threshold speed wastes available runway and increases the possibility of a tail strike.

Note: If the gear is retracted during a go-around and flap position is greater than 20, a landing gear configuration warning occurs.

Trailing Edge Flap Asymmetry - Landing

If a trailing edge flap up asymmetry occurs, full maneuvering capability exists even if the asymmetry occurred at flaps just out of the full up position. Burn off fuel to reduce landing weight and lower approach speed.

Fly accurate airspeeds in the landing pattern. At lesser flap settings excess airspeed is difficult to dissipate, especially when descending on final approach. Pitch attitude and rate of descent on final is higher than for a normal landing. During flare, airspeed does not bleed off as rapidly as normal.

Fly the airplane onto the runway at the recommended touchdown point. Flare only enough to achieve acceptable reduction in the rate of descent. Do not allow the airplane 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.

Note: If the gear is retracted during a go-around and flap position is greater than 20, a landing gear configuration warning occurs.

Jammed or Restricted Flight Controls

Although rare, jamming of the flight control system has occurred on commercial airplanes. 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 airplane. 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 disconnect
- autopilot that cannot be engaged
- undershoot or overshoot of an altitude during autopilot leveloff
- 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.



Some flight controls are linked together through override features. If the jam does not clear, activation of an override feature allows a flight control surface to be moved independently of the jammed control. Applying force to the non-jammed flight control activates the override feature. When enough force is supplied, 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 kg) is normally required to move the surface, and 50 lbs (23 kg) of force is required to activate the override, a total force of 60 lbs (27 kg) is required 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.

Note: There are override features for the aileron and elevator.

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*
*Asymmetric engine thrust may aid roll and directional control.	

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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 airplane.

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.

Jammed Stabilizer

During flight test certification the worst-case jammed stabilizer condition was evaluated. A satisfactory landing could be accomplished without the use of special configurations or speeds. Adequate flare capability was available at flaps 30 and flaps 20 using normal approach speeds. Therefore, a special flight checklist is not considered necessary.

Unscheduled Stabilizer Trim

Hold control column firmly to maintain desired pitch attitude. If uncommanded trim motion continues, the stabilizer trim commands are interrupted when the control column is displaced in the opposite direction.

Flight Instruments, Displays

Airspeed Unreliable

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, trapped pressure within the system reacts unpredictably. The pressure may increase through expansion, decrease through contraction, or remain constant. In each case, the airspeed indications would be abnormal. This could mean increasing indicated airspeed in climb, decreasing indicated speeds in descent, or unpredictable indicated speeds 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 require familiarity with the interrelationship of attitude, thrust setting, and airspeed. A delay in recognition could result in loss of aircraft control.

The flight crew should be familiar with the approximate pitch attitude for each flight maneuver. For example, climb performance is based on maintaining a particular airspeed or Mach number. This results in a specific body attitude that varies slightly with gross weight and altitude. Any significant change from this body attitude required to maintain a desired airspeed should alert the flight crew to a potential problem.

When the abnormal airspeed is recognized, immediately return the airplane to the target attitude and thrust setting for the flight regime. If continued flight without valid airspeed indications is necessary, consult the Flight With Unreliable Airspeed/Turbulent Air Penetration table in the Performance Inflight section of the QRH for the correct attitude, thrust settings, and V/S for actual airplane gross weight and altitude.

Ground speed information is available from the FMC and on the instrument displays. These indications can be used as a cross check. Many air traffic control radars can also measure ground speed.

For airplanes equipped with an Angle of Attack (AOA) indicator, maintain the analog needle at approximately the three o'clock position. This approximates a safe maneuvering speed or approach speed for the existing airplane configuration.

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Descent

Idle thrust descents can be made to 10,000 feet by flying body attitude and checking rate of descent from the QRH tables. At 2,000 feet above the selected level off altitude, reduce rate of descent to 1,000 FPM. On reaching selected altitude, establish attitude and thrust for the airplane configuration. If possible, allow the airplane to stabilize before changing configuration and altitude.

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 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 airplane on to the runway, do not hold it off or let it “float” to touchdown.

Use autobraking if available. If manual braking is used, 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 for fuel balance limitations/alerts on Boeing airplanes is for structural life of the airframe and not due to controllability limitations. 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 Boeing 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 airplane 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 coming unexpectedly from the tank with the lowest quantity.

Note: It is not necessary to terminate fuel balancing on final approach.

Fuel Leak

Any time an unexpected fuel quantity indication, FMC or EICAS fuel message, or imbalance condition is experienced, a fuel leak should be considered as a possible cause. Maintaining a fuel log and comparing it to the flight plan can help the pilot recognize a fuel leak.

Significant fuel leaks, although fairly rare, are difficult to detect. The non-normal checklist assumes the leak is between the strut and the engine. 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 can occur 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 non-normal checklist.

Low Fuel

A low fuel condition exists when the FUEL CONFIG light illuminates and the EICAS message LOW FUEL is displayed.

Approach and Landing

With a low fuel quantity, the clean configuration should be maintained as long as possible during the descent and approach to conserve fuel. However, initiate configuration change early enough to provide a smooth, slow deceleration to final approach speed to prevent fuel running forward in the tanks.

A normal landing configuration and appropriate airspeed 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 airplane. If any wing tank fuel pump low pressure light illuminates, do not turn off fuel pump switches.

Hydraulics

Proper planning of the approach is important. Consideration should be given to the effect the inoperative system(s) has on crosswind capabilities, autoflight, stabilizer trim, control response, control feel, reverse thrust, stopping distance, go-around configuration and performance required to reach an alternate airfield.

Note: Autolands are not certified with any hydraulic system inoperative.

Hydraulic System(s) Inoperative - Landing

If the landing gear is extended using the alternate gear extension, the gear cannot be raised. Flaps can be extended or retracted using the alternate flap drive system. However, the rate of flap travel is significantly reduced.

Flaps 20 and an adjusted VREF are used for landing with multiple hydraulic systems inoperative to improve flare authority, control response and go-around capability. The airplane may tend to float during the flare. Do not allow the airplane to float. Fly the airplane onto the runway at the recommended point.

Landing Gear

Landing on a Flat Tire

Boeing airplanes 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 required to help with 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 wheel to the runway while braking lightly. Runway length permitting, use idle reverse thrust. Autobrakes may be used at the lower settings. 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. Do not use autobrakes.

If uncertain whether a nose tire or main tire has failed, slowly and gently lower the nose wheel to the runway and do not use autobrakes. Differential braking may be required to help steer the airplane. Use idle or higher reverse thrust as required to stop the airplane.

Loss of two aft main gear tires may cause the airplane air/ground sensing system to remain in the in air mode causing loss of thrust reversers and a need to manually deploy the speedbrakes.

Partial or Gear Up Landing

General

Land on all available gear. 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.

If time and conditions permit, reduce weight as much as possible by burning off fuel to provide the slowest possible touchdown speed. Less damage occurs if the airplane is kept on a paved landing area.

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 necessary. Tests have shown that foaming provides minimal benefit and it takes approximately 30 minutes to replenish the fire truck's foam supply.

Prior to Approach

At the captain's command, advise the crew and the passengers of the situation, as necessary. Coordinate with all ground emergency facilities. For example, the fire trucks normally operate on a common VHF frequency with the airplane and can advise the crew of airplane condition during the landing. Advise cabin crew to perform emergency landing procedures and to brief passengers on evacuation procedures.

Position the ground proximity configuration gear override switch to OVRD to prevent nuisance warnings when close to the ground with the gear retracted. Extend all available gear, if desired. Turn pack control selectors OFF to depressurize the airplane. Select all fuel pump switches OFF to reduce the possibility of fire in the event of fuel line rupture.

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Landing Techniques

Plan a normal approach, extending maximum flaps with a normal landing and a normal rate of descent. Use the normal speeds plus headwind component and gust factor corrections. Attempt to keep the airplane on the runway to help passenger evacuation and minimize damage.

Both Main Gear Extended (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 speedbrakes. Use normal reverse thrust. Lower the nose gently before losing elevator effectiveness. Normal braking can be used to minimize structural damage.

Nose Gear Only Extended

Establish a normal approach with maximum flaps. Use normal approach and flare attitude maintaining back pressure on the control column until ground contact. The engines contact the ground prior to the nose gear. Manually extend the speedbrakes after touchdown.

All Gear Up or Partially Extended

Use a normal approach and flare attitude. The engines contact the ground first. Manually extend the speedbrakes after touchdown. There is adequate rudder available to maintain directional control during the initial ground slide.

One Main Gear Only Extended

Land the airplane on the side of the runway that corresponds to the extended main gear down. At touchdown extend the speedbrakes and maintain wings level as long as possible. Use rudder and braking as required to keep the airplane rolling straight. Place the fuel control switch to CUT OFF prior to the corresponding engine contacting the runway.

One Main Gear Extended and Nose Gear Extended

Fly a normal approach and flare profile. The landing gear absorbs the initial shock and delays touchdown of the engine. At touchdown, extend speedbrakes and use rudder and nose wheel steering for directional control. Braking on the side opposite the unsupported wing should be used as required to keep the airplane rolling straight. Maintain the wings level as long as possible.

After Stop

Accomplish passenger evacuation, if required.

Overspeed

Vmo/Mmo is a maximum operating speed limit on the airplane and should not be exceeded. However, momentary exceedance sometimes occurs due to atmospheric effects and airplane anomalies. If encountered, smoothly reduce thrust and, if required, adjust attitude to reduce airspeed to less than Vmo/Mmo. This can be accomplished using the autoflight system or manual flight.

Note: If manual inputs are required, disconnect the autopilot.

Airplanes have been flight tested beyond Vmo/Mmo to ensure smooth pilot inputs will return the airplane safely to the normal flight envelope. Anytime Vmo/Mmo is exceeded, the maximum airspeed should be noted in the flight log.

Passenger Evacuation

If the evacuation is planned and time permits, a thorough briefing and preparation of the crew and passengers will increase the chances of a successful evacuation. Flight deck preparations should include a review of pertinent checklists and any other actions to be accomplished. Appropriate use of autobrakes should be discussed. Notify flight attendants of possible adverse conditions at 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 prevailing 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 will improve the chances for a successful passenger evacuation.

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.

Note: Anytime fuselage contact is suspected or known to have occurred, accomplish the appropriate non-normal checklist.

Takeoff Risk Factors

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

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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 entered incorrectly either 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 load sheet numbers. Comparing the load sheet numbers against past experience in the aircraft can assist in approximating numbers that are reasonable.

Rotation at Improper Speed

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

Excessive Rotation Rate

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

Improper Use of the Flight Director

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 15 degrees. However, an aggressive rotation into the pitch bar at takeoff is not appropriate and can cause a tail strike.

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. Flight crews should stabilize all approach variables - on centerline, on approach path, on speed, and in the final landing configuration - by the time the airplane descends through 1,000 feet above ground level (AGL). This is not always possible. Under normal conditions, if the airplane descends through 1,000 feet AGL (IMC), or 500 feet AGL (VMC), with these approach variables not stabilized, a go-around should be considered.

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 power 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. Conversely, 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. In this case, the momentary addition of power may aid in preventing the tail strike. In addition, unstabilized approaches can result in landing long or a runway over run.

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 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.

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.

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Mishandling of Crosswinds

When the airplane is placed in a forward slip 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 required, 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 time-honored 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.

Wheel Well Fire

Prompt execution of the Wheel Well Fire checklist following a wheel well fire warning is important for timely gear extension. Landing gear speed limitations should be observed during this procedure.



If airspeed is above 270 knots/.82 Mach, the airspeed must be reduced before extending the landing gear. A rapid way to reduce airspeed during climb or descent is to select FLCH to open the MCP command speed window, then set approximately 250 knots. An alternate way to reduce airspeed during a climb or descent is to select altitude hold and select a lower speed. With the autothrottle in a speed mode, thrust levers may be reduced to idle and/or speedbrakes may be used to expedite deceleration.

Note: To avoid unintended deceleration below the new target airspeed, the autothrottle should remain engaged.

Windows

Window Damage

If both forward windows delaminate or forward vision is unsatisfactory, accomplish an autoland, if the ILS facility is satisfactory.

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, the crew should consider continuing the takeoff and close the window after becoming airborne and the flight path is under control.

If required, the windows may be opened in-flight, at or below holding speeds, after depressurizing the airplane. It is recommended that the airplane be slowed since the noise levels increase at higher airspeed. Intentions should be briefed and ATC notified prior to opening the window as the noise level is high, even at slow speeds. Because of airplane 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 Boeing 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 checklists applied as necessary to fit the situation, or be faced with little or no specific guidance except their own judgement and experience. Because of the highly infrequent nature of these occurrences, it is not practical or possible to create definitive flight crew checklists to cover all events.

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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 airplane handling characteristics and a comprehensive understanding of airplane 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 are a brief review of some basic aerodynamic principles and airplane 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 airplane 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 airplane’s natural tendency to oscillate in the pitch axis if the stable pitch attitude is upset. These oscillations are normally self damping in Boeing airplanes, 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 airplane 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 airplanes. 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 limit bank angle to 15 degrees in the event maneuvering capability is in question. Increasing the normal flap/speed maneuvering schedule while staying within flap placard limits provides extra stall margin where greater bank angles are necessary
- all Boeing airplanes have the capability to land using any flap position, including flaps up. Use proper maneuvering and final approach speeds and ensure adequate runway is available to stop the airplane 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 airplane 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 power 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 airplane and maintain a safe flight path. Even in a worst case condition where it is not possible to keep the airplane 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 airplane performance immediately requires such action. Consideration should be given to the possible effects of an asymmetrical flap condition on airplane control, if flap position is changed. If no flap damage exists, wing flaps should be operated as directed in the associated non-normal checklist. Anytime 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 airplane handling characteristics while airborne may continue to adversely affect airplane 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.

Recall Checklists

After flight path control has been established, accomplish the recall steps of appropriate NNCs. The emphasis at this point should be on containment of the problem. Execution of non-normal checklist actions commences when the airplane flight path and configuration are properly established.

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Accomplish all applicable NNCs prior to commencing final approach. Exercise common sense and caution when accomplishing multiple checklists with differing direction. 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 assure 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 Airplane Handling Evaluation

Unless circumstances such as imminent airplane 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. Use caution when reducing airspeed to lower flaps. Make configuration and airspeed changes slowly until a damage and controllability assessment has been accomplished and it is certain that lower airspeeds can be safely used. In addition, limit bank angle to 15 degrees and avoid large or rapid changes in engine thrust and/or airspeed. If possible, conduct this 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 judgement in consideration of the existing conditions and circumstances to determine an appropriate altitude for this evaluation.

The assessment 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 airplane 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 airplane is visible to the flight crew from the flight deck, any visual observation data could be used to gain maximum knowledge of airplane configuration and status and could be valuable in determining subsequent actions.



The flight crew should consider contacting the company to both inform them of the situation and as a potential source of useful information. In addition to current and forecast weather, and airfield conditions, it may be possible to obtain technical information and recommendations from expert sources. These expert sources are available from within the company as well as from Boeing.

If controllability is in question, consider performing a check of the airplane handling characteristics. The purpose of this check is to determine minimum safe speeds and appropriate configuration for landing. Limit bank to 15 degrees and avoid rapid thrust and airspeed changes which might adversely affect controllability. If flap damage has occurred, prior to accomplishing this check, consider the possible effects on airplane 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 gear only if available thrust permits.

As a starting point, use the flap/speed schedule as directed in the appropriate non-normal checklist. 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.

If airplane performance is a concern, use of the alternate flap or gear extension systems may dictate that the configuration portion of this check be accomplished in conjunction with 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 airplane configuration.

After the damage assessment and handling characteristics are evaluated, the crew should formulate a sequential plan for the completion of the flight.

Approach and Landing

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.

Plan an extended straight-in approach with time allotted for the completion of any lengthy NNCs such as the use of alternate flap or landing gear extension systems. Arm autobrakes and speedbrakes unless precluded by the checklist.

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If possible fly a normal approach profile, and attempt to land in the normal touchdown zone. If asymmetrical thrust is being used for roll control or pitch authority is limited, leave thrust on until touchdown. After landing, use available deceleration measures to bring the airplane to a complete stop on the runway. Circumstances dictate the requirement for an airplane evacuation or if the airplane can be taxied off the runway.



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