737-200
Flight Crew Training Manual

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FCTM

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General

The airplane models listed in the table below are covered in this Flight Crew Training Manual.

Model
737-200
737-200A

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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General

The Flight Crew Training Manual (FCTM) 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 including taxi operations in adverse weather conditions. Chapters 3 through 6 are titled by phase-of-flight and contain information about airplane operations in each phase. The Maneuvers chapter covers maneuvers associated with climb, cruise, and descent, i.e., approach to stall or stall recovery and rapid descent. The Non-Normal Operations 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.

This manual also contains two appendices. Appendix A - Section 1, Operational Information is available for the operator to use as desired. It provides a convenient location to supplement the FCTM with operator specific information. Appendix A - Section 2, Supplemental Information contains information for the operations staff of organizations rather than individual pilots. These are considerations for each operator to evaluate and use as they see fit for their operations. The operator may wish to remove this appendix before distributing the manual to their pilots.

Note: In the event of a conflict, the procedures and restrictions published in the FCOM, QRH, MMEL/MEL, or DDG take precedence over the information, techniques, and recommendations in the FCTM.

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

Note: 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 submitted through a Service Request (SR). The Boeing Company will accept initial SRs through the Service Request Application found on the MyBoeingFleet.com portal. To establish an SR Application account, please contact your company's MyBoeingFleet Electronic Access Focal. To establish MyBoeingFleet access, please contact Boeing's Digital Data Customer Support via email.

Email: ddcs@boeing.com

Regulatory Agencies

Regulatory information in this manual is based upon FAA regulations and requirements unless otherwise indicated. Other regulatory agencies may have different regulations and requirements that need to be addressed by non-FAA operators. Examples of regulations and requirements include, but are not limited to, FAR takeoff field requirements, airplane approach categories, and low visibility approach criteria.

Airplane Configuration

The FCTM is intended to provide information in support of procedures listed in the Flight Crew Operations Manual (FCOM) 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 FCOM. 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 to the desired position and the airspeed approaches maneuver speed, ensure CLB thrust is set." This statement is not intended to tell the crew how to set climb thrust, only to emphasize that the flight crew must ensure that CLB thrust is set. It is recognized that crew actions required to set climb thrust are different in different models. Reference to the applicable FCOM 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 FCOM.

This manual is written as if all airplanes are configured with an autothrottle and Performance Data Computing System (PDCS). For operators of airplanes without an autothrottle, disregard references to autothrottle modes. Operators of airplanes without a PDCS should realize that although these terms do not specifically apply to their airplanes, most of the PDCS functions can be accomplished manually.

This manual contains information for airplanes configured with either the SP-77 or the Sperry SP-177 autopilot. The annotation “SP-77” or “SP-177” is used to indicate information, procedures, or techniques that are applicable to only one autopilot configuration.

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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	
AC	Alternating Current
ADF	Automatic Direction Finder
ADI	Attitude Director Indicator
AFCS	Automatic Flight Control System
AFDS	Autopilot Flight Director System
AFE	Above Field Elevation
AFM	Airplane Flight Manual (FAA approved)
AGL	Above Ground Level
ALT ACQ	Altitude Acquire
ALT HOLD	Altitude Hold
AMM	Aircraft Maintenance Manual
A/P	Autopilot
APU	Auxiliary Power Unit
ASI	Airspeed Indicator
ASR	Airport Surveillance Radar
A/T	Autothrottle
ATC	Air Traffic Control
ATM	Assumed Temperature Method
B	
BARO	Barometric
B/B	Back Beam
B/CRS B/C	Back Course
C	
C	Captain Celsius Center
CAA/JAA	Civil Aviation Authority/Joint Aviation Authority
CDFA	Continuous Descent Final Approach
CDU	Control Display Unit
CFIT	Controlled Flight Into Terrain
CFP	Computer Flight Plan
CG	Center of Gravity
CLB	Climb
CMD	Command
CON	Continuous
CRM	Crew Resource Management
CRT	Cathode Ray Tube

CRZ	Cruise
CWS	Control Wheel Steering
D	
D/D	Drift Down
DDPG	Dispatch Deviations Procedures Guide
DES	Descent
DIR	Direct
DA(H)	Decision Altitude (Height)
DME	Distance Measuring Equipment
E	
EASA	European Aviation Safety Agency
ECON	Economy
EGT	Exhaust Gas Temperature
ENG OUT	Engine Out
EOT	Engine Out Taxi
EPR	Engine Pressure Ratio
ETOPS	Extended Operations
EXT	Extend
F	
F	Fahrenheit
FCOM	Flight Crew Operations Manual
F/D	Flight Director
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FAR	Federal Aviation Regulation
FCC	Flight Control Computer
FMA	Flight Mode Annunciator
F/O	First Officer
FPM	Feet Per Minute
ft	Foot or Feet
G	
g	free fall acceleration of a body
GA	Go-Around
GP	Glide Path
GPWS	Ground Proximity Warning System
G/S	Glide Slope
GS	Ground Speed
H	
HAA	Height Above Airport
HAT	Height Above Touchdown
HDG SEL	Heading Select
HSI	Horizontal Situation Indicator
I	
IAF	Initial Approach Fix
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IGS	Instrument Guidance System
ILS	Instrument Landing System
IM	Inner Marker

IMC	Instrument Meteorological Conditions
IP	Instructor Pilot
K	
K	Knots
KCAS	Knots Calibrated Airspeed
KGS	Kilograms
KIAS	Knots Indicated Airspeed
L	
LBS	Pounds
LDA	Localizer-type Directional Aid
LOC	Localizer
LRC	Long Range Cruise
M	
M	Mach
m	Meters
MAP	Missed Approach Point
MASI	Mach/Airspeed Indicator
MAX	Maximum
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
MORA	Minimum Off Route Altitude
MSL	Mean Sea Level
N	
NAV	Navigation
NM	Nautical Mile
NNC	Non-Normal Checklists
NNM	Non-Normal Maneuvers
O	
OAT	Outside Air Temperature
OM	Outer Marker
P	
PAPI	Precision Approach Path Indicator
PAR	Precision Approach Radar
PDCS	Performance Data Computer System
PF	Pilot Flying
PI	Performance Inflight
PM	Pilot Monitoring
PMC	Power Management Control
Q	
QRH	Quick Reference Handbook
R	
RA	Radio Altitude Resolution Advisory
RDMI	Radio Distance Magnetic Indicator

RMI	Radio Magnetic Indicator
RNAV	Area Navigation
RSEP	Rudder System Enhancement Program
RTO	Rejected Takeoff
RVR	Runway Visual Range
RVSM	Reduced Vertical Separation Minimum
S	
SAT	Static Air Temperature
SDF	Simplified Directional Facility
SPD	Speed
T	
T	True
TA	Traffic Advisory
TACAN	Tactical Air Navigation
TAS	True Airspeed
TAT	Total Air Temperature
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
TRK	Track
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
VOR	VHF Omnidirectional Range
VR	Rotation Speed
VREF	Reference Speed
V/S	Vertical Speed
VSI	Vertical Speed Indicator
V1	Takeoff Decision Speed
V2	Takeoff Safety Speed
W	
WGS-84	World Geodetic system of 1984
WPT	Waypoint
X	
XTK	Cross Track

Revision Transmittal Letter

To: All holders of the 737-200 Flight Crew Training Manual, Boeing Document Number FCT 737-200 (TM)).

Subject: Flight Crew Training Manual Revision.

This revision reflects the most current information available to The Boeing Company 45 days before the subject revision date. The following revision highlights explain changes in this revision. General information below explains the use of revision bars to identify new or revised information.

Revision Record

No.	Revision Date	Date Filed	No.	Revision Date	Date Filed
Initial	April 30, 2005		1	April 30, 2009	
2	March 30, 2014				

General

The Boeing Company issues FCTM revisions to provide new or revised recommendations on maneuvers and techniques, or information supporting changes to FCOM procedures. Revisions may also incorporate appropriate information from previously issued flight operations technical bulletins.

The revision date is the approximate date the manual is posted for customer retrieval.

Formal 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 Flight Crew Training Manual is provided in quantities as specified in each operator’s contract.

Additional copies of this manual are available through the Boeing Data and Services Management (DSM) Catalog. This manual is also available in FrameMaker© format for use in airline modification. Advise if information about FrameMaker© 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. However, retain all tabs. There are no replacement tabs included with this revision.

Revision Highlights

This section (0.4) replaces the existing section 0.4 in your manual.

This manual is published from a database; the text and illustrations are marked with configuration information. Occasionally, because database markers are rearranged, or because items are marked with configuration information due to the additions of new database content, some pages may contain revision bars when content appears to be unchanged. Pages may also be republished without revision bars due to slight changes in the flow of the document.

Chapter 0 - Preface

Section 3 - Abbreviations

0.3.2 - Added "g" to Abbreviations table.

Chapter 1 - General Information

Events Requiring Maintenance Inspection

1.1 - Modified section to clarify that the list of events that require a maintenance inspection is valid whether or not the operator has provided guidance.

1.1 - Added a recommendation to identify which gear or gears are suspected when reporting a hard landing.

1.2 - Added list item to include operator specific procedures or policies.

Qualification Requirements (Checkride)

1.2 - Removed transition because there are other training programs to qualify for a type rating.

Crew Resource Management

1.3 - Clarified that monitoring is also an important part of maintaining situational awareness.

Maneuver Speeds and Margins

1.3 - Changed section title to more accurately reflect section contents.

Flap Maneuver Speeds

1.3 - Deleted redundant paragraph that described what the flap maneuver speed schedule provides.

Maneuver Margins to Stick Shaker

1.4 - Replaced "G" with "g". The lower case "g" is the more correct abbreviation for the free fall acceleration of a body.

Landing

1.9 - Moved paragraph describing steady state and gust corrections to chapter 6.

Non-Normal Conditions

1.9 - Modified discussion about setting VREF speed for non-normal conditions.

Thrust Management

1.11 - Added discussion of Thrust Management.

Callouts

1.12 - Added an explanation of "recommended callouts" and explained the difference between "recommended callouts" and "procedural callouts".

1.12 - Added (as installed) for voice callouts. Voice callouts are not installed on all 737-200s. Clarified PM response to GPWS callouts.

Recommended Callouts

1.13 - Changed the term Standard Callouts to Recommended Callouts which more accurately describes the callouts.

1.13 - Added complete spelling for callouts.

1.14 - Removed criteria for fail passive airplanes.

Standard Phraseology

1.16 - Changed "recommended" to "standard" words and phrases.

1.16 - Removed procedural callouts. These are listed in the FCOM Takeoff Procedure.

Cold Temperature Altitude Corrections

1.16 - Corrected the definition of ISA.

Ice Crystal Icing

1.17 - Added new section based upon a Boeing Flight Operations Technical Bulletin and a Supplementary Procedure titled Ice Crystal Icing.

Autopilot / AFDS Guidelines

1.19 - Added Autopilot to title. Airplanes using the SP-77 autopilot system do not address AFDS in their FCOM.

Manual Flight

1.20 - Removed reference to autopilot engagement.

1.21 - Added Note regarding autopilot engagement. Information move from previous section.

Automatic Flight

1.21 - Automatic Flight section rewritten for clarity.

AFDS Mode Control Panel Faults (SP-177 Autopilot)

1.22 - Added a table describing alternate pitch or roll modes to be considered in the event an AFDS mode becomes unusable.

Chapter 2 - Ground Operations

Static Port Obstructions

2.1 - Added section title of Static Port Obstructions.

Setting the Cabin Pressure Control System

2.1 - Added new section to explain the Boeing recommended method for using the Cabin Pressure Control System.

Push Back or Towing

2.3 - Changed "marshaller clears airplane to taxi" to "marshaller indicates the airplane is clear to taxi".

Taxi General

2.3 - Added information and recommendations applicable to all operators from a Safety Alert for Operators (SAFO) titled Runway Incursion Prevention Actions, published June 10, 2011.

2.3 - Added list item to review NOTAMS and current ATIS.

2.3 - Added briefing of hold short lines.

2.4 - Added list item for airport diagram.

2.4 - Added "pertinent" to list item.

2.4 - Added "request clarification" to list item.

2.4 - Changed "company communications" to "non-essential radio or cabin communications".

Taxi Speed and Braking

2.6 - Added a note to emphasize that extended taxi with continuous or very light brake application to control speed may cause damage to the airplane.

Visual Cues and Techniques for Turning while Taxiing

2.9 - Added "During the turn" to sentence.

Sharp Turns to a Narrow Taxiway

2.9 - Added a new section to provide crews a technique for making sharp turns and turns onto a narrow taxiway.

Taxi - Adverse Weather

2.15 - Deleted the paragraph about exercising the nose gear steering during taxi. This was deleted from the Cold Weather Operations Supplementary Procedure because engineering confirmed it was not required.

Chapter 3 - Takeoff and Initial Climb

Takeoff

3.1 - Added a paragraph to explain that the takeoff profile may need to be modified to satisfy some noise abatement requirements.

Takeoff - General

3.4 - Removed paragraph indicating that flaps up speed to 3,000 feet is generally recommended. Most all airport have special noise abatement procedures for the 737-200 that use altitudes other than 3,000 feet.

Initiating Takeoff Roll

3.5 - Modified discussion about setting EPR by 60 knots to indicate that minor thrust "increases" may be made after 60 knots instead of thrust "adjustments". There should be no reason to reduce thrust to target EPR after 60 knots. Other non-technical changes made for clarity.

3.6 - Removed the discussion about using the nose wheel steering wheel for a normal takeoff. The proper use of the nose wheel steering wheel is described in both the description of the rolling takeoff and the standing takeoff earlier in this section. Information about recommended maximum taxi speeds are covered in the Taxi Speed and Braking section in chapter 2.

3.6 - Moved the paragraph that discusses pushing TO/GA when in the air to a section titled Thrust Control later in this chapter.

Rotation and Liftoff - All Engines

3.7-8 - Non technical editorial change.

Takeoff Crosswind Guidelines

3.11 - Modified format to place information about the table in a bulleted list immediately preceding the table. This modification is for clarity only, no technical changes were made.

Directional Control

3.12 - Modified text for simplicity and clarity.

Thrust Control

3.14 - Added new section for crew awareness.

Adverse Runway Conditions

3.15 - Removed recommended maximum depth of runway contaminates. These are found in the FCOM and vary depending on the regulatory agency recommendations when the airplane was certified and individual operator preferences.

3.16 - Non technical editorial change.

Federal Aviation Regulation (FAR) Takeoff Field Length

3.17 - Modified paragraph to clarify how the AFM accelerate-stop distance is determined and to emphasize that reverse thrust and autobrakes are recommended during normal operations.

Rejected Takeoff Decision

3.18 - Non technical editorial change.

RTO Execution Operational Margins

3.23 - Modified distance for the effect of using dry runway performance on a wet runway to match data published in the Takeoff Safety Training Aid.

Initial Climb - All Engines

3.24 - Simplified the text about automatic wheel braking during gear retraction. Reference the FCOM for more detailed information if desired.

Flap Retraction Schedule

3.26 - Added information about flap retraction removed from chapter 1. This information is more appropriately located in the takeoff phase of flight, chapter 3.

Initial Climb - One Engine Inoperative

3.29 - Non technical editorial change.

Flap Retraction - One Engine Inoperative

3.31 - Added "on the MCP" to sentence.

3.31 - Added "takeoff" to clarify takeoff flap retraction speed schedule.

Flaps Up - One Engine Inoperative (SP-177)

3.31 - Added at "or above" flaps up maneuver speed because it is realistic to assume that the actions are not always taken exactly at flaps up maneuver speed.

3.31 - Non technical editorial change.

Engine Failure During a Reduced Thrust (ATM) Takeoff

3.32 - Section on Engine Failure During an ATM Takeoff is rewritten for clarity and standardization with other 737 variants.

Chapter 4 - Climb, Cruise, Descent and Holding

Climb Constraints

4.1 - Non technical editorial change.

Economy Climb

4.3 - Clarified use of climb speed above 250 knots below 10,000 feet.

Maximum Rate Climb

4.3 - Modified section for clarity.

Maximum Angle Climb

4.3 - Added an explanation the maximum angle climb speed varies with gross weight.

Maximum Altitude

4.4 - Modified buffet or maneuver margin limited altitude definition to more accurately define minimum margin available and to simplify the text. Removed specific FAA and CAA/JAA requirements; these are beyond the purpose of this manual.

Optimum Altitude

4.5 - Non technical editorial change.

Low Fuel Temperature

4.7 - Removed "cold day" from " "...under most extreme cold day conditions".

High Altitude High Speed Flight

4.11 - Changed "disconnecting" to "disengaging the autopilot".

ETOPS

4.12 - Non technical editorial change.

Descent Constraints

4.13 - Added an explanation of why Boeing recommends the setting procedure described above.

Descent Rates

4.14 - Added "from the runway" to clarify statement.

Holding Airspeeds Not Available from the PDCS

4.17 - Added reference to the appropriate section of the FCOM. Currently, holding speeds are available in Volume 1 of the FCOM for all engine operation and in the QRH for engine-out operation.

Chapter 5 - Approach and Missed Approach

Instrument Approaches

5.1 - Added that the marker beacon is selected on the audio control panel only if needed for the approach.

Approach Briefing

5.2 - Added a bullet to remind the crew to check landing distance required compared to landing distance available.

Approach Clearance

5.3 - Moved information from section titled Flap Setting while Maneuvering to the new section titled Flap Configurations for Approach and Landing later in this chapter.

Stabilized Approach Requirements

5.4 - Changed "aircraft" to "airplane" multiple instances in this section.

5.4 - Modified the airspeed recommendation on final approach to use approach speed as the baseline instead of VREF. This allows a more reasonable tolerance if wind corrections required an approach speed of VREF plus significant additives for wind.

Flap Setting for Landing

5.6 - Modified section to include information for chapter 1. This information is more appropriately located in the Approach phase of flight, chapter 5.

ILS Approach

5.9 - Non techncial editorial change.

ILS Approach Profile (SP-77)

5.10 - Aligned flight pattern with associated Normal and Supplementary Procedures.

ILS Approach Profile (SP-177)

5.11 - Aligned flight pattern with associated Normal and Supplementary Procedures.

Approach (SP-177 Autopilot)

5.14 - Non technical editorial change.

5.16 - Changed wind corrections to wind additives in several places to make text consistent.

5.16 - Added reference to Note later in section regarding Intercepting Glide Slope from Above.

5.17 - Added guidance to provide the crew a method for safely intercepting the glide slope from above.

5.17 - Added Note regarding unexpected pitch-up potential when intercepting G/S from above.

Low Visibility Approaches

5.20 - Changed "regulations" to "criteria".

5.21 - Added information about a mistrim condition when the autopilots are disconnected below 400 feet RA during a dual channel approach. This information is available for fail operational airplanes in the section titled "At or Below Alert Height" later in this chapter.

5.21 - Added information about a mistrim condition when the autopilots are disconnected below 400 feet RA during a dual channel approach.

5.21 - Added information about a mistrim condition when the autopilot are disconnected below 400 feet RA during a dual channel approach.

5.22 - Changed "Cat IIIa" to "Cat III".

ILS Approach - Landing Geometry

5.22 - Added "knots" to sentence.

Non - ILS Instrument Approaches

5.25 - Clarified that the use of LVL CHG is not recommended after the FAF during non-ILS instrument approaches. The LVL CHG mode does not provide a constant angle approach.

Non-ILS Instrument Approach

5.27 - Inbound (2NM): changed sequence of actions. At MDA:added disengage A/P.

5.27 - Aligned flight pattern with associated Normal and Supplementary Procedures.

5.28 - Clarified that setting MDA(H) + 50 feet is a technique rather than a procedure.

5.28 - Merged 2 paragraphs for clarity.

5.29 - Modified the recommended actions at the DA(H) to allow the use of the autopilot to lower altitudes in accordance with regulatory requirements.

Circling Approach

5.31 - Aligned flight pattern with associated Normal and Supplementary Procedures.

Circling Approach - General

5.32 - Section reorganized to more clearly identify what phase of the approach (instrument approach procedure or maneuvering portion of the circling approach) is being discussed.

5.33 - Clarified why Boeing recommends flying the approach manually after intercepting the landing profile.

Obstruction Clearance

5.34 - Added expanded circling approach obstruction clearance criteria effective in 2013.

Downwind and Base Leg

5.38 - Non technical editorial change.

Go-Around and Missed Approach Profile - SP-77 Autopilot

5.43 - Added separate profiles for the SP-77 and SP-177 autopilots to make the profiles easier to follow.

5.43 - Aligned flight pattern with associated Normal and Supplementary Procedures.

Go-Around and Missed Approach Profile - SP-177 Autopilot

5.44 - Added separate profiles for the SP-77 and SP-177 autopilots to make the profiles easier to follow.

5.44 - Aligned flight pattern with associated Normal and Supplementary Procedures.

Go–Around and Missed Approach - All Engines Operating

5.46 - Removed as during the takeoff procedure because some operators use a different altitude for acceleration height.

Engine Failure During Go–Around and Missed Approach

5.48 - Changed "wind correction" to "wind additive".

Chapter 6 - Landing

Preface

6.1 - Moved information on flap configurations for approach and landing to chapter 5. Moved information on non-normal landing configuration distance to the Factors Affecting Landing Distance section later in this chapter.

VASI Landing Geometry

6.2 - Added "knots" for clarity.

Precision Approach Path Indicator

6.4 - Changed "feet down runway" to "feet beyond the threshold" for clarity.

Flare and Touchdown

6.6 - Added a technique pilots should consider when planning a manual landing from an automatic approach, This recommendation is taken from a presentation on industry best practices about techniques to help prevent hard landings.

6.6 - Moved sentence regarding main gear touchdown to end of paragraph.

6.7 - Added discussion of control column movements during flare.

Airspeed Control

6.7 - Added a section to clarify how wind additives and managed during the flare and touchdown.

Landing Flare Profile

6.7 - Changed VREF 3 + 0 (landing) to VREF 30 + 0 (touchdown) for clarity.

6.8 - Removed redundant paragraph.

Normal Touchdown Attitude

6.10 - Removed section titled Body Clearance at Touchdown and the associated figure. Body clearance at various pitch angles is of little value and a survey of instructors found that these figures were rarely used. Body or tail skid contact (as applicable) is found in the preceding figure titled Touchdown Body Attitudes. This figure also relates pitch attitude to airspeed as a function of gross weight. Additionally, the Pitch and Roll Limit Conditions figures show ground contact angles of airplane structure during various pitch and roll combinations.

Pitch and Roll Limit Conditions

6.11 - Moved the discussion about flying the airplane onto the runway at the desired touchdown point and the note to the section titled Landing Flare Profile, earlier in this chapter.

6.11 - Added an explanation that figures are based upon a rigid wing and that this must be taken into consideration when using the figures.

6.11 - Modified the condition to indicate that measurements were obtained while the compressed strut was in a static state.

Bounced Landing Recovery

6.12 - Added discussion of Bounced Landing Recovery.

Rejected Landing

6.12 - Added discussion of Rejected Landing.

Landing Roll

6.13 - Modified text to indicate that holding the nose up after touchdown does result in higher nose sink rates and reduces breaking effectiveness.

Speedbrakes

6.13 - Removed the first paragraph in the section that described how the speedbrake system operates. How the speedbrake system operates is mor accurately described in the FCOM.

Factors Affecting Landing Distance

6.15 - Relocated section to a position earlier in the Landing Roll discussion. Added a paragraph before the diagram explaining what conditions were used to develop the data and how it is intended to be used. Removed the asterisk and explanation from the bottom of the diagram because it is included in the new paragraph. Other non-technical changes to the diagram were made for clarity.

6.16 - Added reference to possible degraded capability of deceleration devices.

6.17 - Added discussion of Slippery Runway Landing Performance.

Wheel Brakes

6.19 - Non technical editorial change.

6.21 - Removed the text that tells the crew not to pump the pedals. This text is provided in the NNC and the reason for the recommendation is contained in the next paragraph.

6.21 - Added an explanation of why Boeing recommends that the pilot should not pump the brakes during landing if the antiskid system is inoperative.

6.21 - Note moved for clarity.

Reverse Thrust Operation

6.23 - Added an explanation of why a reduction to reverse idle is recommended between 60 knots and taxi speed.

6.23 - Moved the recommendation to select reverse idle quickly if an engine surges during reverse thrust operation to a note for emphasis.

Crosswind Landing Techniques

6.27 - Non technical editorial change.

Chapter 7 - Maneuvers

Preface

7.1 - Corrected "Approach to Stall or Stall Recovery".

High Altitude Maneuvering, “G” Buffet

7.4 - Non technical editorial change.

Autopilot Entry and Level Off

7.6 - Added "manually" reset to VMO as needed.

7.7 - Added crew guidance if short-term increases above VMO/MMO are encountered during the Rapid Descent. Removed duplicated information about the level off and combined the final three paragraph into one paragraph for clarity.

Approach to Stall or Stall

7.9 - Revised section to align with the newly revised Approach to Stall Recovery maneuver. This section is not intended for use until the revised QRH Approach to Stall Recovery maneuver is received. Boeing training has shifted emphasis of the recovery from min

7.9 - Revised section to align with the newly revised Approach to Stall Recovery maneuver.

Approach to Stall or Stall Recovery

7.9 - Revised section to align with the newly revised Approach to Stall Recovery maneuver.

Approach to Stall or Stall Recovery Training

7.11 - Revised section to align with the newly revised Approach to Stall Recovery maneuver.

Stick Shaker and Stall Speeds

7.14 - Moved the conditions to precede the graphics.

7.15-18 - Modified graphics to provide kilograms only figures for each model variant.

7.19-22 - Modified graphics to provide pounds only figures for each model variant.

During Turn

7.23 - Removed reference to trimming during the maneuver. This is addressed in the note earlier in this section.

Resolution Advisory (RA)

7.25 - Removed the text indication that RA commands do not need to be followed if visual contact indicates other action. In accordance with PANS-OPS, visual acquisition is no longer an acceptable reason not to follow an RA.

Avoidance, Precautions and Recovery

7.31 - Non technical editorial change.

Chapter 8 - Non–Normal Operations

Section 2 - Supplemental Information

Troubleshooting

8.2 - Expanded the definition of troubleshooting and clarified the examples.

8.2 - Modified text to clarify that troubleshooting is in reference to steps beyond contained in the NNC.

Cabin Altitude Warning

8.5 - Addressed indications for airplanes with and without the takeoff configuration and cabin altitude warning lights installed.

Initiate Evacuation

8.6 - Modified order of events to match the EVACUATION NNC.

8.6 - Deleted section titled Approach and Landing on Standby Power. If this information is considered necessary, it will be added to a QRH.

Loss of Engine Thrust Control

8.7 - Moved the NNC title to the first paragraph of the section.

8.7 - Modified the description of the condition to match the condition statement in the QRH.

8.7 - Added "thrust" to engine thrust control for clarity.

Recommended Technique for an In-Flight Engine Shutdown

8.8 - Added reference to a coordinated confirmation step for clarity.

Bird Strikes

8.9 - Added a new section to provide recommendations and considerations for bird strikes that might affect the engines.

Leading Edge or Trailing Edge Device Malfunctions

8.11 - Non-technical change. Added "all" to all flaps up landing.

8.12 - Non technical editorial change.

8.12 - Non-technical change. Added "use".

8.13 - Added reference to the LEADING EDGE FLAPS TRANSIT NNC.

8.13 - Added reference to the Trailing Edge Flap Asymmetry NNC. Removed recommendation to burn off fuel to reduce landing weight. This option is always available to the pilot depending upon conditions.

Stabilizer Trim Inoperative

8.16 - Non-technical, editorial change. Changed title case to match QRH.

Airspeed Unreliable

8.18-19 - Added information to support Airspeed Unreliable procedure and memory items.

8.20 - Added pitch and thrust references for Airspeed Unreliable (all models).

Fuel Leak

8.22 - Modified general information describing the purpose and objective of the Engine Fuel Leak NNC.

Landing Gear Lever Jammed in the Up Position

8.24 - Modified section to match the changes made to the LANDING GEAR LEVER JAMMED IN THE UP POSITION NNC.

8.24 - Modified text for clarity.

Landing on a Flat Tire

8.26 - Non technical editorial change.

Overspeed

8.29 - Expanded section for clarity and coverage. Incorporated windshear encounter in overspeed discussion.

8.29 - Removed section titled Passenger Oxygen On. Managing and equipping an airplane for gaseous oxygen use for routes requiring supplemental oxygen is a dispatch and airline SOP operational requirement.

Landing Risk Factors

8.31 - Added reference to Stabilized Approach Recommendations in this manual to provide more information on this subject.

8.32 - Changed "forward slip" to "side slip" to compensate for wind effects.

Warning Systems

8.32 - New section added to provide general guidance on unexpected warnings.

Flight with the Side Window(s) Open

8.34 - Clarified use of current flap setting for maneuver speed.

Basic Aerodynamics and Systems Knowledge

8.35 - Corrected "maneuvering" to "maneuver capability".

Chapter A - Appendices

Section 2 - Supplemental Information

Callouts

A.2.1 - Added a recommendation that operators develop their own "recommended callouts" based upon their fleet configuration and specific operational needs.

Takeoff Crosswind Guidelines

A.2.3 - Added a recommendation that operators address wind gusts when developing their own crosswind policies.

Low Visibility Takeoff

A.2.3 - Added new section: Low Visibility Takeoff..

ETOPS

A.2.4 - Clarified that ETOPS rules listed in this paragraph are for passenger airplanes with more than two engines operating under FAA regulations. Other regulatory agencies may have different requirements.

Approach

A.2.4 - Added new section on Approach Category.

Landing Crosswind Guidelines

A.2.6 - Added a recommendation that operators address wind gusts when developing their own crosswind policies.

Recommended Technique for an In-Flight Engine Shutdown

A.2.7 - Removed the section titled Passenger Oxygen On.

FCTM

* Title Page 1-2	March 30, 2014
Chapter Table of Contents	
* 0.TOC.1-2	March 30, 2014
Model Identification	
* 0.1.1-2	March 30, 2014
Introduction	
* 0.2.1	March 30, 2014
* 0.2.2	March 30, 2014
* 0.2.3	March 30, 2014
* 0.2.4	March 30, 2014
Abbreviations	
* 0.3.1	March 30, 2014
* 0.3.2	March 30, 2014
* 0.3.3	March 30, 2014
* 0.3.4	March 30, 2014
Revision Record	
* 0.4.1-16	March 30, 2014
List of Effective Pages	
* 0.5.1-4	March 30, 2014
General Information (tab)	
* 1.TOC.1-2	March 30, 2014
* 1.1	March 30, 2014
* 1.2	March 30, 2014
* 1.3	March 30, 2014
* 1.4	March 30, 2014
* 1.5	March 30, 2014
* 1.6	March 30, 2014
* 1.7	March 30, 2014
* 1.8	March 30, 2014
* 1.9	March 30, 2014
* 1.10	March 30, 2014
* 1.11	March 30, 2014
* 1.12	March 30, 2014
* 1.13	March 30, 2014
* 1.14	March 30, 2014
* 1.15	March 30, 2014
* 1.16	March 30, 2014
* 1.17	March 30, 2014
* 1.18	March 30, 2014
* 1.19	March 30, 2014
* 1.20	March 30, 2014
* 1.21	March 30, 2014
* 1.22	March 30, 2014
* 1.23	March 30, 2014
* 1.24	March 30, 2014
Ground Operations (tab)	
* 2.TOC.1-2	March 30, 2014
* 2.1	March 30, 2014
* 2.2	March 30, 2014
* 2.3	March 30, 2014
* 2.4	March 30, 2014
* 2.5	March 30, 2014
* 2.6	March 30, 2014
* 2.7	March 30, 2014
* 2.8	March 30, 2014
* 2.9	March 30, 2014
* 2.10	March 30, 2014
* 2.11	March 30, 2014
* 2.12	March 30, 2014
* 2.13	March 30, 2014
* 2.14	March 30, 2014
* 2.15	March 30, 2014
* 2.16	March 30, 2014
Takeoff and Initial Climb (tab)	
* 3.TOC.1-2	March 30, 2014
* 3.1	March 30, 2014
* 3.2	March 30, 2014
* 3.3	March 30, 2014
* 3.4	March 30, 2014
* 3.5	March 30, 2014
* 3.6	March 30, 2014
* 3.7	March 30, 2014
* 3.8	March 30, 2014
* 3.9	March 30, 2014
* 3.10	March 30, 2014
* 3.11	March 30, 2014

* = Revised, Added, or Deleted

Climb, Cruise, Descent and Holding (tab)

Approach and Missed Approach (tab)

* = Revised, Added, or Deleted

Landing (tab)

* 6.TOC.1-2	March 30, 2014
* 6.1	March 30, 2014
* 6.2	March 30, 2014
* 6.3	March 30, 2014
* 6.4	March 30, 2014
* 6.5	March 30, 2014
* 6.6	March 30, 2014
* 6.7	March 30, 2014
* 6.8	March 30, 2014
* 6.9	March 30, 2014
* 6.10	March 30, 2014
* 6.11	March 30, 2014
* 6.12	March 30, 2014
* 6.13	March 30, 2014
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* 6.15	March 30, 2014
* 6.16	March 30, 2014
* 6.17	March 30, 2014
* 6.18	March 30, 2014
* 6.19	March 30, 2014
* 6.20	March 30, 2014
* 6.21	March 30, 2014
* 6.22	March 30, 2014
* 6.23	March 30, 2014
* 6.24	March 30, 2014
* 6.25	March 30, 2014
* 6.26	March 30, 2014
* 6.27	March 30, 2014
* 6.28	March 30, 2014
* 6.29	March 30, 2014
* 6.30	March 30, 2014

Maneuvers (tab)

* 7.TOC.1-2	March 30, 2014
* 7.1	March 30, 2014
* 7.2	March 30, 2014
* 7.3	March 30, 2014
* 7.4	March 30, 2014
* 7.5	March 30, 2014
* 7.6	March 30, 2014
* 7.7	March 30, 2014
* 7.8	March 30, 2014
* 7.9	March 30, 2014
* 7.10	March 30, 2014
* 7.11	March 30, 2014
* 7.12	March 30, 2014
* 7.13	March 30, 2014
* 7.14	March 30, 2014
* 7.15	March 30, 2014
* 7.16	March 30, 2014
* 7.17	March 30, 2014
* 7.18	March 30, 2014
* 7.19	March 30, 2014
* 7.20	March 30, 2014
* 7.21	March 30, 2014
* 7.22	March 30, 2014
* 7.23	March 30, 2014
* 7.24	March 30, 2014
* 7.25	March 30, 2014
* 7.26	March 30, 2014
* 7.27	March 30, 2014
* 7.28	March 30, 2014
* 7.29	March 30, 2014
* 7.30	March 30, 2014
* 7.31	March 30, 2014
* 7.32	March 30, 2014

Non-Normal Operations (tab)

* 8.TOC.1-4	March 30, 2014
* 8.1	March 30, 2014
* 8.2	March 30, 2014
* 8.3	March 30, 2014
* 8.4	March 30, 2014
* 8.5	March 30, 2014
* 8.6	March 30, 2014
* 8.7	March 30, 2014
* 8.8	March 30, 2014
* 8.9	March 30, 2014
* 8.10	March 30, 2014
* 8.11	March 30, 2014
* 8.12	March 30, 2014
* 8.13	March 30, 2014
* 8.14	March 30, 2014
* 8.15	March 30, 2014
* 8.16	March 30, 2014
* 8.17	March 30, 2014
* 8.18	March 30, 2014
* 8.19	March 30, 2014
* 8.20	March 30, 2014
* 8.21	March 30, 2014
* 8.22	March 30, 2014
* 8.23	March 30, 2014

* = Revised, Added, or Deleted

Appendices - Operational Information (tab)

Index

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* = Revised, Added, or Deleted

General Information — Chapter 1
Table of Contents — Section TOC

General Information Chapter 1

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).

Events Requiring Maintenance Inspection

Appendix A.2.1

During ground or flight operations, events may occur which require a maintenance inspection after flight. Use the following guidance to determine what events require a maintenance inspection:

- hard landing (identify if the hard landing is suspected on the main gear, the nose gear, or both)
- severe turbulence
- overspeed - flap/slat, MMO/VMO, landing gear, landing gear tires
- high-energy stop (refer to the AMM for guidance)
- lightning strike
- extreme dust
- tail strike
- overweight landing

- any event that the pilot feels a maintenance inspection could be needed. 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
- operator specific procedures or policies may include additional events which require a maintenance inspection.

Note: If in doubt, the best course of action is to report it.

Training Objectives

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

Qualification Requirements (Checkride)

Following satisfactory completion of 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

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 airplane 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 airplane, requires ongoing monitoring, 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.

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.

Maneuver Speeds and Margins

This section explains the difference between flap maneuver speeds and minimum maneuver speeds. It also describes maneuver margin or bank capability to stick shaker as a function of airspeed during both a flap extension and flap retraction scenario.

Flap Maneuver Speeds

The following tables contain flap maneuver speeds for various flap settings. The flap maneuver speed is the recommended operating speed during takeoff or landing operations. These speeds guarantee full maneuver capability or at least 45° of bank (30° of bank and 15° overshoot) to stick shaker within a few thousand feet of the airport altitude. While the flaps may be extended up to 20,000 feet, less maneuver margin to stick shaker exists for a fixed speed as altitude increases.

The table shows maneuver speeds for airplanes with a Rudder Pressure Reducer (RPR) operating. If RPR is not operating, refer to the DDG for maneuver speeds.

Flap Position	At & Below 117,000 LB (53,070 KG)	Above 117,000 LB (53,070 KG)
Flaps UP	210knots	220 knots
Flaps 1	190 knots	200 knots
Flaps 5	170 knots	180 knots
Flaps 10	160 knots	170 knots
Flaps 15	150 knots	160 knots
Flaps 25	140 knots	150 knots
Flaps 30	VREF 30	
Flaps 40	VREF 40	

Maneuver Margins to Stick Shaker

The following figures are representative illustrations of airplane maneuver margin or bank capability to stick shaker as a function of airspeed. This includes both a flap extension and flap retraction scenario.

When reviewing the maneuver margin illustrations, note that:

- there is a direct correlation between bank angle and load factor (g) in level, constant speed flight. For example, 1.1g corresponds to 25° of bank, 1.3g ~ 40°, 2.0gs ~ 60°
- the illustrated maneuver margin assumes a constant speed, level flight condition
- stick shaker activates prior to actual stall speed
- flap retraction or extension speed is that speed where the flaps are moved to the next flap position in accordance with the flap extension or retraction schedule
- flap retraction and extension schedules provide speeds that are close to minimum drag, and in a climb are close to maximum angle of climb speed. In level flight they provide a relatively constant pitch attitude and require little change in thrust at different flap settings.
- the bold line designates flap configuration changes at the scheduled flap retraction or extension speeds
- the black dots on the bold lines indicate:
  - maneuver speed for the existing flap setting
  - flap retraction or extension speed for the next flap setting
- maneuver margin to stick shaker speeds during flap retraction and extension are shown for airplanes with a Rudder Pressure Reducer (RPR) operating and the Rudder System Enhancement Program (RSEP) installed.

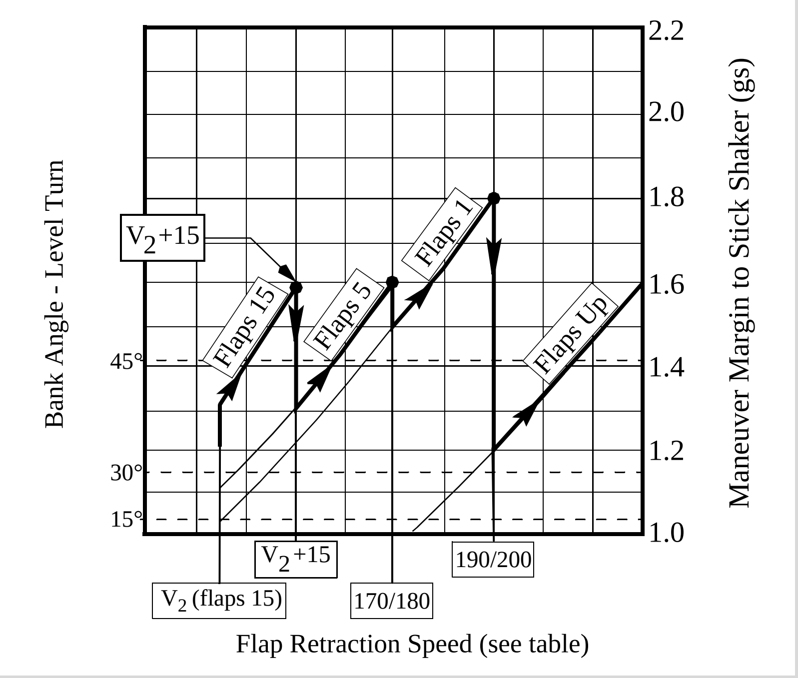
The distance between the bold line representing the flap extension or retraction schedule and a given bank angle represents the maneuver margin to stick shaker at the given bank angle for level constant speed flight. Where the flap extension or retraction schedule extends below a depicted bank angle,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

Conditions Affecting Maneuver Margins to Stick Shaker

For a fixed weight and altitude, maneuver margin to stick shaker increases when airspeed increases. Other factors may or may not affect maneuver margin:

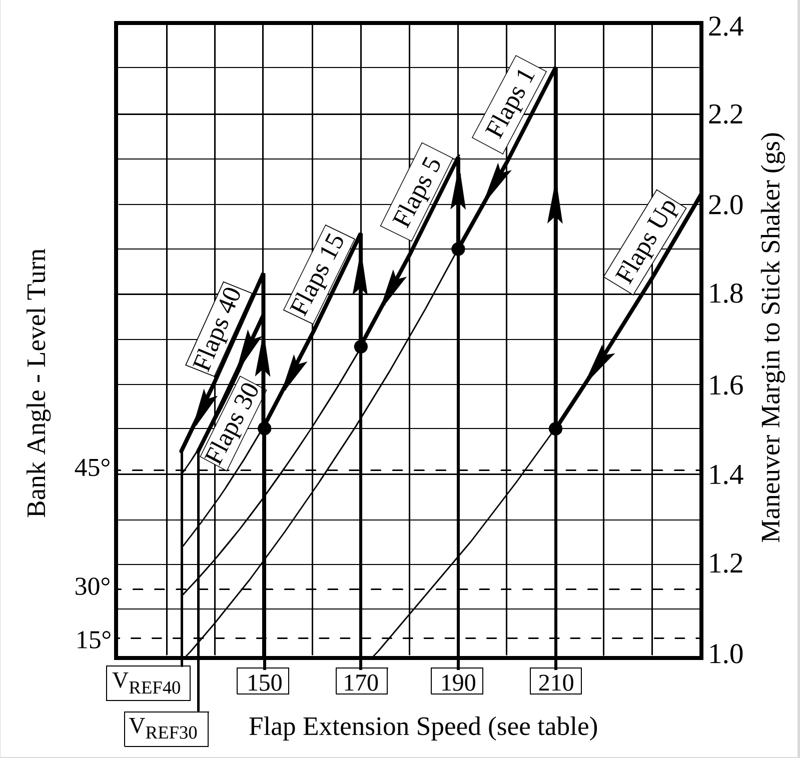
- Gross weight: generally maneuver margin decreases as gross weight increases. The base speed (V2 or VREF) increases with increasing weight. The speed additive is a smaller percent increase for heavier weights
- Altitude: maneuver margin decreases with increasing altitude for a fixed airspeed
- Temperature: the affect of a temperature change on maneuver margin is negligible
- Landing gear: a small decrease in maneuver margin may occur when the landing gear is extended. This loss is equivalent to 2 knots of airspeed or less
- Speedbrakes: maneuver margin decreases at any flap setting when speedbrakes are extended
- Engine failure during flap retraction: a small decrease in maneuver margin occurs due to the reduced lift experienced with the loss of thrust. The loss is equivalent to 4 knots of airspeed or less
- Anti-ice: the use of engine or wing anti-ice has no affect on maneuver margin.

Maneuver Margins to Stick Shaker- Flap Retraction



Takeoff Flaps	Flap Retraction Speed		Select Flaps
	At & Below 117,000 Lb (53,070 Kg)	Above 117,000 Lb (53,070 Kg)	
25	V2 + 15 150 170 190	V2 + 15 160 180 200	15 5 1 UP
15	V2 + 15 170 190	V2 + 15 180 200	5 1 UP
5	V2 + 15 190	V2 + 15 200	1 UP
1	190	200	UP
Limit bank angle to 15 degrees until reaching V2 + 15.			

Maneuver Margins to Stick Shaker - Flap Extension



Current Flap Position	At Speed (knots)	Select Flaps	Command Speed for Selected Flaps
Up	210	1	190
1	190	5	170
5	170	10*	160
10*	160	15	150 / VREF
15	150 / VREF	25	140
25	140	30 or 40	(VREF 30 or VREF 40) plus wind additives

* As needed

Command Speed

For airplanes equipped with the SP-77 autopilot, command speed may be set by the pilot using the airspeed cursor control.

For airplanes equipped with the SP-177 autopilot, command speed may be set by the pilot using the airspeed cursor control on the MCP and is displayed by an orange airspeed cursor on the airspeed indicator.

Takeoff

Command speed remains set at V2 until changed by the pilot for acceleration and flap retraction, or on airplanes equipped with the SP-177 autopilot, until a subsequent pitch mode is engaged. Manually select flaps up maneuver speed at acceleration height.

Climb, Cruise and Descent

Command speed is set to the appropriate speed 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 maneuver speed for the selected flap position.

Landing

For airplanes equipped with the SP-177 autopilot, when using the autothrottle, position command speed to VREF + 5 knots. Sufficient wind and gust protection is available with the autothrottle connected 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.

For airplanes without an autothrottle or if the autothrottle is disconnected, or is planned to be disconnected prior to landing, the recommended method for approach speed correction is to add one half of the reported steady headwind component plus the full gust increment above the steady wind to the reference speed. The minimum command speed setting is VREF + 5 knots. One half of the reported steady headwind component can be estimated by using 50% for a direct headwind, 35% for a 45° crosswind, zero for a direct crosswind and interpolation in between.

When making adjustments for winds, the maximum command speed should not exceed VREF + 20 knots or landing flap placard speed minus 5 knots, whichever is lower. This technique provides sufficient low speed maneuver capability and reduces the possibility of flap load relief activation. Margin to load relief activation may also be increased by using a reduced landing flap setting. 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

* If VREF + 20 exceeds landing flap placard speed minus 5 knots, use landing flap placard speed minus 5 knots.

Note: Do not apply wind additives 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 15 + 5 knots. When VREF has been adjusted by a NNC, this becomes the VREF used for landing. This VREF does not include wind additives. For example, if a Non-Normal Checklist specifies “Set VREF 15 + 5 knots”, the flight crew would look up the VREF 15 speed in the PDCS and add 5 knots to that speed to achieve the required Vref. All wind corrections need to be applied to this corrected speed.

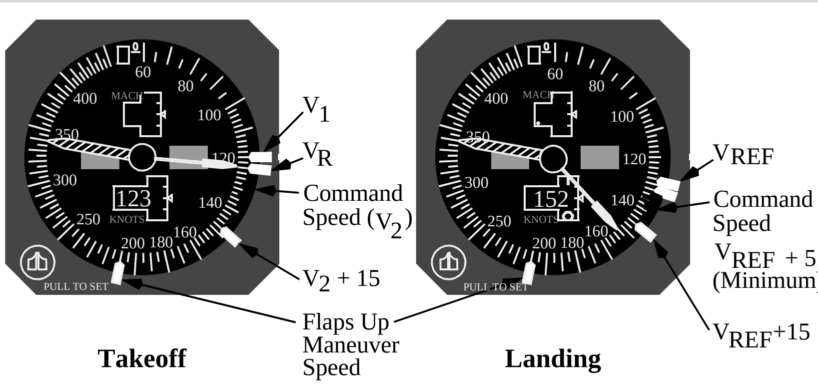
When using the autothrottle, position command speed to VREF + 5 knots. Sufficient wind and gust protection is available with the autothrottle engaged that no further wind additives are needed.

If the autothrottle is disconnected, or is planned to be disconnected prior to landing, appropriate wind additives must be added to the VREF to arrive at command speed, the speed used to fly the approach. For example, if the checklist states “Set VREF 40 + 30 knots”, command speed should be positioned to VREF (VREF 40 + 30) + wind additive (5 knots minimum, 20 knots maximum).

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 airspeed bugs are set at V1, VR, takeoff flap maneuver speed (V2 + 15 knots), and flaps up maneuver speed. Command speed is set to V2. V2 is the minimum takeoff safety speed and provides at least 30° bank capability (15° + 15° overshoot) for all takeoff flaps. V2 + 15 knots is recommended maneuver speed for all takeoff flaps and the initial flap retraction speed for takeoffs with flaps greater than 1. V2 + 15 knots provides 45° bank capability (30° + 15° overshoot) for all takeoff flaps.

Approach - Landing

Position two white airspeed bugs at VREF for landing flaps, a single white airspeed bug at VREF + 15 knots, and a single white airspeed bug at the flaps up maneuver speed.

Thrust Management

Setting Thrust

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

Maximum Thrust

The term “maximum thrust” is used in various places in the FCTM and the FCOM. Maximum thrust is attained by advancing the thrust levers to the full rated takeoff or go-around limit only. Advancing the thrust levers to the full forward stop should only be considered if terrain contact is imminent.

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.

Recommended callouts are provided in the interest of good Crew Resource Management. These callouts may be modified by the operator. Recommended callouts differ from procedural callouts that are found in the Procedures section of the FCOM. Procedural callouts are required.

The Pilot Monitoring (PM) makes callouts based on instrument indications or observations for the appropriate condition. The Pilot Flying (PF) should verify the condition/location from the flight instruments and acknowledge. If the PM does not make the required callout, the PF should make it.

The PM 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 recommended 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 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 PF should acknowledge all GPWS voice callouts (as installed) except altitude callouts during approach while below 500 feet AFE. The recommended callout of “CONTINUE” or “GO-AROUND” at minimums is not considered an altitude callout and should always be made. If the automatic electronic voice callout is not heard by the flight crew, the PM should make the callout. No callout is necessary from the PM if the GPWS voice callout has been acknowledged by the PF.

Note: If automatic callouts are not available, the PM 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.

Recommended Callouts

	CONDITION / LOCATION	CALLOUT (Pilot Monitoring, unless noted)
Climb And Descent	Approaching Transition Altitude	"TRANSITION ALTITUDE, SET STANDARD"
	Approaching Transition Level	"TRANSITION LEVEL, ALTIMETERS RESET ______" (in. or mb)
	1,000 ft. above/below assigned altitude/Flight Level (IFR)	"1,000 FEET TO LEVEL OFF"
Descent	10,000 ft. MSL / FL100 (Reduce airspeed if required) (IFR and VFR)	"10,000 FEET" or "FLIGHT LEVEL 100"

Recommended Callouts - ILS or GLS Approach

CONDITION / LOCATION	CALLOUT (Pilot Monitoring, unless noted)
First positive inward motion of localizer pointer	“LOCALIZER ALIVE”
Final approach fix inbound	“OUTER MARKER/FIX, ___FEET”
500 ft. AFE (Check autoland status annunciator, if applicable)	“500 FEET” (F/D or single autopilot approach)
100 ft. above DA(H)	“APPROACHING MINIMUMS”
Individual sequence flasher lights visible	“STROBE LIGHTS”
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., PM calls visual cues	PF: “CONTINUE”
At DA(H) - Suitable visual reference not established, i.e., PM 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., PM does not call any visual cues	PF: “GO AROUND”

Recommended Callouts - Non-ILS or Non-GLS Approach

CONDITION / LOCATION	CALLOUT (Pilot Monitoring, 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 MDA(H)	“APPROACHING MINIMUMS”
Individual sequence flasher lights visible	“STROBE LIGHTS”
At MDA(H) with individual approach light bars visible	“MINIMUMS - APPROACH LIGHTS / RED BARS” (if installed)
At MDA(H) - Suitable visual reference established, i.e., PM calls visual cues	PF: “CONTINUE”
At MDA(H)- Suitable visual reference not established, i.e., PM 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 MDA(H)- Suitable visual reference established	“THRESHOLD/RUNWAY TOUCHDOWN ZONE”
Below MDA(H)- Suitable visual reference established	PF: “LANDING”
Below MDA(H)- Suitable visual reference not established, i.e., PM does not call any visual cues	PF: “GO AROUND”

Standard Phraseology

A partial list of standard 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 TEN"
- "FLAPS FIFTEEN"
- "FLAPS TWENTY-FIVE"
- "FLAPS THIRTY"
- "FLAPS FORTY"

Airspeed:

- "SET _____ KNOTS"
- "SET VREF PLUS (additive)"

Cold Temperature Altitude Corrections

Appendix A.2.2

If the outside air temperature (OAT) is different from the International Standard Atmospheric (ISA) temperature, 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.

Consider doing the Cold Temperature Altitude Corrections Supplementary Procedure in the FCOM 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). 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.

Aircrews 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.

Ice Crystal Icing

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

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

Boeing has been an integral part of ongoing studies to better understand ice crystal icing. For more detailed information on this subject, see the Boeing Flight Operations Technical Bulletin titled Ice Crystal Icing. This bulletin provides information about actual events, including those experiencing engine power loss and damage associated with flight in ice crystal icing. It also provides methods of recognizing ice crystal icing conditions and suggested actions if ice crystal icing is suspected. An Ice Crystal Icing Supplementary Procedure is also available in the Adverse Weather section, Volume 1 of the FCOM.

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 may indicate the need for maintenance and should be noted in the airplane log.

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

- ensure the autopilot is engaged in HDG SEL 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 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 bank 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.

Autopilot / AFDS Guidelines

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.

Control Wheel Steering

After autopilot engagement, the airplane may be maneuvered using the control wheel steering (CWS) pitch mode, roll mode, or both using the control wheel and column. Manual inputs by the pilot using CWS are the same as those required for manual flight. Climbs and descents may be made using CWS pitch while the roll mode is in HDG SEL or VOR/LOC. Autopilot system feel control is designed to simulate control input resistance similar to manual flight. Refer to the FCOM for a more detailed description of CWS operation.

Autothrottle Use (SP-177 Autopilot)

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 in CMD.

Autothrottle ARM Mode

The autothrottle ARM mode is normally not recommended because its function can be confusing. The primary feature the autothrottle ARM mode provides is minimum speed protection in the event the airplane slows to minimum maneuver speed. Other features normally associated with the autothrottle, such as gust protection, are not provided. The autothrottle ARM mode should not be used with Non-Normal Checklists. Some malfunctions that affect maneuver speeds cause the autothrottle to maintain a speed above approach speed.

Manual Flight

The PM should make autopilot mode selections at the request of the PF. On airplanes where the PM has access to set the applicable indicator, heading and altitude changes from air traffic 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.

For airplanes equipped with the SP-77 autopilot, ensure the proper approach progress display modes (if applicable) are annunciated for the desired maneuver. If the flight director commands are not to be followed, the flight director should be turned off.

For airplanes equipped with the SP-177 autopilot, ensure the proper flight director modes (if applicable) are selected for the desired maneuver. If the flight director commands are not to be followed, the flight director should be turned off.

Note: Autopilot engagement requires relaxing forces on the control column and is normally done by the PF.

Automatic Flight

Autoflight systems can enhance operational capability, improve safety, and reduce workload. Automatic approach, Category III operations, and fuel-efficient flight profiles are examples of some of the enhanced operational capabilities provided by autoflight systems. 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. Using automatic systems allows the pilot to devote additional time to monitoring the airplane's flight path.

Note: For airplanes equipped with the SP-77 autopilot, when the autopilot is in use, the PF makes autopilot panel mode selections. The PM may select new altitudes, but must ensure the PF is aware of any changes. Both pilots must monitor approach progress display mode annunciations and the current flight plan.

Note: For airplanes equipped with the SP-177 autopilot, when the autopilot is in use, the PF makes AFDS mode selections. The PM may select new altitudes, but must ensure the PF is aware of any changes. Both pilots must monitor autopilot mode annunciations and the current flight plan.

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.

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

AFDS Mode Control Panel Faults (SP-177 Autopilot)

In-flight events have occurred where various AFDS pitch or roll modes have become un-selectable or ceased to function normally. These faults may be caused by an MCP hardware (switch) problem.

If an AFDS anomaly is observed where individual pilot-selected AFDS modes are not responding normally to MCP switch selections, attempt to correct the problem by disengaging the autopilot and selecting both flight director switches to OFF. This clears all engaged AFDS modes. When an autopilot is re-engaged or a flight director switch is selected ON, the AFDS default pitch and roll modes should engage. The desired AFDS pitch and roll modes may then be selectable.

If this action does not correct the fault condition, the desired flight path can be maintained by selecting an alternate pitch or roll mode. Examples are included in the following table:

Inoperative or Faulty Autopilot Mode	Suggested Alternate Autopilot Mode or Crew Technique
HDG SEL	Set desired heading, disengage AFDS and manually roll wings level on the desired heading, then re-engage the AFDS. The AFDS will hold the established heading.
VOR/LOC	Use HDG SEL. Monitor and fly the approach referencing localizer raw data.
G/S	Use V/S to descend on an ILS approach. Monitor and fly the approach referencing glide slope raw data.

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.

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 should take over the controls and check the position of essential controls and switches.

- after ensuring the airplane is under control, engage the autopilot to reduce workload
- declare an emergency
- 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.

Flight in Moderate to Heavy Rain, Hail, or Sleet

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

Reference the Supplementary Procedure for Flight in Moderate to Heavy Rain, Hail, or Sleet for more information. The Supplementary Procedure recommends that the crew should consider starting the APU, if available, because it provides quick access to backup electrical and pneumatic sources.

Turbulent Air Penetration

Severe turbulence should be avoided if at all possible. However, if severe turbulence is encountered, use the Severe Turbulence procedure listed in the Supplementary Procedures section of the FCOM. Turbulent air penetration speeds provide high/low speed margins in severe turbulent air.

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

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

Ground Operations — Chapter 2

Table of Contents — Section TOC

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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.

Preflight

Static Port Obstructions

Fluctuating and inaccurate airspeed and altimeter indications after takeoff have been attributed to static ports obstructed by ice formed while the airplane was on the ground. Precipitation or water rundown after snow removal may freeze on or near the static ports. This may cause an ice buildup which disturbs airflow over the static ports resulting in erroneous airspeed and altimeter readings, even when static ports appear to be clear. Since static ports for the standby instruments and the surrounding surfaces are not heated when probe heat is activated, a thorough preflight inspection and clearing of all contaminants around these static ports are critical.

The aircrew should pay particular attention to the static ports during the exterior inspection when the airplane has been subjected to freezing precipitation. Clear ice on the static ports can be difficult to detect. If in doubt, contact maintenance for assistance.

Setting the Cabin Pressure Control System

The Cabin Pressure Control System allows the flight crew to set the planned cruise flight altitude (FLT ALT) and the altitude of the intended landing field (LAND ALT). These altitudes are then used by the pressurization system to calculate a pressure schedule specific to the planned flight. The pressurization system is designed to maintain a comfortable and safe cabin altitude throughout the duration of the flight based on the FLT ALT and LAND ALT set during preflight. The only time a change in FLT ALT or LAND ALT is required in flight is when the final cruise or landing altitude is different than that selected during preflight.

Investigation of pressurization incidents in the fleet has indicated that some operators are setting the FLT ALT before takeoff to an intermediate altitude and then resetting the FLT ALT one or more times during climb until the final cruise altitude or flight level is reached. Although this method of operation also provides a safe and comfortable cabin altitude for the duration of the flight, there are some considerations which may make this method of operation less desirable:

- multiple adjustments of the FLT ALT unnecessarily increase crew workload during climb
- intermediate FLT ALT settings are likely to result in higher cabin altitudes than if the final planned cruise flight altitude is selected. This is because the pressure schedule for lower altitudes uses lower differential pressure limits
- if the flight crew does not reset the FLT ALT when appropriate, flying above the selected FLT ALT can result in an overpressure situation and activation of the pressure relief valves.

Takeoff Briefing

The takeoff briefing should be accomplished as soon as practical so it does not 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 or Towing

Appendix A.2.2

Pushback and towing present serious hazards to ground personnel. There have been many accidents where personnel were run over by the airplane wheels during the pushback or towing process. Good communication between the flight deck and ground personnel are essential for a safe operation.

Pushback or towing involves three phases:

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

The headset operator, who is walking in the vicinity of the nose wheels, 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 help to reduce the possibility of these types of accidents.

737-200A

Note: For airplanes with the nose wheel steering lockout system installed, pushback or tow out is normally accomplished with all hydraulic systems pressurized and the nose wheel steering locked out. If the nose wheel steering is not locked out, hydraulic system A must be depressurized.

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 the tow tractor and tow bar have been connected, obtain a pushback or towing clearance from ground control. Engine start may be accomplished during pushback or towing, or delayed until pushback or towing is completed. Ground personnel should be on headset to observe and communicate any possible safety hazards to the flight crew.

Note: The airplane should be taxied away from a gate, or pushback position, with marshaller guidance when available.

Taxi

Taxi General

Most reported runway incursions are attributed to a loss of situational awareness and not following ATC instructions. All pilots should be aware that incursions are a persistent problem and they must be proactive in preventing them during all ground operations.

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

Prior to Taxi

- review NOTAMS and current ATIS for any taxiway or runway closures, construction activity, or other airport risks that could effect the taxi route
- brief applicable items from airport diagrams and related charts to include the location of hold short lines
- ensure both crewmembers understand the expected taxi route

- write down the taxi clearance when received
- an airport diagram should be readily available to each crewmember during taxi.

During Taxi

- progressively follow taxi position on the airport diagram
- during low visibility conditions, call out all pertinent signs to verify position
- if unfamiliar with the airport consider requesting a FOLLOW ME vehicle or progressive taxi instructions
- use standard radio phraseology
- read back all clearances. If any crewmember is in doubt regarding the clearance, verify taxi routing with the assigned clearance or request clarification. Stop the airplane if the clearance is in doubt
- if ground/obstruction clearance is in doubt, stop the airplane and verify clearance or obtain a wing-walker
- avoid distractions during critical taxi phases; plan ahead for checklist accomplishment and company communications
- consider delaying checklist accomplishment until stopped during low visibility operations
- do not allow ATC or anyone else to rush you
- verify the runway is clear (both directions) and clearance is received prior to entering a runway
- be constantly aware of the equipment, structures, and airplanes behind you 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 FCOM 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 non-essential radio or cabin 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 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. Run-ups and taxi operations should only be conducted over well maintained paved surfaces and runways.

Backing with Reverse Thrust

If no other means are available to move the airplane, thrust reversers may be used for backing. Wing flaps should be retracted to provide maximum clearance and visibility for the ground crew giving hand signals.

The air conditioning should be OFF to prevent ingestion of exhaust gases.

The ramp area must be free of debris to prevent engine foreign object damage.

Back the airplane at very low speeds. The amount of reverse thrust required varies with ramp slope and "set" of the tires. If possible, allow the airplane to roll forward slightly to unset the tires. Apply idle reverse to begin backing, modulating as required to obtain the desired taxi speed. Avoid high reverse thrust power levels.

Use forward thrust to stop. The amount varies with ramp slope and taxi speeds. Application of brakes while moving backwards may cause the airplane to tip onto its tail.

Taxi Speed and Braking

To begin taxi, release brakes, smoothly increase thrust to minimum required for the airplane to roll forward, and then reduce thrust as required to maintain normal taxi speed. A turn should normally not be started until sufficient forward speed has been attained to carry the 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 appropriate taxi speed depends on turn radius and surface condition.

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

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

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

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

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 airplanes too closely. Jet blast is a major cause of foreign object damage.

During taxi, the use of reverse thrust above reverse idle is not recommended due to the possibility of foreign object damage and engine surge. Momentary use of idle reverse thrust may be necessary on slippery surfaces for airplane control while taxiing. Consider having the airplane towed rather than relying on extended use of reverse thrust for airplane control.

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.

Nose Wheel/Rudder Pedal Steering

The captain's position is equipped with a nose wheel steering wheel. The nose wheel steering wheel is used to turn the nosewheel through the full range of travel at low taxi speeds. Maintain a positive pressure on the nose wheel steering wheel 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.

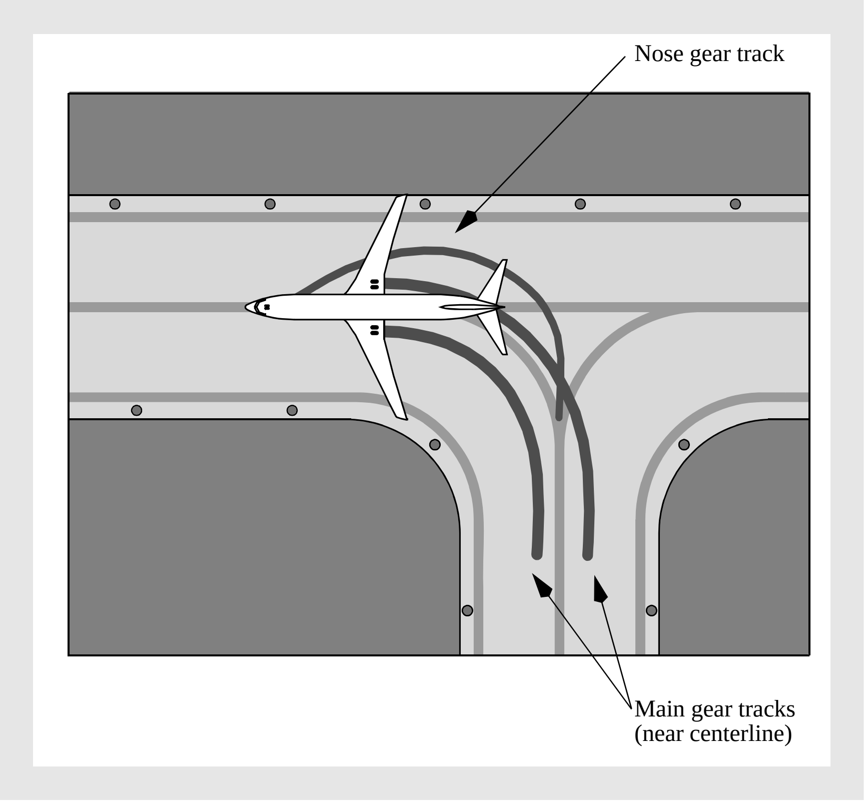
If nose wheel "scrubbing" occurs while turning, reduce steering angle and/or taxi speed. Avoid stopping the airplane in a turn as excessive thrust is required to start taxiing again.

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.

Turning Radius and Gear Tracking

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

As the following diagram illustrates, while the airplane is turning, the main gear tracks inside the nose gear. The smaller the radius of the turn, the greater the distance that the main gear tracks inside the nose gear and the greater the need to steer the nose gear outside of the taxi path (oversteer).



Visual Cues and Techniques for Turning while Taxiing

The following visual cues assume the pilot's seat is adjusted for optimum eye position. The following techniques also assume a typical taxiway width. Since there are many combinations of turn angles, taxiway widths, fillet sizes and taxiway surface conditions, pilot judgment must dictate the point of turn initiation and the amount of nose wheel steering wheel required for each turn. Except for turns less than approximately 30°, speed should be 10 knots or less prior to turn entry. For all turns, keep in mind the main gear are located behind the nose wheels, which causes them to track inside the nose wheels during turns. The pilot position being forward of the nose 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)
737 - 200	4.8 (1.5)	42 (12.8)

Turns less than 90 degrees

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

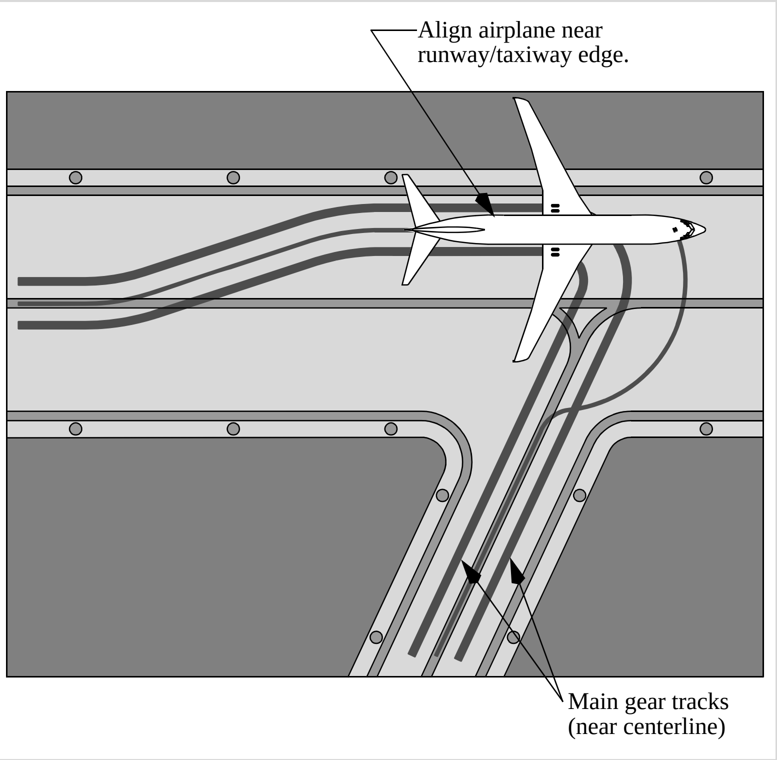
Turns of 90 degrees or more

Initiate the turn as the intersecting taxiway centerline (or intended exit point) approaches approximately the center of the number 3 window. Initially use approximately full nose wheel steering wheel displacement. Adjust the steering wheel 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 steering wheel input as the airplane lines up with the intersecting taxiway centerline or intended taxi path.

Sharp Turns to a Narrow Taxiway

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

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



Turns of 180 Degrees

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

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

Note: Monitor the nose gear track closely, as it will leave the pavement in the turn before the main gear.

Approach the edge of the taxi surface at a shallow angle until the outboard side of the main gear wheels are near the edge. The main gear are just inside the engine nacelles. Maneuver to keep the engine nacelles over the prepared surfaces.

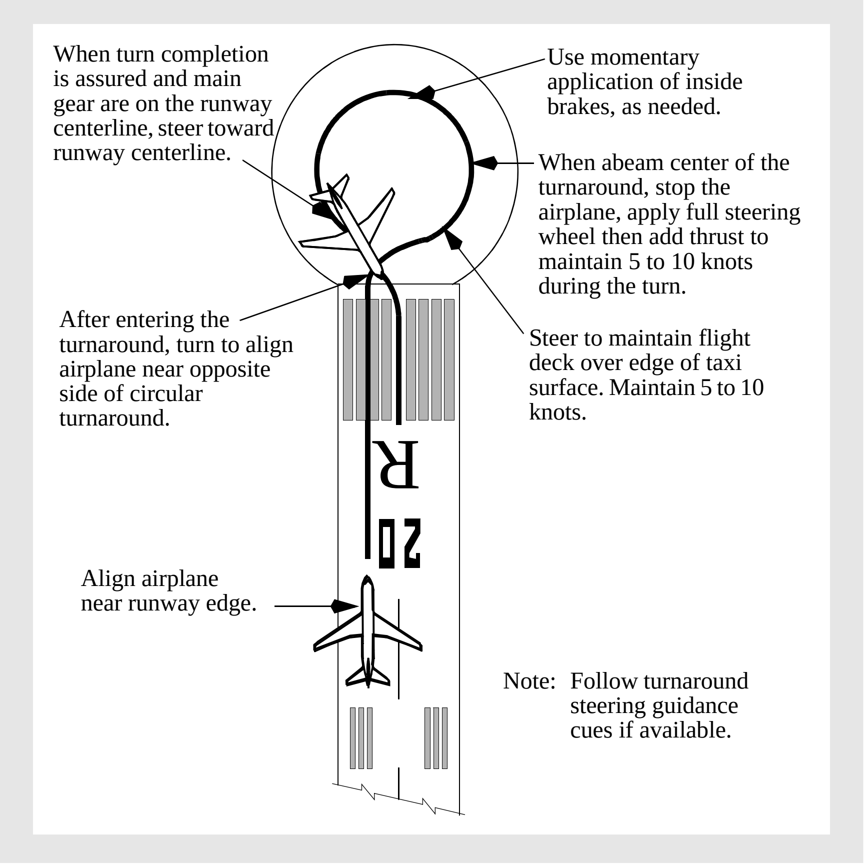
Note: Painted runway markings are slippery when wet and may cause skidding of the nose gear during the turn.

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

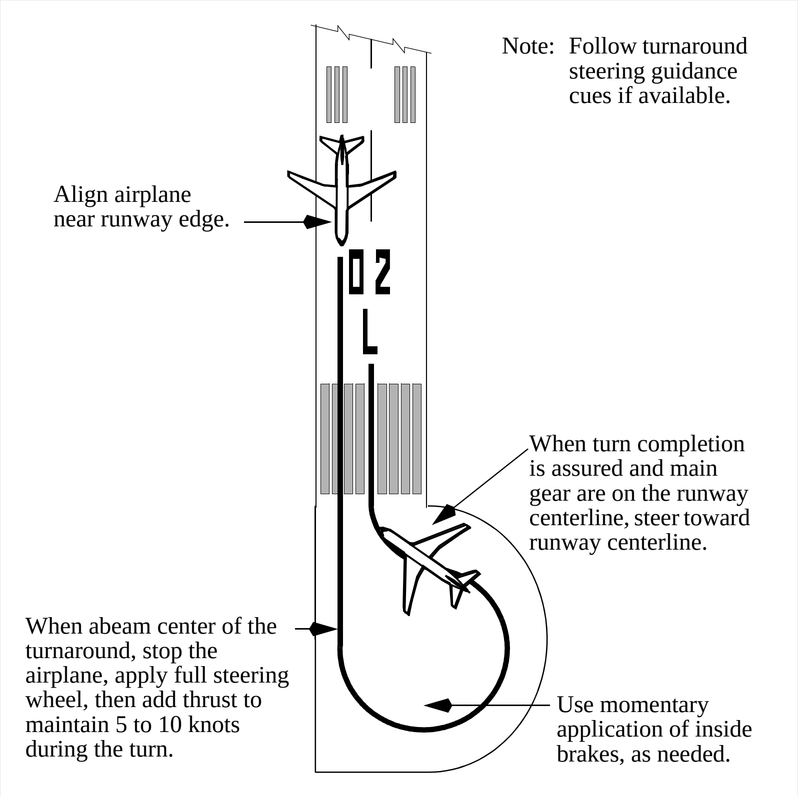
This technique results in a low speed turn and less runway being used. It does not impose undue stress on the landing gear and tires provided the wheel brakes are not locked during the turn. If the nose gear skids, a good technique is to apply the inside wheel brake briefly and keep the airplane turning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

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

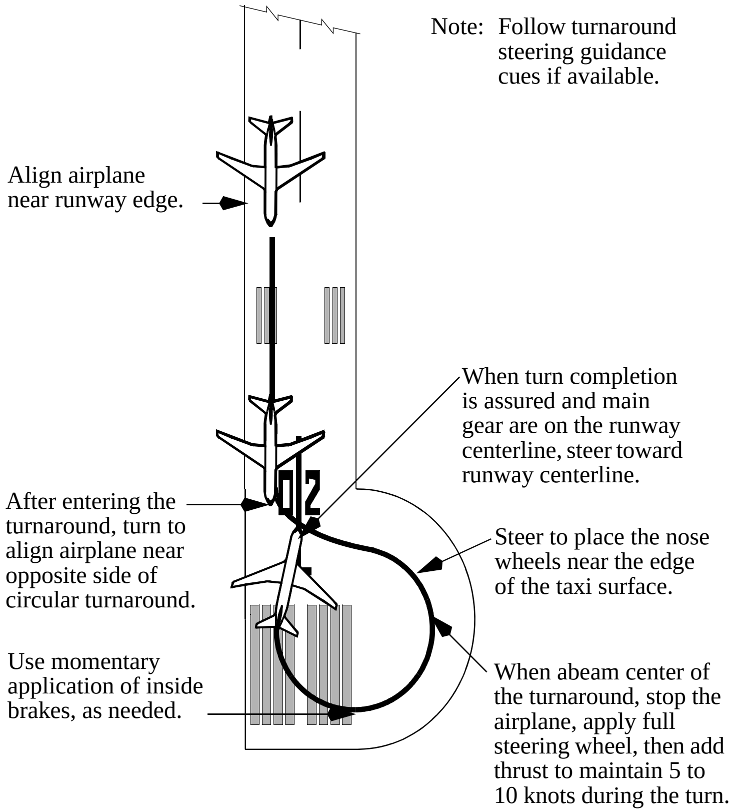
Techniques when using a Circular Turnaround



Techniques when using a Hammerhead Turnaround



Techniques when using a Hammerhead Turnaround



Taxi - Adverse Weather

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

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

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

If icing conditions are present, use anti-ice as required by the FCOM. During prolonged ground operations, periodic engine run-ups should be accomplished to minimize ice build-up. These engine run-ups should be performed as defined in the FCOM.

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.

Low Visibility

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

Flap Retraction after Landing

The Cold Weather Operations Supplementary Procedure defines how far the flaps may be retracted after landing in conditions where ice, snow, or slush may have contaminated the flap areas. If the flap areas are found to be contaminated, the flaps should not be retracted until maintenance has cleared the contaminants. Removal of the contaminates is a maintenance function addressed in the AMM.

Engine Out Taxi

Appendix A.2.2

Engine Out Taxi (EOT) operations have the potential to save fuel and to reduce carbon emissions.

During EOT operations, the crew’s attention should be focused on taxiing the airplane. Distractions should be kept to a minimum.

Boeing does not publish specific procedures for EOT operations. Each operator develops EOT policies, procedures, and flight crew familiarization materials specific to their operation and in accordance with the requirements of their regulatory authorities.

Takeoff and Initial Climb — Chapter 3

Preface

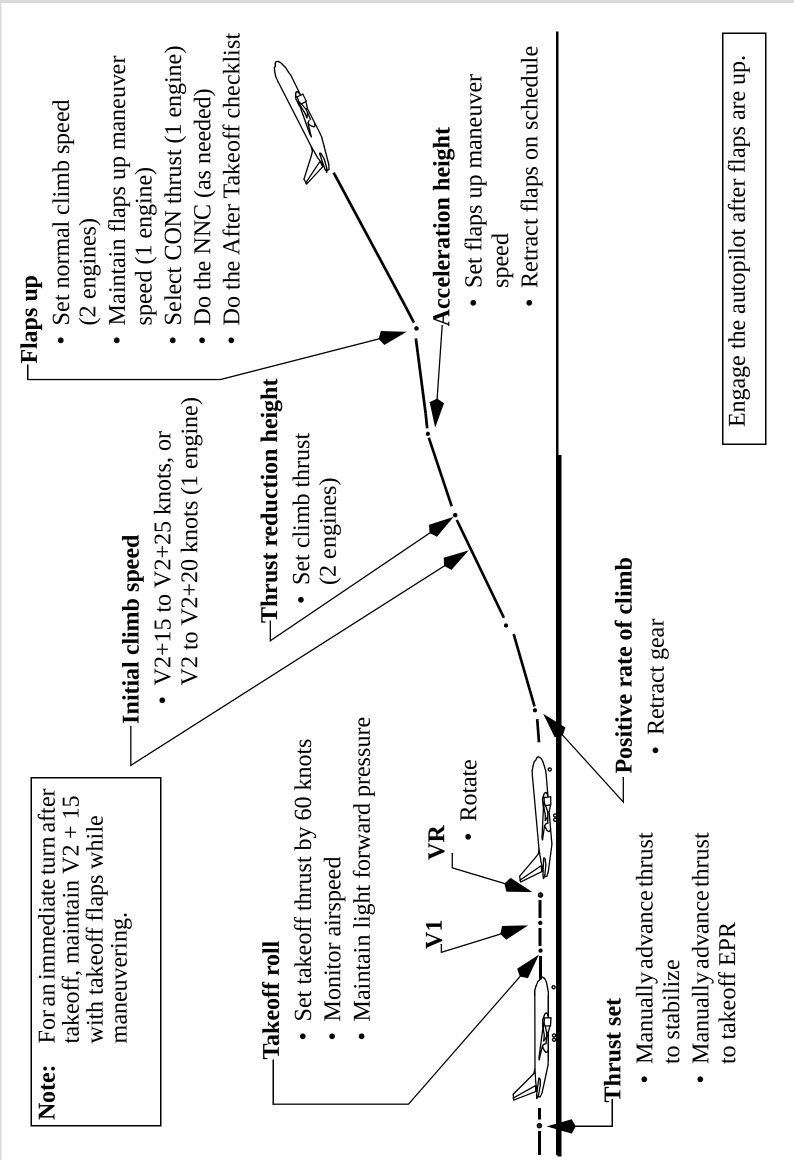
This chapter outlines the recommended operating practices and techniques for takeoff and initial climb. Engine failure during takeoff/initial climb is also addressed. The discussion portion of each illustration highlights important information.

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.

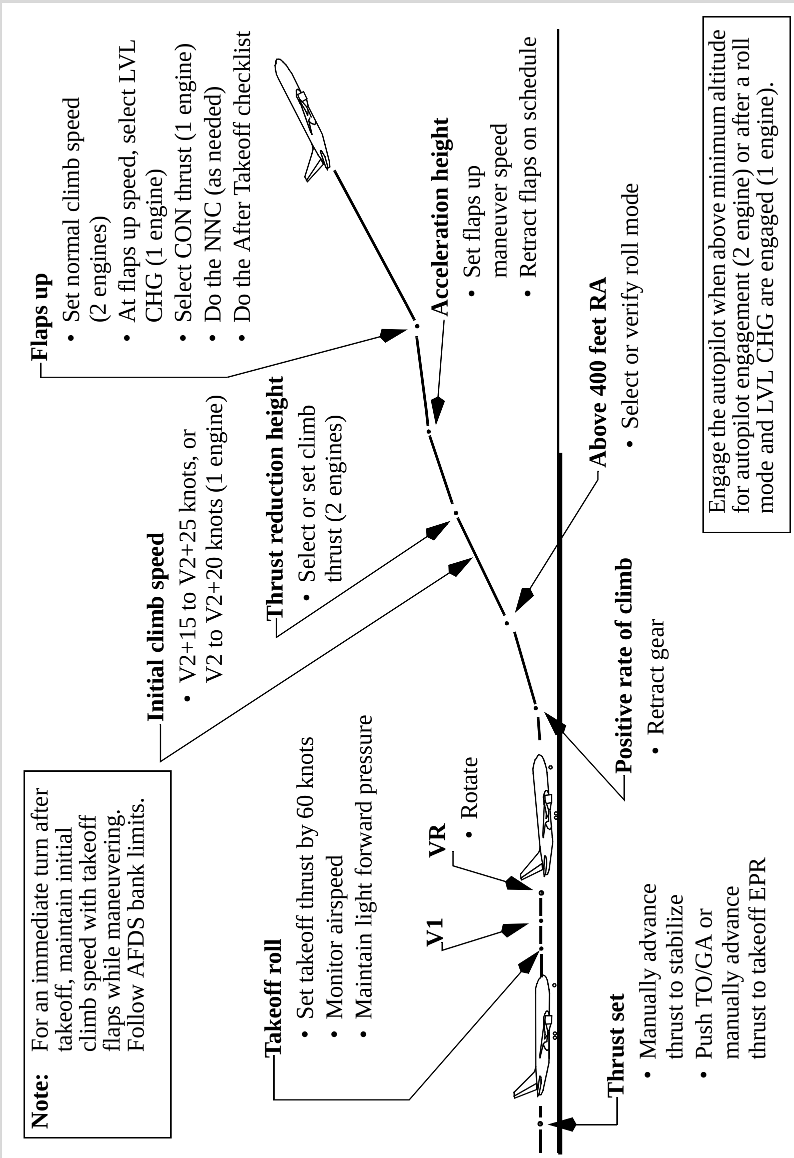
Takeoff

This profile may not satisfy noise abatement guidelines established by the FAA. Some airports may have special procedures that require modification of the takeoff profile.

Takeoff Profile - SP-77 Autopilot



Takeoff Profile - SP-177 Autopilot



Takeoff - General

As part of the before start procedure, review the takeoff page on the PDCS to ensure the entries are correct. Ensure V2 is set on the MCP.

Review the PDCS for any climb constraints. Ensure the PDCS contains the appropriate altitude and airspeed restrictions consistent with the departure procedure.

Takeoff Flap Setting

For takeoffs, when conditions permit, consider using larger flap settings to provide shorter takeoff distance. Larger flap settings also provide greater tail clearance. Refer to the Typical Takeoff Tail Clearance table in this chapter to determine minimum tail clearance for different takeoff flap settings.

Thrust Management

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

For airplanes equipped with the SP-77 autopilot, the flight director is normally off for takeoff. Flight director commands may be used after flaps are retracted and climb thrust is set.

For airplanes equipped with the SP-177 autopilot, 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 the risk of foreign object damage or engine surge/stall due to a tailwind or crosswind. Flight test and analysis prove that the change in takeoff roll distance due to the rolling takeoff procedure is negligible when compared to a standing takeoff.

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 wheel is released and apply takeoff thrust by advancing the thrust levers to approximately 1.4 EPR (levers in vertical position.). Allow the engines to stabilize momentarily then promptly advance the thrust levers to takeoff thrust (autothrottle TO/GA). There is no need to stop the airplane before increasing thrust.
- if holding in position on the runway, ensure the nose wheel steering wheel 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 in icing conditions is required.

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

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. If thrust is to be set manually, smoothly advance thrust levers toward takeoff thrust.

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.

Ensure the target EPR is set by 60 knots. Minor increases in thrust may be made immediately after 60 knots to reach the target EPR. After takeoff thrust is set, a small deviation in EPR between the engines should not warrant a decision to reject the takeoff unless this deviation is accompanied by a more serious event. (Refer to the QRH, Maneuvers Chapter, Rejected Takeoff, for criteria.) Due to variation in thrust settings, runway conditions, etc., it is not practical to specify a precise tolerance for EPR difference between the engines.

Limited circumstances such as inoperative rudder pedal steering may require the use of the nose wheel steering wheel at low speeds during takeoff when the rudder is not effective. Reference the airplane Dispatch Deviations Guide (DDG) for more information concerning operation with rudder pedal steering inoperative.

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.

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 PM should monitor engine instruments and airspeed indications during the takeoff roll and announce any abnormalities. The PM should announce passing 80 knots and the PF should verify that his airspeed indicator is in agreement.

A pitot system blocked by protective covers or foreign objects can result in no airspeed indication, or airspeed indications that vary between instruments. It is important that aircrews ensure airspeed indicators are functioning and reasonable at the 80 knot callout. If the accuracy of either primary airspeed indication is in question, reference the standby airspeed indicator. Early recognition of a malfunction is important in making a sound go/stop decision. Refer to the Airspeed Unreliable section in chapter 8 for an expanded discussion of this subject.

Use of Autothrottle (SP-177)

The PM should verify that takeoff thrust has been set and the throttle hold mode (THR HOLD) is engaged. Once THR HOLD annunciates, the autothrottle cannot change thrust lever position, but thrust levers can be positioned manually. The THR HOLD mode remains engaged until another thrust mode is selected.

Note: Takeoff into headwind of 20 knots or greater may result in THR HOLD before the autothrottle can make final thrust adjustments.

The THR HOLD 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 autothrottle should then be disconnected and desired thrust set manually. If full thrust is desired when THR HOLD mode is displayed, the thrust levers must be manually advanced.

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 PI Chapter of the FCOM or airport analysis are developed 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. The use of stabilizer trim during rotation is not recommended.

For airplanes equipped with the SP-77 autopilot, after liftoff use the attitude indicator as the primary pitch reference, cross checking indicated airspeed and other flight instruments to maintain the proper vertical flight path.

For airplanes equipped with the SP-177 autopilot, after liftoff use the attitude indicator as the primary pitch reference. The flight director, in conjunction with indicated airspeed and other flight instruments is used to maintain the proper vertical flight path.

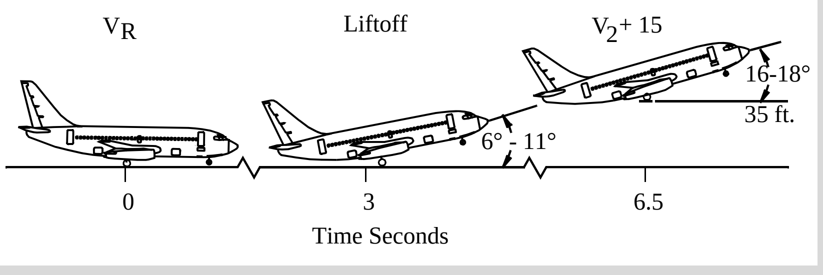
Note: For airplanes equipped with the SP-177 autopilot, the flight director pitch command is not used for rotation.

737-200
Using the technique above, liftoff attitude is achieved in approximately 3 to 6 seconds. Rotate smoothly at an average pitch rate of 3 degrees/second.

737-200A
Using the technique above, liftoff attitude is achieved in approximately 4 to 7 seconds. Rotate smoothly at an average pitch rate of 3 degrees/second.

Typical Rotation, All Engines

The following figure shows typical rotation with both engines operating.

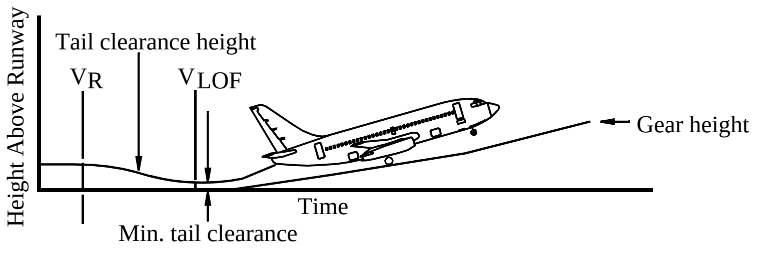


Retract the landing gear after a positive rate of climb is indicated on the altimeter.

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 minimum tail clearance during takeoff. Additionally, the last column shows the pitch attitude for tail contact with wheels on the runway and landing gear struts extended. For a discussion of tail strike procedures see Chapter 8 and the FCOM.



Model	Flap	Liftoff Attitude (degrees)	Minimum Tail Clearance inches (cm)	Tail Strike Pitch Attitude (degrees)
737-200	1 5 15 25	10.2 8.5 5.8 6.2	30 (77) 37 (95) 47 (119) 46 (116)	15.5
737-200A	1 2 5 15 25	10.9 10.0 9.6 8.9 8.8	27 (69) 31 (79) 33 (84) 36 (92) 36 (92)	15.5

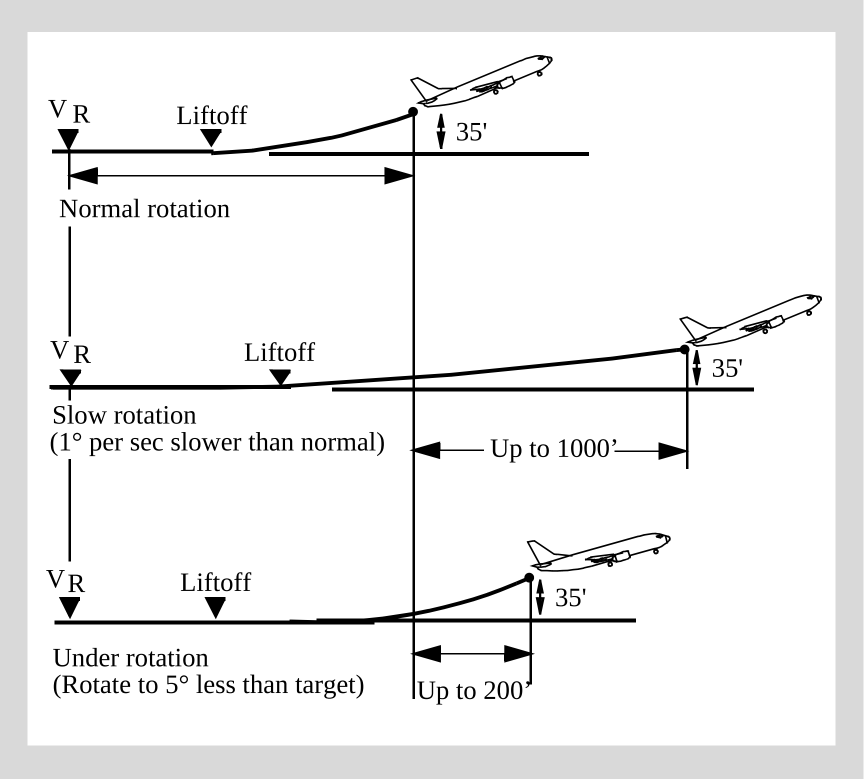
Effect of Rotation Speed and Pitch Rate on Liftoff

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 V2 + 20 knots, the speed commanded by the flight director is rotation speed up to a maximum of V2 + 25 knots. An earlier liftoff does not affect the commanded initial climb speed, however, either case degrades overall takeoff performance.

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

Slow or Under Rotation (Typical)



Center-Of-Gravity (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 CG, use of reduced thrust and rolling takeoff technique is recommended whenever possible. The rudder becomes effective between 40 and 60 knots.

Operation with Alternate Forward Center of Gravity Limit for Takeoff

Takeoff performance is based on the forward CG limitations as defined in the AFM. However, takeoff performance can be improved by taking credit for an alternate (further aft) forward CG limit if shown in the AFM. Use of this data provides higher performance-limited takeoff weights than the basic AFM performance data.

Typically alternate forward CG is used to increase performance-limited takeoff weight for field length, climb or obstacle limited departures. Another potential benefit of alternate forward CG is to allow greater thrust reduction which increases engine reliability and reduces engine maintenance costs. However, this improved performance capability is only available if the operator has the certified data in their AFM and has approval from their regulatory agency to operate the airplane at an alternate forward CG limit.

A more aft CG increases the lift available at a given angle of attack due to the reduction in nose up trim required from the horizontal stabilizer. This allows VR and V2 to be reduced, which in turn reduces the field length required for takeoff. Reduction in field length required can also permit an increased field length limited weight. In most instances this reduction in nose up trim also results in a decrease in drag which improves the airplane's climb capability.

Note: The QRH takeoff speeds are not valid for operations using alternate forward CG. Takeoff speeds must be calculated using alternate forward CG performance data normally provided by dispatch or flight operations.

Crosswind Takeoff

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

Note: Engine surge can occur with a strong crosswind or tailwind component if takeoff thrust is set prior to brake release. Therefore, the rolling takeoff procedure is strongly advised when crosswinds exceeds 20 knots or tailwinds exceed 10 knots.

Takeoff Crosswind Guidelines

Appendix A.2.3

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

Takeoff crosswind guideline considerations:

- takeoff crosswind guidelines are based on the most adverse airplane loading (light weight and aft center of gravity), and assume an engine out RTO and proper pilot technique
- on slippery runways, crosswind guidelines are a function of runway surface condition
- takeoff on untreated snow or ice should only be attempted when no melting is present
- winds measured at 33 feet (10 m) tower height and apply for runways 148 feet (45m) or greater in width.

Runway Condition	Crosswind Component (knots)
Dry	40
Wet	25
Standing Water/Slush	16
Snow - No Melting	21
Ice - No Melting	7

Directional Control

Initial runway alignment and smooth symmetrical thrust application result in good crosswind control capability during takeoff. Light forward pressure on the control column during the initial phase of the takeoff roll (below approximately 80 knots) increases nose wheel steering effectiveness. Any deviation from the centerline during thrust application should be countered with immediate, smooth and positive control inputs. Smooth rudder and 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: With wet or slippery runway conditions, the PM should give special attention to ensuring the engines have symmetrically balanced thrust indications.

Rotation and Takeoff

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

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

At liftoff, the airplane is in a sideslip with crossed controls. A slow, smooth recovery from this sideslip is accomplished by slowly neutralizing the control wheel and rudder pedals after liftoff.

Gusty Wind and Strong Crosswind Conditions

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

To increase tail clearance during strong crosswind conditions, consider using a higher VR if takeoff performance permits. This can be done by:

- using improved climb takeoff performance
- increasing VR speed to the performance limited gross weight rotation speed, not to exceed actual gross weight VR + 20 knots. Set V speeds for the actual gross weight. Rotate at the adjusted (higher) rotation speed. This increased rotation speed results in an increased stall margin, and meets takeoff performance requirements.

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. 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 prefer a less than maximum thrust takeoff whenever performance limits and noise abatement procedures permit. The reduced thrust takeoff lowers EGT and extends engine life. Operation with reduced takeoff thrust requires that the engine inoperative climb gradient is not less than the regulatory minimum, or that required to meet obstacle clearance criteria. Therefore, there is no need for additional thrust beyond the reduced takeoff thrust in the event of an engine failure.

The reduced thrust takeoff may be done using the Assumed Temperature Method (ATM). Use the takeoff speeds provided by the airport analysis, PI chapter in the FCOM, Flight Planning and Performance Manual (FPPM), AFM, or other approved source corresponding to the assumed (higher) temperature.

Note: Reduced thrust takeoffs are not recommended if potential windshear conditions exist.

Assumed Temperature Method (ATM)

The ATM achieves a takeoff thrust less than the maximum takeoff thrust by assuming a temperature that is higher than the actual temperature. The thrust reduction authorized by most regulatory agencies is limited to 25% below any certified takeoff thrust rating.

The primary thrust setting parameter (EPR) is not considered a limitation. Takeoff speeds consider ground and in-air minimum control speeds (VMCG and VMCA) with full takeoff thrust for the actual temperature. If conditions are encountered during the takeoff where additional thrust is desired, such as windshear, the crew should not hesitate to manually advance thrust levers to maximum rated thrust.

The assumed temperature method of computing reduced thrust takeoff performance is always conservative. Actual performance is equal to or better than the performance obtained if actually operating at the assumed temperature. This is because the true airspeed at the actual temperature is lower than at the assumed temperature.

Note: Do not use the ATM if conditions that affect braking such as a runway contaminated by slush, snow, standing water, or ice exist. ATM takeoffs are allowed on a wet runway if suitable performance accountability is made for the 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.

Thrust Control

For airplanes equipped with the SP-77 autopilot, when conducting a reduced thrust (ATM) takeoff, if more thrust is needed (up to maximum thrust) the thrust levers must be advanced manually.

For airplanes equipped with the SP-177 autopilot, when conducting a reduced thrust (ATM) takeoff, if more thrust is needed (up to maximum thrust) when thrust is in THR HLD mode, the thrust levers must be advanced manually.

If conditions are encountered during the takeoff where additional thrust is needed, such as a windshear condition, the crew should not hesitate to manually advance thrust levers to maximum thrust.

For airplanes equipped with the SP-177 autopilot, after the airplane is in the air, pushing a TO/GA switch advances the thrust to maximum available thrust and TO/GA is annunciated.

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 and obstacle limited weights. V1, VR and V2 are increased and must be obtained from dispatch or by airport analysis.

Low Visibility Takeoff

Appendix A.2.4

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 apply 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

Appendix A.2.4

Slush, standing water, or deep snow reduces the airplane takeoff performance because of increased rolling resistance and reduced tire-to-ground friction. In addition to performance considerations, slush or standing water may cause damage to the airplane.

Most operators specify weight reductions to the AFM field length or obstacle limited takeoff weight based on the depth of the slush or standing water, wet snow, or dry snow, and a maximum depth beyond which a takeoff should not be attempted. Reference the Takeoff - Wet or Contaminated Runway Conditions Supplementary Procedure in the FCOM for more information including recommended maximum depth of runway contaminates for takeoff.

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

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

During wet runway or slippery conditions, the PM must give special attention to ensuring 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.

737-200
Takeoff weight reductions and speed increases are necessary to ensure adequate stall margins are maintained. Takeoff operations with reduced thrust are not permitted. Use normal rotation rates.

737-200A
No performance adjustments are required for the application of deicing/anti-icing fluids. Use flaps 10 or greater for takeoff whenever possible to ensure leading edge slats are fully extended. Takeoff operations with reduced thrust based on the assumed temperature method is 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.

The AFM accelerate-stop distance includes the distance traveled while initiating the stop and is based on the measured stopping capability as demonstrated during certification flight test. This distance includes the use of speedbrakes and maximum braking; it does not include the use of reverse thrust. Operationally, the use of reverse thrust and autobrakes are recommended, however, maximum braking can be achieved either manually or with the autobrake set to RTO (as installed).

Calculating a V1 speed that equates accelerate-go and accelerate-stop distances defines the minimum field length required for a given weight. This is known as a “balanced field length” and the associated V1 speed is called the “balanced V1”. The QRH provides takeoff speeds based on a balanced V1. If an ATM is used, the QRH takeoff speeds provide a balanced V1 applicable to the lower thrust setting.

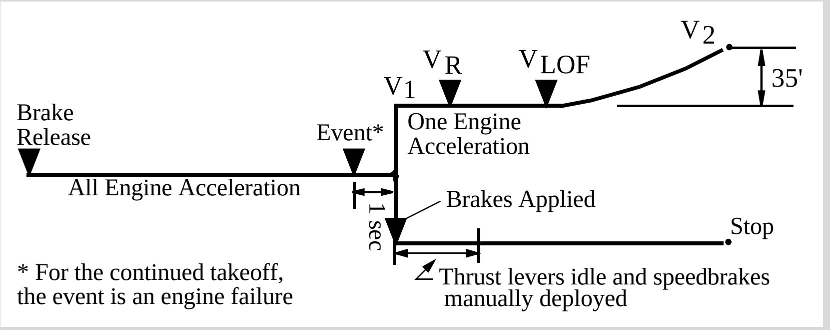
Takeoff gross weight must not exceed the climb limit weight, field length limit weight, obstacle limit weight, tire speed limit weight, or brake energy limit. If the weight is limited by climb, obstacle, or brake considerations, the limit weight may be increased by using takeoff speeds that are different from the normal balanced takeoff speeds provided by the QRH.

Different (unbalanced) takeoff speeds can be determined by using:

- improved climb to increase climb or obstacle limited weights
- maximum V1 policy to increase obstacle limited weights
- minimum V1 policy to increase brake energy limited weights
- clearway or stopway to increase field or obstacle limited weights.

If the takeoff weight is not based on normal balanced V1, the QRH takeoff speeds are not applicable and the operator should provide the pilot with a method to obtain the appropriate takeoff speeds.

FAR Takeoff



Note: The graphic above refers to dry runway conditions only.

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 V1 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 V1.

Historically, rejecting a takeoff near V1 has often resulted in the airplane stopping beyond the end of the runway. Common causes include initiating the RTO after V1 and failure to use maximum stopping capability (improper procedures/techniques). Effects of improper RTO execution are shown in the diagrams located in the RTO Execution Operational Margins section, of 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 V1 is not recommended unless the captain judges the airplane incapable of flight. Even if excess runway remains after V1, there is no assurance that the brakes have the capacity to stop the airplane prior to the end of the runway.

There have been incidents where pilots have forgotten to set the airspeed bugs. If, during a takeoff, the crew discovers that the V speeds are not set and there are no other fault indications, the takeoff may be continued. The lack of V speeds with no other fault indications does not fit any of the published criteria for rejecting a takeoff (refer to the Rejected Takeoff NNM in the QRH). In the absence of V speeds, the PM should announce V1 and VR speeds to the PF at the appropriate times during the takeoff roll.

For airplanes equipped with the SP-77 autopilot, the V2 speed should be displayed on airspeed indicators. If neither pilot recalls the correct rotation speed, rotate the airplane 5 to 10 knots before the displayed V2 speed.

For airplanes equipped with the SP-177 autopilot, the V2 speed should be displayed on the MCP and primary airspeed indicators. If neither pilot recalls the correct rotation speed, rotate the airplane 5 to 10 knots before the displayed V2 speed.

Rejected Takeoff Maneuver

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

Note: If the decision is made to reject the takeoff, the flight crew should accomplish the rejected takeoff non-normal maneuver as described in the Maneuvers chapter of the QRH.

For airplanes equipped with the SP-177 autopilot, 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 airplane 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 an engine at which the pilot can continue the takeoff and achieve the required height above the takeoff surface within the takeoff distance.

Pilots know that V1 is fundamental to making the Go/Stop decision. Under runway limited conditions, if the reject procedure is initiated at V1, the airplane can be stopped prior to reaching the end of the runway. See RTO Execution Operational Margins diagrams for the consequences of initiating a 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 example, if the engine fails 2 seconds before 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.

It is important to note here is that the majority of past RTO accidents were not engine failure events. Full takeoff thrust from all engines was available. With normal takeoff thrust, 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.

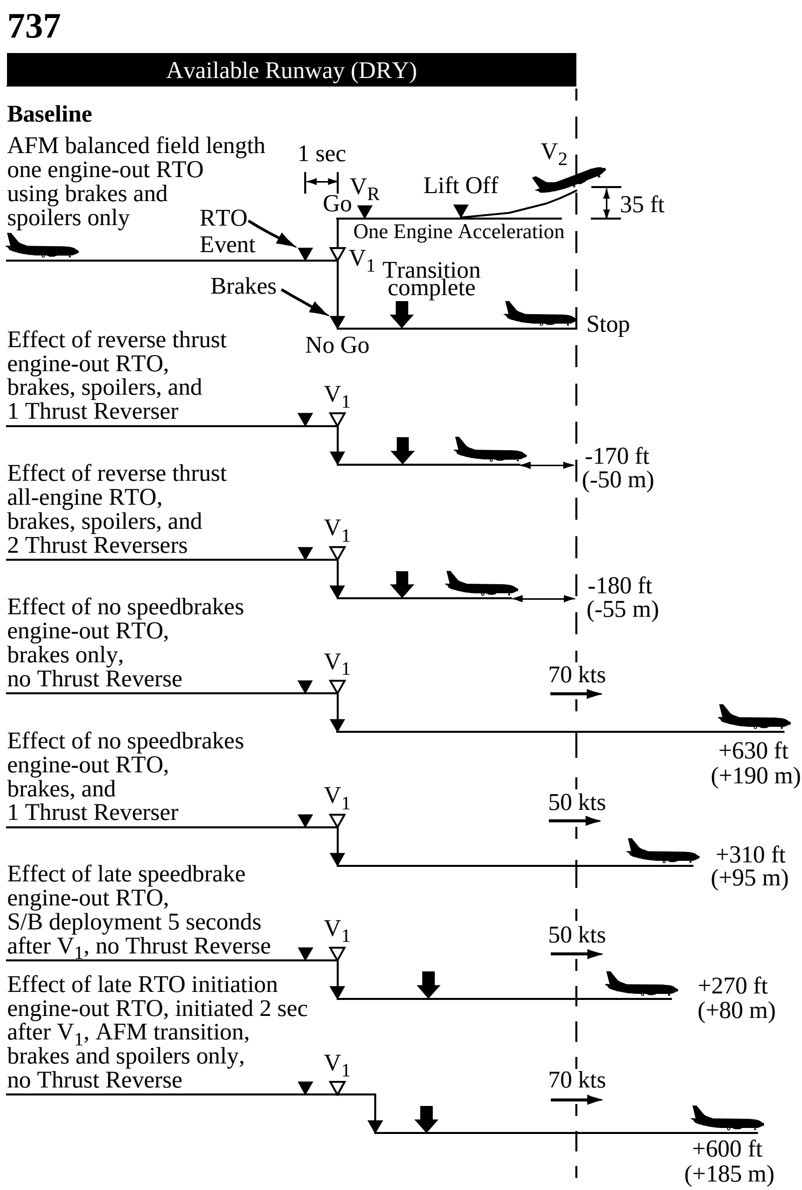
Making the Go/Stop decision starts long before V1. Early detection, good crew coordination and quick reaction are the keys to a successful takeoff or stop.

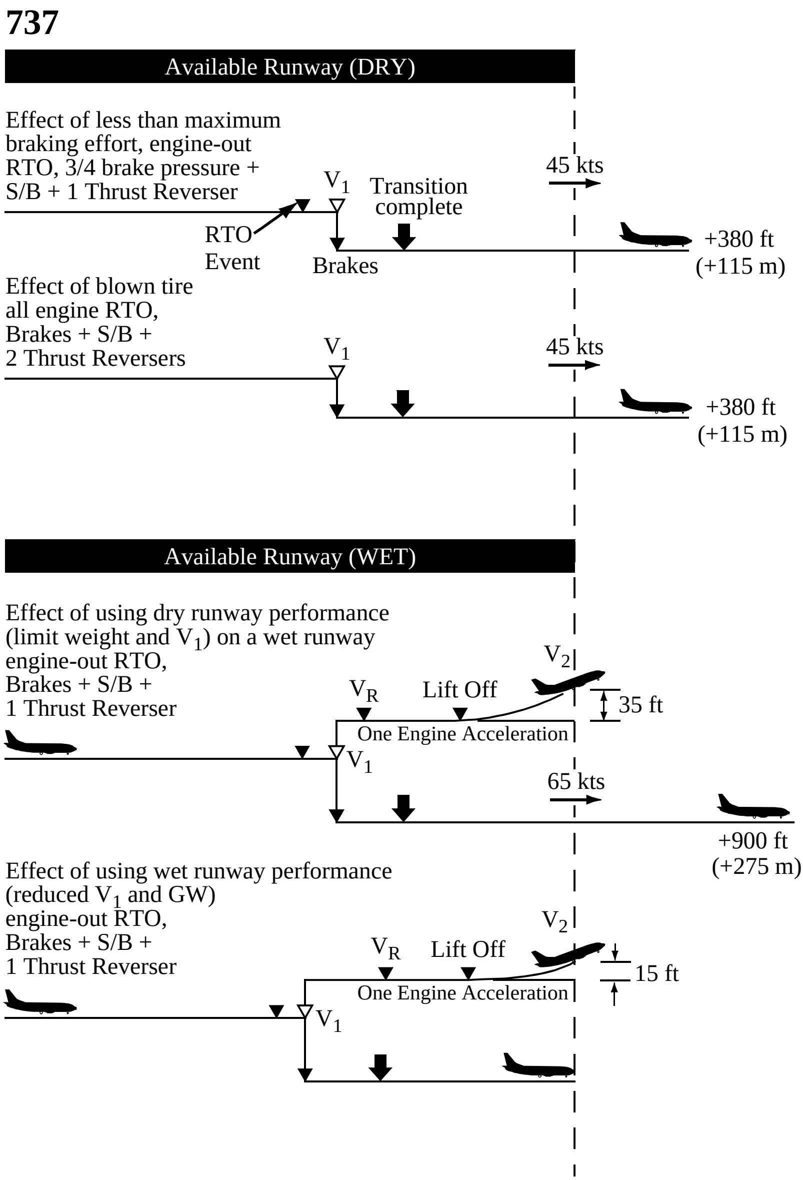
RTO Execution Operational Margins

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 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.

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.


737
Available Runway (DRY)
Baseline
AFM balanced field length one engine-out RTO using brakes and spoilers only
1 sec
V2
VR
Go
Lift Off
35 ft
RTO Event
One Engine Acceleration
V1
Transition complete
Brakes
Stop
No Go
Effect of reverse thrust engine-out RTO, brakes, spoilers, and 1 Thrust Reverser
V1
-170 ft (-50 m)
Effect of reverse thrust all-engine RTO, brakes, spoilers, and 2 Thrust Reversers
V1
-180 ft (-55 m)
Effect of no speedbrakes engine-out RTO, brakes only, no Thrust Reverse
V1
70 kts
+630 ft (+190 m)
Effect of no speedbrakes engine-out RTO, brakes, and 1 Thrust Reverser
V1
50 kts
+310 ft (+95 m)
Effect of late speedbrake engine-out RTO, S/B deployment 5 seconds after V1, no Thrust Reverse
V1
50 kts
+270 ft (+80 m)
Effect of late RTO initiation engine-out RTO, initiated 2 sec after V1, AFM transition, brakes and spoilers only, no Thrust Reverse
V1
70 kts
+600 ft (+185 m)


737
Available Runway (DRY)
Effect of less than maximum braking effort, engine-out RTO, 3/4 brake pressure + S/B + 1 Thrust Reverser
V1
Transition complete
45 kts
RTO Event
Brakes
+380 ft (+115 m)
Effect of blown tire all engine RTO, Brakes + S/B + 2 Thrust Reversers
V1
45 kts
+380 ft (+115 m)
Available Runway (WET)
Effect of using dry runway performance (limit weight and V1) on a wet runway engine-out RTO, Brakes + S/B + 1 Thrust Reverser
V2
VR
Lift Off
35 ft
One Engine Acceleration
V1
65 kts
+900 ft (+275 m)
Effect of using wet runway performance (reduced V1 and GW) engine-out RTO, Brakes + S/B + 1 Thrust Reverser
V2
VR
Lift Off
15 ft
One Engine Acceleration
V1

Initial Climb - All Engines

After liftoff, use the attitude indicator as the primary pitch reference.

For airplanes equipped with the SP-77 autopilot, pitch, airspeed, and airspeed trends must be cross-checked. Adjust pitch to maintain a target airspeed of V2 + 20 knots.

For airplanes equipped with the SP-177 autopilot, the flight director, in conjunction with indicated airspeed and other flight instruments is used to maintain the proper vertical flight path. Pitch, airspeed, and airspeed trends must be cross-checked whether the flight director is used or not. After liftoff, the flight director commands pitch to maintain a target airspeed of V2 + 20 knots until another flap setting is selected. The pilot is then responsible for updating the MCP window to the desired target speeds. If the flight director is not used, indicated airspeed and attitude become the primary pitch references.

V2 + 20 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 V2 + 20 during the initial climb, stop the acceleration but do not attempt to reduce airspeed to V2 + 20. Any speed between V2 + 15 and V2 + 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. Automatic wheel breaking occurs during gear retraction. After gear and flaps are retracted, the PM 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

Obstruction 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 V2 + 15 to V2 + 25 with takeoff flaps.

Note: A maximum bank angle of 30° is permitted at V2 + 15 knots with takeoff flaps.

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

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

Roll Modes (SP-177)

On airplanes with wings level takeoff mode, if an immediate turn after takeoff is necessary, heading may be preselected prior to takeoff. Use HDG SEL when the turn is desired (minimum 400 feet AGL).

Note: For all airplanes equipped with the HDG SEL takeoff option, leave runway heading selected until turn initiation.

Pitch Mode (SP-177)

At thrust reduction altitude, select or verify that climb thrust is set. At acceleration height, set flaps up maneuver speed and retract flaps on the Flap Retraction Schedule.

After flaps and slats retraction is complete, set normal climb speed in the MCP speed window.

When the autopilot is engaged, the AFDS reverts to LVL CHG, and the FMA pitch mode changes from TO/GA to MCP SPD. If a pitch mode other than TO/GA is engaged when the autopilot is engaged, the AFDS will remain in that mode.

Autopilot Engagement

The autopilot is FAA certified to allow engagement at or above 1,000 feet AGL after takeoff. Other regulations or airline operating directives may specify a different 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

The minimum altitude for flap retraction is 400 feet.

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 standard 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.

During training flights, 1,000 feet AFE is normally used as the 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.

During flap retraction, selection of the next flap position is initiated when reaching the maneuver speed for the existing flap position. Therefore, when the new flap position is selected, the airspeed is below the maneuver speed for that flap position. For this reason, the airspeed should be increasing when selecting the next flap position. During flap retraction, at least adequate maneuver capability or 30° of bank (15° of bank and 15° overshoot) to stick shaker is provided at the flap retraction speed. Full maneuver capability or at least 45° of bank (30° of bank and 15° overshoot) is provided when the airplane has accelerated to the recommended maneuver speed for the selected flap position.

At thrust reduction altitude, select or verify that climb thrust is set. At acceleration height, set flaps up maneuver speed and retract flaps on the Flap Retraction Schedule.

Begin flap retraction at V2 + 15 knots, except for a flaps 1 takeoff. For a flaps 1 takeoff, begin flap retraction when reaching the flaps 1 maneuver speed.

With airspeed increasing, subsequent flap retractions should be initiated when airspeed reaches the fixed maneuver speed for the existing flap position.

Takeoff Flap Retraction Speed Schedule

Takeoff Flaps	Flap Retraction Speed		Select Flaps
	At & Below 117,000 LB (53,070 KG)	Above 117,000 LB (53,070 KG)	
25	V2 + 15 150 170 190	V2 + 15 160 180 200	15 5 1 UP
15	V2 + 15 170 190	V2 + 15 180 200	5 1 UP
5	V2 + 15 190	V2 + 15 200	1 UP
1	190	200	UP
Limit bank angle to 15° until reaching V2 + 15			

Noise Abatement Takeoff

Normal takeoff procedures may not satisfy noise abatement requirements at all airports. Refer to specific local airport procedures or current FAA or ICAO noise abatement profiles to accomplish the noise abatement takeoff.

Takeoff - Engine Failure

General

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

Engine Failure Recognition

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 and Liftoff - One Engine Inoperative

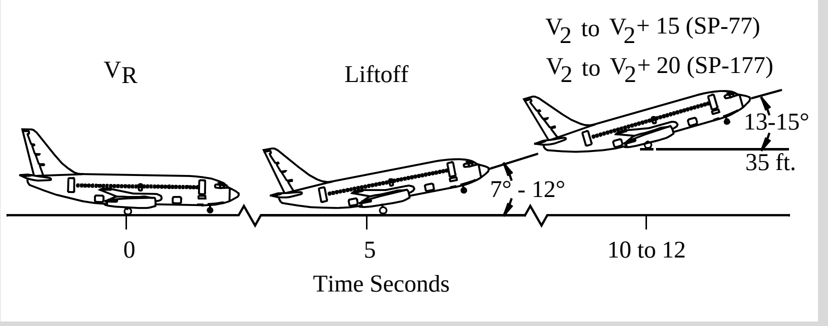
If an engine fails between V1 and liftoff, maintain directional control by smoothly applying rudder proportionate with thrust decay.

During a normal all engine takeoff, a smooth continuous rotation toward 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 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.

Typical Rotation - One Engine Inoperative

Liftoff attitude depicted in the following table should be achieved in approximately 5 seconds. Adjust pitch attitude, as needed, to maintain desired airspeed of V2 to V2+20.

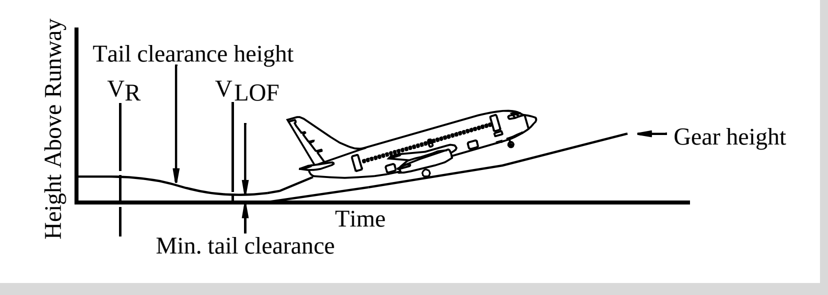


Retract the landing gear after a positive rate of climb is indicated on the altimeter.

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

Typical Takeoff Tail Clearance - One Engine Inoperative

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



Model	Flap	Liftoff Attitude (degrees)	Minimum Tail Clearance inches (cm)	Tail Strike Pitch Attitude (degrees)
737-200	1 5 15 25	11.2 9.4 7.4 6.9	24 (65) 34 (85) 41 (105) 43 (110)	15.0
737-200A	1 2 5 15 25	12.2 11.5 11.2 10.7 10.8	20 (51) 24 (61) 26 (65) 28 (70) 28 (70)	15.0

Initial Climb - One Engine Inoperative

For airplanes equipped with the SP-77 autopilot, the initial climb attitude should be adjusted to maintain a minimum of V2 and a positive climb. After liftoff attitude and indicated airspeed are the primary pitch references. Crosscheck indicated airspeed, vertical speed and other flight instruments as needed.

For airplanes equipped with the SP-177 autopilot, the initial climb attitude should be adjusted to maintain a minimum of V2 and a positive climb. After liftoff, the flight director provides proper pitch guidance. Crosscheck indicated airspeed, vertical speed and other flight instruments. The flight director commands a minimum of V2, or the existing speed up to a maximum of V2 + 20. If the flight director is not used, indicated attitude and airspeed 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 V2. If an engine fails at an airspeed between V2 and V2 + 20 knots, climb at the airspeed at which the failure occurred. If engine failure occurs above V2 + 20 knots, increase pitch to reduce the airspeed to V2 + 20 knots and maintain V2 + 20 knots until reaching acceleration height.

For airplanes equipped with the SP-177 autopilot, the flight director roll mode commands wings level or HDG SEL (as installed) after liftoff until another roll mode is selected. If ground track is not consistent with the desired flight path, use HDG SEL 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 memory 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 a special engine out departure procedure. If an immediate turn is required, initiate the turn at the appropriate altitude (normally at least 400 feet AGL). Maintain V2 to V2 + 15 knots (SP-77) or V2 to V2 + 20 knots (SP-177) with takeoff flaps while maneuvering.

Note: Limit bank angle to 15° until V2 + 15 knots. Bank angles up to 30° are permitted at V2 + 15 knots with takeoff flaps.

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

Autopilot Engagement - One Engine Inoperative

When at a safe altitude above 1,000 feet AGL with correct rudder pedal or trim input, the autopilot may be engaged. However, autopilot engagement is normally delayed until the flaps are up and LVL CHG is selected. This allows the AFDS to remain in the TO/GA mode during flap retraction.

Flap Retraction - One Engine Inoperative

The minimum altitude for flap retraction with an engine inoperative is 400 feet AGL. During training, Boeing uses 1,000 feet AFE as a standard altitude to initiate acceleration for flap retraction.

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 the maximum continuous thrust limits within 5 minutes 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 1,000 feet before beginning flap retraction. Therefore, during training 1,000 feet is used as the acceleration height for engine failure after V1.

For airplanes equipped with the SP-77 autopilot, at engine out acceleration height, select flaps up maneuver speed. Engine-out acceleration and climb capability for flap retraction are functions of airplane thrust to weight ratio. Decrease pitch attitude to maintain approximately level flight while accelerating. Accelerate and retract flaps on the takeoff flap retraction speed schedule.

For airplanes equipped with the SP-177 autopilot, at engine out acceleration height, select flaps up maneuver speed on the MCP. Engine-out acceleration and climb capability for flap retraction are functions of airplane thrust to weight ratio. The flight director TO/GA mode commands a near level or a slight climb (0-200 fpm) during flap retraction. When the autopilot is engaged, the AFDS reverts to LVL CHG, and the FMA pitch mode changes from TO/GA to MCP SPD mode.

Note: When the autopilot is engaged, the flight crew needs to monitor the autopilot performance to ensure a near level or slight climb is maintained.

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

As the 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 (SP-77)

After flap retraction and at flaps up maneuver speed, set maximum continuous thrust and continue to climb to the obstacle clearance altitude.

Initiate the appropriate engine failure non-normal checklist followed by the After Takeoff checklist when the flaps are up and thrust is set. Remain at flaps up maneuver speed until all obstructions are cleared, then select the engine-out schedule from the PDCS. After level off, set thrust as required.

Flaps Up - One Engine Inoperative (SP-177)

After flap retraction and at or above flaps up maneuver speed, select LVL CHG, set maximum continuous thrust, and to continue climb to the obstacle clearance altitude.

Initiate the appropriate engine failure non-normal checklist followed by the After Takeoff checklist when the flaps are up and thrust is set. Remain at flaps up maneuver speed until all obstructions are cleared, then select the engine-out schedule from the PDCS. Ensure the autothrottle is disconnected before reaching level off altitude. After level off, set thrust as needed.

Noise Abatement - One Engine Inoperative

When an engine failure or abnormal situation affecting safety occurs after takeoff, noise abatement is no longer a requirement.

Engine Failure During a Reduced Thrust (ATM) Takeoff

Since the reduced thrust (ATM) takeoff must still comply with all regulatory takeoff performance requirements, it is not necessary to increase thrust beyond the reduced level on the operating engine in the event of an engine failure. However, if more thrust is needed during an ATM takeoff, thrust on the operating engine may be increased to full rated takeoff thrust by manually advancing the thrust lever. This is because the takeoff speeds consider VMCG and VMCA at the full rated takeoff thrust.

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

Climb, Cruise, Descent and Holding — Chapter 4

Table of Contents — Section TOC

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

The climb EPRs displayed by the PDCS are always the maximum for existing conditions. No reduced climb thrust option is provided.

Climb Constraints

All hard altitude climb restrictions, including "at or below" constraints, should be set in the altitude alert controller (SP-77) or MCP altitude window (SP-177). The next altitude may be set when the restriction has been assured or further clearance has been received. This procedure provides altitude alerting and ensures compliance with altitude clearance limits.

For airplanes equipped with the SP-177 autopilot, when relieved of constraints by ATC, the use of LVL CHG is recommended in congested areas, or during times of high workload.

Low Altitude Level Off

For airplanes equipped with the SP-77 autopilot, when a low altitude climb restriction is required after takeoff the altitude restriction should be set in the altitude alert controller (SP-77). When the airplane approaches this altitude, the airplane levels off if ALT SEL (as installed) is selected. If ALT SEL is not installed, manually select ALT HOLD approaching the desired altitude.

For airplanes equipped with the SP-177 autopilot, when a low altitude climb restriction is required after takeoff, the altitude restriction should be set in the MCP altitude window. When the airplane approaches this altitude, the mode annunciation initially changes to ALT ACQ. As the airplane levels off, ALT HOLD is annunciated.

Note: For airplanes equipped with the SP-177 autopilot, if ALT ACQ occurs before EPR is selected, automatic thrust reduction occurs and the autothrottle speed mode engages.

High Takeoff Thrust - Low Gross Weight

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

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

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

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

Transition to Climb

Maintain flaps up maneuver 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.

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 PDCS minimizes trip cost. It varies with gross weight and ambient conditions.

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

Economy Climb Schedule - PDCS Data Unavailable

- 250 knots - Below 10,000 feet
- 280 knots/0.74M - 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 flaps up maneuver speed + 50 knots until intercepting 0.70M.

Note: The PDCS provides maximum rate climb speeds.

Maximum Angle Climb

The PDCS does not provide 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 can be approximated by manually entering flaps up maneuver speed.

Engine Inoperative Climb

To approximate engine inoperative climb speed, use flaps up maneuver speed and maximum continuous thrust. If a thrust loss occurs at other than takeoff thrust, set maximum continuous thrust on the operative engine and adjust the pitch to maintain airspeed.

Cruise

This section provides 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 maximum altitude is the lowest of:

- maximum certified altitude (structural) - determined during certification and is usually set by the pressurization load limits on the fuselage.
- thrust limited altitude - the altitude at which sufficient thrust is available to provide a specific minimum rate of climb. (Reference the Long Range Cruise Maximum Operating Altitude table in the PI chapter of the FCOM). Depending on the thrust rating of the engines, the thrust limited altitude may be above or below the maneuver limited altitude capability.
- buffet or maneuver limited altitude - the altitude at which a specific maneuver margin exists prior to buffet onset. This altitude provides a margin prior to buffet chosen by airline policy. The minimum margin available is 0.3g (40° bank) prior to buffet.

Turbulence at or near maximum altitude can momentarily increase the airplane’s angle-of attack and activate the stick shaker. Maneuvering increases the load factor and further reduce the margin to buffet onset and stick shaker.

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 short trips, optimum altitude as defined above may not be achievable, since the optimum descent point occurs prior to completing the climb to optimum altitude.

Trip altitude further constrains optimum altitude by reducing the altitude for short trips until minimum cruise segment time is satisfied. This cruise time is a minimum of 5 minutes. For short trips, operation at the trip altitude results in the minimum trip fuel while also satisfying the minimum cruise time requirement.

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 without consideration for cruise winds. It provides approximately a 1.5 g load factor (approximately 48° bank to buffet onset) or better buffet margin (0.5). As deviation from optimum cruise altitude increases, performance economy deteriorates.

Some loss of thrust limited maneuver margin can be expected above optimum altitude. Levels 2,000 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 PDCS and displayed on the CRZ pages. The default cruise speed mode is economy (ECON) cruise. The pilot can also select long range cruise (LRC), engine out modes, or manually enter speeds. For airplanes equipped with the SP-177 autopilot, cruise speed is also displayed by the command air speed when PDC is selected.

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

Headwinds increase the ECON cruise speed. Tailwinds decrease ECON cruise 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 PDCS applies wind corrections to LRC.

Step Climb

Flight plans not constrained by short trip distance are typically based on conducting the cruise portion of the flight within plus or minus 2000 ft. 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 ft. above optimum altitude and then cruising at that flight level until 2000 ft. below optimum. For most flights, one or more step climbs may be required before reaching optimum descent point.

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 most of the flight. The requested/accepted initial cruise altitude should be compared to the thrust limited or the maneuver margin limited altitudes. 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.

Optimum step points are a function of the route length, flight conditions, speed mode, present aircraft altitude, STEP to altitude and the gross weight.

The PDCS does not compute an optimum step point. Initiate a cruise climb to a predetermined altitude above optimum altitude when the airplane is at a predetermined altitude below the optimum altitude displayed on the PDCS. For example, when the airplane is 2,000 feet below the optimum altitude displayed on the PDCS, initiate a climb to a cruise altitude 2,000 feet above the optimum altitude. Maintain this new cruise altitude until the airplane is again 2,000 feet below the cruise altitude displayed on the PDCS, and repeat the process.

Fuel for Enroute Climb

The additional fuel required for a 4,000 foot enroute climb varies from 300 to 600 lbs (135 to 275 kgs) depending on the airplane gross weight. This additional fuel is offset by the savings in the descent. It is usually beneficial to climb to a higher altitude if recommended by the flight plan, provided the wind information used is reliable.

Note: The fuel saved at higher altitude does not normally justify a step climb unless the cruise time of the higher altitude is approximately 20 minutes or longer.

Low Fuel Temperature

Fuel temperature changes relative to total air temperature. For example, extended operation at high cruise altitudes tends to reduce fuel temperature. In some cases the fuel temperature may approach the minimum fuel temperature limit.

Fuel freezing point should not be confused with fuel ice formation caused by frozen water particles. The fuel freezing point is the temperature at which the formation of wax crystals appears in the fuel. The Jet A fuel specification limits the freezing point to -40°C maximum, while the Jet A-1 limit is -47°C maximum. In the Commonwealth of Independent States (CIS), the fuel is TS-1 or RT, which has a maximum freezing point of -50°C, which can be lower in some geographical regions. The actual uplifted freezing point for jet fuels varies by the geographical region in which the fuel is refined.

Unless the operator measures the actual freezing point of the loaded fuel at the dispatch station, the maximum specification freezing point must be used. At most airports, the measured fuel freezing point can yield a lower freezing point than the specification maximum freezing point. The actual delivered freezing temperature can be used if it is known. Pilots should keep in mind that some airports store fuel above ground and, in extremely low temperature conditions, the fuel may already be close to the minimum allowable temperature before being loaded.

For blends of fuels, use the most conservative freezing point of the fuel on board as the freezing point of the fuel mixture. This procedure should be used until 3 consecutive refuelings with a lower freezing point fuel have been completed. Then the lower freezing point may be used. If fuel freezing point is projected to be critical for the next flight segment, wing tank fuel should be transferred to the center wing tank before refueling. The freezing point of the fuel being loaded can then be used for that flight segment.

Fuel temperature should be maintained within AFM limitations as specified in the Limitations Chapter of the FCOM.

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

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

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

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

It takes from 15 minutes to one hour to stabilize the fuel temperature. In most cases, the required descent would be 3,000 to 5,000 feet below optimum altitude. In more severe cases, descent to altitudes of 25,000 feet to 30,000 feet might be required. An increase of 0.01M results in an increase of 0.5° to 0.7° C total air temperature.

Cruise Performance Economy

The flight plan fuel burn from departure to destination is based on certain assumed conditions. These include takeoff gross weight, cruise altitude, route of flight, temperature, enroute winds, and cruise speed.

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

The planned fuel burn can increase due to:

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

Cruise fuel penalties can be approximated using the following guidance. For flight planning purposes, reference the appropriate airplane Flight Planning and Performance Manuals:

- 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 0.01M above LRC: 1% to 2% increase in trip fuel.

For cruise within 2,000 feet of optimum, long range cruise speed can be approximated by using 0.72M. Long range cruise also provides the best buffet margin at all cruise altitudes.

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

Engine Inoperative Cruise/Driftdown

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

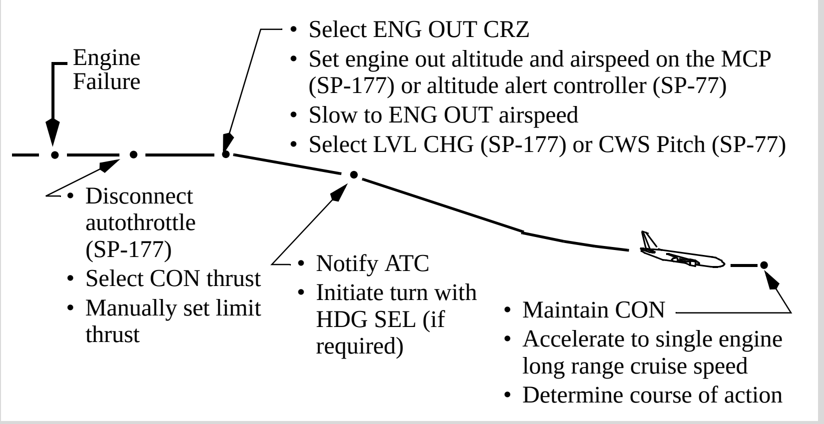
If an engine failure occurs while at cruise altitude, it may be necessary to descend.

Engine inoperative cruise information pertaining to altitude capability, thrust setting and target airspeed is available from the PDCS.

For airplanes equipped with the SP-77 autopilot, set the engine out altitude in the altitude alert controller and set the engine out target airspeed using the airspeed cursor control. If the engine out target airspeed and MCT are maintained, the airplane will level off above the original engine out altitude.

For airplanes equipped with the SP-177 autopilot, the autothrottle should be disconnected and the thrust manually set to CON. Set the engine out altitude in the MCP altitude window, and the engine out target airspeed in the MCP IAS window. Allow the airspeed to slow to engine out speed then engage LVL CHG. If the engine out target airspeed and maximum continuous thrust (MCT) are maintained, the airplane levels off above the original engine out altitude.

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. Refer to Engine Out Familiarization, chapter 7, for trim techniques.



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. However, even in Mach buffet, control response is smooth and normal. The airplane does not have a Mach tuck tendency.

With Mach trim inoperative, the airplane exhibits a slight nose down trim change when accelerating to speeds approaching MMO, however, control force changes are light and easily managed. When the Mach trim system is operative, the nose down trim change is nearly imperceptible except by referencing the control column position.

As speed nears MMO, drag increases rapidly. At high weights, sufficient thrust may not be available to accelerate to MMO in level flight at normal cruising altitudes.

Flight Control Sensitivity at High Speed and High Altitude

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

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

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

ETOPS

Extended Operations (ETOPS) for two engine airplanes are those flights which include points at a flying distance greater than one hour (in still air) from an adequate airport, at engine out cruise speed.

ETOPS Requirements and Approval

Appendix A.2.4

The Minimum Equipment List (MEL) and the Dispatch Deviations Guide (DDG) include dispatch relief levels appropriate to ETOPS. Refer to operators procedures and policies for more information on ETOPS requirements.

Flight and Performance

Appendix A.2.4

Crews undertaking ETOPS flights must be familiar with the ETOPS alternate airports listed in the flight plan. These airports must meet ETOPS weather minima which require an incremental increase above conventional alternate minimums at dispatch, 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 Flight Planning and Performance Manual (FPPM) provides one engine inoperative altitude capability and cruise and diversion fuel information at ETOPS planning speeds. This information is not included in the FCOM/QRH. Fuel reserve corrections must be made for winds, non-standard atmospheric conditions, performance deterioration caused by engines or airframe, and when needed, flight through forecast icing conditions.

Note: Critical fuel calculations are part of the ETOPS dispatch process and are not normally calculated by the flight crew. The crew normally receives ETOPS critical fuel information in the Computer Flight Plan (CFP).

Procedures

During the last hour of cruise on all ETOPS flights, a fuel crossfeed valve check is done. This verifies that the crossfeed valve is operating so that on the subsequent flight, if an engine fails, fuel is available from both main tanks through the crossfeed valve.

ETOPS engine-out procedures may be different from standard non-normal procedures. Following an 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 allows the airplane to reach an alternate airport within the specific time limits authorized for the operator. These cruise speeds and altitudes are determined by the operator and approved by its regulatory agency and usually differ from the engine-out speeds provided by the PDCS. The captain, however, has the discretion to modify this speed if actual conditions following the diversion decision dictate such a change.

Descent

Descent Speed Determination

Use the ECON speed indicated on the Descent page of the PDCS. The pilot may manually enter another speed if desired. If the information is not available from the PDCS, use 0.74M / 250 knots for the best average fuel economy descent.

Descent Constraints

Set all mandatory altitude restrictions and “at or above” constraints in the altitude alert controller (SP-77) or MCP altitude window (SP-177). The next altitude may be set when the restriction has been assured or further clearance has been received. This procedure provides altitude alerting and ensures compliance with altitude clearance limits.

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. Perform essential duties early in the descent so more time is available during the critical approach and landing phases.

Operational factors and/or terminal area requirements may not allow following the optimum descent schedule. Terminal area requirements can be incorporated into basic flight planning but ATC, weather, icing and other traffic may require adjustments to the planned descent schedule.

Proper descent planning is necessary to arrive at the desired altitude at the proper speed and configuration. The distance required for the descent is approximately 3 NM/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 Rate tables provide typical rates of descent below 20,000 feet with idle thrust and speedbrakes extended or retracted.

	Rate of Descent (Typical)	
Target Speed	**Clean**	**With Speedbrake**
0.74 M/ 280	2100 fpm	3900 fpm
250	1500 fpm	2600 fpm
210	1000 fpm	1700 fpm

Normally, descend with idle thrust and in clean configuration (no speed brakes). 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 Descent Procedure is normally initiated before the airplane descends below the cruise altitude for arrival at destination, and should be completed by 10,000 feet MSL. The Approach Procedure is normally started at transition level.

Plan the descent to arrive at traffic pattern altitude at flaps up maneuver speed approximately 12 miles from the runway when proceeding straight-in or about 8 miles from the runway when making an abeam approach. A good crosscheck is to be at 10,000 feet AGL, 30 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 25 seconds and 2 NM to decelerate from 280 to 250 knots in level flight without speedbrakes. It requires an additional 35 seconds and 3 NM to decelerate to flaps up maneuver speed at average gross weights. Using speedbrakes to aid in deceleration reduces these times and distances by approximately 50%.

Maintaining the desired descent profile and 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 beginning the descent. This allows full attention to be given airplane control.

Speedbrakes

The PF should keep a hand on the speedbrake lever when the speedbrakes are used in-flight. This helps prevent leaving the speedbrake extended when no longer required.

Use of speedbrakes between the down detent and flight detent can result in rapid roll rates and normally should be avoided. While using the speedbrakes in descent, allow sufficient altitude and airspeed margin to level off smoothly. Lower the speedbrakes before adding thrust.

Note: In flight, do not extend the speedbrake lever beyond the FLIGHT detent.

The use of speedbrakes with flaps extended should be avoided, if possible. With flaps greater than 15, the speedbrakes should be retracted. 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.

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:

- For airplanes equipped with the SP-77 autopilot, it may be necessary to reduce the speed and/or descent rate prior to altitude capture or reduce the speed and delay speedbrake retraction until after level off is complete.
- For airplanes equipped with the SP-177 autopilot, this condition is caused because the AFDS captures the selected altitude smoothly by maintaining a fixed path while the thrust is at or near idle. It may be necessary to reduce the selected speed and/or descent rate prior to altitude capture or reduce the selected speed and delay speedbrake retraction until thrust is increased to maintain level off airspeed.

Flaps and Landing Gear

Normal descents are made in the clean configuration to pattern or instrument approach altitude. If greater descent rates are desired, extend the speedbrakes. When thrust requirements for anti-icing result in less than normal descent rates with speedbrakes extended, or if higher than normal descent rates are required by ATC clearance, 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 maneuver 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 maneuver speed may exceed these limits. Consider extending the flaps to attain a lower maneuver 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.

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 PDCS holding speed is greater than the ICAO or FAA maximum holding speed, holding may be conducted at flaps 1, using flaps 1 maneuver speed. Flaps 1 uses approximately 10% more fuel than flaps up. Holding speeds in the PDCS provide minimum fuel burn; but are never lower than flaps up maneuver speed.

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

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 holding speeds, the defined holding pattern protected airspace may be exceeded.

Holding Airspeeds

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 following tables.

ICAO Holding Airspeeds (Maximum)

Altitude	Speed
Through 14,000 feet	230 knots

Altitude	Speed
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	0.83M

FAA Holding Airspeeds (Maximum)

Altitude	Speed
Through 6,000 feet MSL	200 knots
6,001 feet MSL through 14,000 feet MSL	230 knots (210 knots Washington D. C. & New York FIRs)
14,001 feet MSL and above	265 knots

Holding Airspeeds Not Available from the PDCS

If holding speed is not available from the PDCS, refer to the appropriate PI section of the FCOM. If time does not permit immediate reference to the QRH, the following speed schedule may be used temporarily. This simplified holding speed schedule may not match the PDCS or QRH holding speeds because the PDCS and QRH holding speeds are based on many conditions that cannot be generalized into a simple schedule. However, this schedule provides a reasonable approximation of minimum fuel burn speed with appropriate margins to initial buffet.

Recommended holding speeds can be approximated by using the following guidance until more accurate speeds are obtained from the QRH:

- flaps up maneuver speed approximates minimum fuel burn speed and may be used at low altitudes
- above FL250, use VREF 40 + 100 knots to provide adequate buffet margin.

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Approach and Missed Approach — Chapter 5

Table of Contents — Section TOC

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Approach and Missed Approach Chapter 5

Preface

This chapter outlines recommended operating practices and techniques for ILS, non-ILS, circling and visual approaches, and the Go–Around and Missed Approach 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.

Complete the approach preparations before arrival in the terminal area. Set decision altitude or height DA(H) or minimum descent altitude or 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 bearing pointer switches 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, if needed. 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

Before the start of an instrument approach, the PF should brief the PM of his 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
- speed restrictions
- determination of the Missed Approach Point (MAP) and the missed approach procedure
- landing distance required for current conditions compared to landing distance available
- 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

An aircraft approach category is used for straight-in approaches. The designated approach category for an aircraft is defined using the maximum certified landing weight as listed in the AFM. Under FAA criteria, the speed used to determine the approach category is the landing reference speed (VREF). ICAO and other regulatory agencies may use different criteria.

Category	IAS
C	121 knots or more but less than 141 knots
D	141 knots or more but less than 166 knots

Under FAA criteria:

- the 737 is classified as a Category “C” airplane.

Obstruction Clearance for a Circling Approach

For circling approaches, maximum airplane speeds are shown on the approach plate instead of airplane approach categories. Circling approach minimums for both FAA and ICAO criteria are based on obstruction clearance for approach maneuvering within a defined region of airspace. This region of airspace is determined by maximum IAS. This region gets larger with higher speed, which may result in higher approach minimums depending on the terrain characteristics surrounding the airport. Similarly, lower airspeed may result in a lower approach minimum. See the section titled Circling Approach later in this chapter for more information on obstruction clearance.

Approach Clearance

When cleared for an approach and on a published segment of that approach, the pilot is authorized to descend to the minimum altitude for that segment. When cleared for an approach and not on a published segment of the approach, maintain assigned altitude until crossing the initial approach fix or established on a published segment of that approach. If established in a holding pattern at the final approach fix, the pilot is authorized to descend to the procedure turn altitude when cleared for the approach.

When conducting an instrument approach from the holding pattern, continue on the same pattern as holding, extend flaps to five 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 most approaches the procedure turn must be completed within specified limits, such as within 10 NM of the procedure turn fix or beacon. Airplane configuration and ground speed outbound must be considered. The published procedure turn altitudes are normally minimum altitudes.

Adjust time outbound for airspeed, wind effects, and location of the procedure turn fix. If the procedure turn fix is crossed at an excessively high ground speed, the procedure turn protected airspace may be exceeded. The procedure turn should be monitored using all navigation aids available to assure the airplane remains within protected airspace.

Stabilized Approach Requirements

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 AFE in instrument meteorological conditions (IMC) and by 500 feet AFE in visual meteorological conditions (VMC). An approach is considered stabilized when all of the following criteria are met:

- the airplane is on the correct flight path
- only small changes in heading and pitch are required to maintain the correct flight path
- the airplane should be at approach speed. Deviations of +10 knots to – 5 knots are acceptable if the airspeed is trending toward approach speed
- the airplane 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
- thrust setting is appropriate for the airplane 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, or within the expanded localizer scale (as installed)
- during a circling approach, wings should be level on final when the airplane reaches 300 feet AFE.

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 AFE in IMC or below 500 feet AFE 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 airplane should be positioned so the flight deck is within, and tracking so as to remain within, the lateral confines of the runway extended.

As the airplane crosses the runway threshold it should be:

- stabilized on approach 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 or crosswind components
- runway length available.

Mandatory Missed Approach

On all instrument approaches, where suitable visual reference has not been established and maintained, execute an immediate missed approach when:

- a navigation radio or flight instrument failure occurs which affects the ability to safely complete the approach
- the navigation instruments show significant disagreement
- on ILS final approach and either the localizer or glide slope indicator shows full deflection
- on a radar approach and radio communication is lost.

Landing Minima

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

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 Touchdown Zone Elevation (TDZE) or threshold elevation. Example: A DA(H) of 1,440’ (200’) is a DA of 1,440’ with a corresponding height above the touchdown zone of 200’.

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

Radio Altimeter

A Radio Altimeter (RA) is normally used to determine DH when a DA(H) is specified for Category II or Category III approaches. Procedures at airports with irregular terrain use a barometric 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.

Flap Configurations for Approach and Landing

During maneuvering for an approach, when the situation dictates an earlier than normal speed reduction, the use of flaps 10 with the gear up is acceptable.

Flap Setting for Landing

For normal landings, use flaps 15, 30, or flaps 40. Flaps 15 is normally limited to airports where approach climb performance is a factor. Flaps 30 provides better noise abatement and reduced flap wear/loads. When performance criteria are met, use flaps 40 to minimize landing speed, and landing distance, and provide additional aft body clearance from the runway compared to a flaps 30 landing.

Note: Runway length and condition must be taken into account when selecting a landing flap position.

Flap Extension

During flap extension, selection of the flaps to the next flap position should be made when approaching, and before decelerating below, the maneuver speed for the existing flap position. The flap extension speed schedule is based on a fixed speed for each flap setting for a range of gross weights and provides full maneuver capability or at least 45° of bank (30° of bank and 15° overshoot) to stick shaker at all weights.

Note: If the maneuver speed for the next flap setting is below VREF + wind additive, select the next flap position when approaching the VREF + wind additive speed. Maintain the VREF + wind additive speed rather slowing to the maneuver speed for the selected flap setting.

Flap Extension Schedule

Flap extension speeds are shown for airplanes with a Rudder Pressure Reducer (RPR) operating. If the RPR is not operating, refer to the DDG.

Current Flap Position	At Speed (knots)	Select Flaps	Command Speed for Selected Flaps
Up	210	1	190
1	190	5	170
5	170	10*	160
10*	160	15	150/VREF
15	150/VREF	25	140
25	140	30 or 40	(VREF 30 or VREF 40) + wind additives

* As needed.

Maneuver Margin

Flight profiles should be flown at, or slightly above, the recommended maneuver speed for the existing flap configuration. These speeds approximate maximum fuel economy and allow full maneuvering capability (30° bank with a 15° overshoot).

Full maneuver margin exists for all normal landing procedures whenever speed is at or above the maneuver speed for the current flap setting. Full maneuver margin exists with flaps 15 at VREF 30 + 5 knots or VREF 40 + 5 knots 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 additives to the VREF speeds. See the Command Speed section in chapter 1 for an explanation of wind additives.

Missed Approach Point

A Missed Approach Point (MAP) 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, the DA(H) in conjunction with the glide slope is used to determine the MAP. For non-ILS or G/S out approaches, the MAP may be determined by timing, DME or the middle marker.

Timing During Approaches

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.

Instrument Landing System

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.

Localizer

The MAP for a localizer approach is not the same as for the corresponding ILS approach. Normally the depiction on the approach chart indicates the ILS and not the localizer procedure. For most localizer approaches, the published MAP is the threshold of the runway. The common method of determining the MAP is by timing from the final approach fix, though other methods may be used such as DME or the middle marker.

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) before reaching the MAP. When the MAP is at or beyond the runway threshold, the airplane must reach MDA(H) before arrival at the MAP if a normal final approach is to be made.

Precision Approach Radar

The MAP for a Precision Approach Radar (PAR) approach 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.

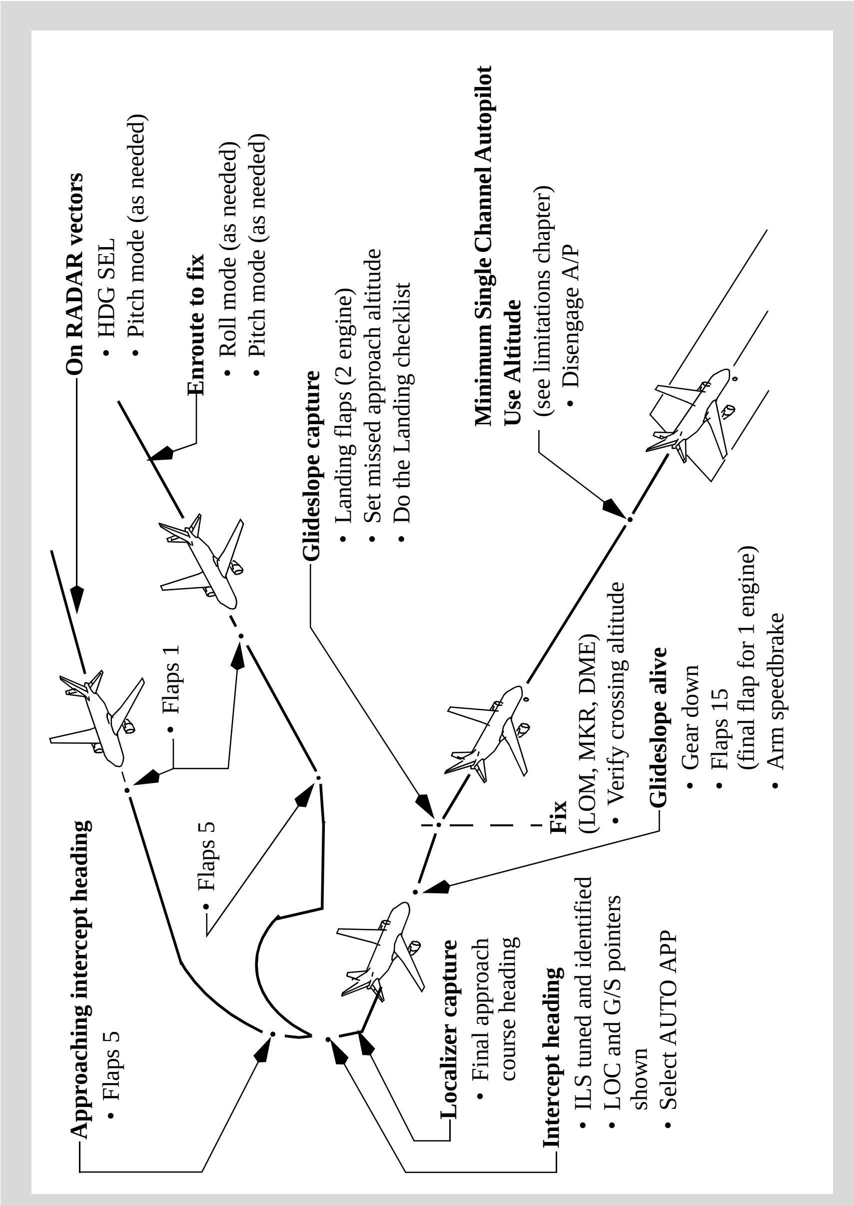
Airport Surveillance Radar

During an Airport Surveillance Radar (ASR) approach, the radar controller is required to discontinue approach guidance when the airplane is at the MAP or one NM from the runway, whichever is greater. Perform the missed approach when instructed by the controller.

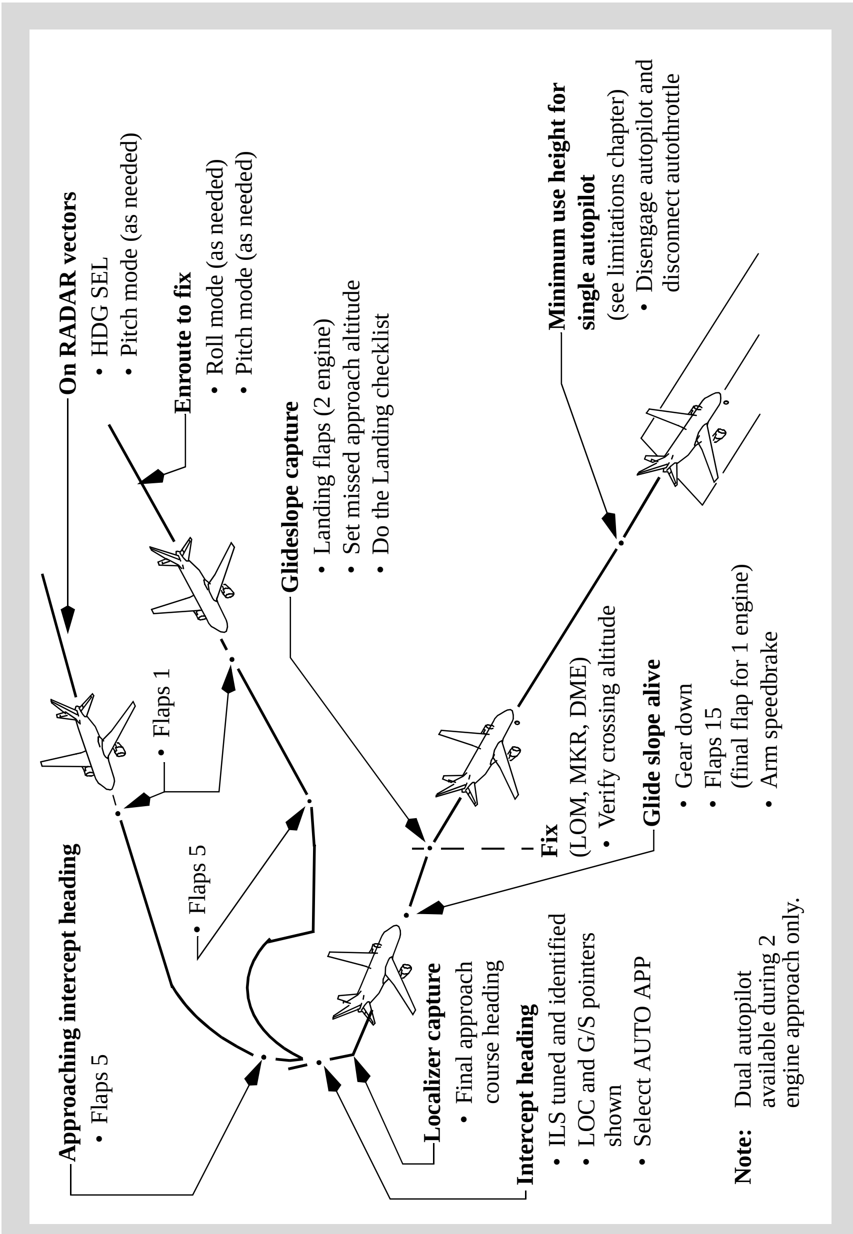
ILS Approach

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 flight pattern may be modified to suit local traffic and air traffic requirements.

ILS Approach Profile (SP-77)



ILS Approach Profile (SP-177)



Decision Altitude/Height - DA(H)

A Decision Altitude or Height is a specified altitude or height in an ILS or PAR 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. 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 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.

Procedure Turn and Initial Approach

Cross the procedure turn fix at flaps 5 maneuver airspeed.

Approach and Final Approach (SP-77 Autopilot)

Both pilots should not be “heads-down” during the approach.

Note: Before commencing the approach, applicable HSI/NAV switches (as installed) must be set so that the HSI for the pilot flying indicates ILS navigation signals.

The approach procedure may be flown using HDG SEL or VOR/LOC for lateral tracking and CWS Pitch for altitude changes.

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

A 45° intercept angle is optimum. Higher intercept angles and airspeeds may cause course overshoot. Approach mode should be selected prior to 5° of course centerline, otherwise the capture feature may not be able to capture the course correctly, resulting in undesirable overshoots.

Prior to selecting AUTO APP, the captain’s radio must be tuned to the primary approach facility. The remaining NAV radio may be used for determination of intersections and continued enroute navigation when necessary. Both should be tuned to the primary approach facility as soon as conditions permit.

AUTO 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. To avoid unwanted glide slope capture, LOC mode may be selected initially, followed by the APP mode.

Localizer capture occurs at approximately 2/5 dot for VOR and 2 dots for LOC. During LOC capture, bank limit is 32°. At capture the F/D and A/P annunciate VOR/LOC captured and G/S armed.

Note: Early capture of false localizer or glide slope signals is possible if AUTO APP is selected prematurely. Deselect AUTO APP mode and select Heading Select mode if this occurs.

When on intercept heading, select the AUTO APP mode and observe the VOR/LOC and G/S arm annunciations on the approach progress display. AUTO APP mode should not be selected until both the localizer and glide slope pointers appear on the ADI and you have received clearance for the approach.

The pilots should monitor the quality of the approach, including speedbrake deployment and autobrake (as installed) application.

After LOC capture, select a heading to match the approach course or missed approach heading. For normal localizer intercept angles, very little overshoot occurs. Bank angles up to 32° may be commanded during the capture maneuver. For large intercept angles some overshoot can be expected.

When the glide slope pointer begins to move (glide slope alive), extend the landing gear, select flaps 15, and decrease the speed to flaps 15 speed.

At glide slope capture, observe the approach progress display for correct modes. At this time, select landing flaps and VREF + wind additive (minimum VREF + 5), and complete the Landing checklist. The pilot monitoring 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 alert window. Extension of landing flaps at speeds in excess of flaps 15 speed may cause flap load relief activation (as installed) 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 verifying a normal pitch attitude and descent rate is 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. 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.

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

Approach (SP-177 Autopilot)

Both pilots should not be “heads-down” during the approach.

Note: Before to commencing the approach, applicable HSI/NAV switches (as installed) must be set so that the HSI for the pilot flying indicates ILS navigation signals.

The approach procedure may be flown using HDG SEL or VOR/LOC for lateral tracking and LVL CHG, or V/S for altitude changes. LVL CHG is the preferred descent mode for altitude changes greater than 1000 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 maneuver speed prior to localizer capture.

When operating in an autothrottle speed mode (MCP SPD), timely speed selection will 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.

A 45° intercept angle is optimum. Higher intercept angles and airspeeds may cause course overshoot. Approach mode should be established prior to 5° of course centerline, otherwise the capture feature may not be able to capture the course correctly, resulting in undesirable overshoots.

Prior to selecting APP, the VHF NAV radio on the same side as the A/P in use must be tuned to the primary approach facility. The remaining NAV radio may be used for determination of intersections and continued enroute navigation when necessary. Both should be tuned to the primary approach facility as soon as conditions permit.

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. To avoid unwanted glide slope capture, LOC mode may be selected initially, followed by the APP mode.

Localizer capture occurs at a variable point dependent on intercept angle, speed, LOC deviation, and rate, but never at less than 1/2 dot. During LOC capture, bank limit is 30° regardless of bank limit selection. At capture the following will occur:

- F/D and A/P annunciate VOR/LOC captured
- A/P STATUS annunciates SINGLE CH (as installed).

Note: Early capture of false localizer or glide slope signals is possible if APP is selected prematurely. Deselect APP mode by pressing the APP mode switch and select Heading Select mode if this occurs. If both LOC and G/S have captured, the A/P and F/Ds must be OFF to deselect APP.

When on intercept heading, select the APP mode and observe the VOR/LOC and G/S arm annunciations on the FMA. APP mode should not be selected until both the localizer and glide slope pointers appear on the ADI and you have received clearance for the approach.

When in the APP mode after LOC capture with the A/P in CWS or OFF and both F/D's ON, the captain's FMA is driven from the "A" FCC and the first officer's FMA is driven from the "B" FCC. In all other modes, both FMAs are driven from the master F/D.

The captain's F/D command bars are always driven from the "A" FCC. The first officer's F/D command bars are always driven from the "B" FCC. Both F/Ds should be on for the approach to provide F/D guidance in the event of a GA. The pilot flying should place his F/D switch ON first.

Final Approach (SP - 177 Autopilot)

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

Note: The APP mode should be selected, both autopilots engaged in CMD, and the airplane stabilized on localizer and glide path prior to descending below 800 feet RA.

After LOC capture, select a heading to match the approach course or missed approach heading. 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.

When the glide slope pointer begins to move (glide slope alive), extend the landing gear, select flaps 15, and decrease the speed to flaps 15 speed.

At glide slope capture, observe the FMAs for correct modes. At this time, select landing flaps and VREF + 5 knots or VREF + wind additive if landing manually, and complete the Landing checklist. When using the autothrottle to touchdown, no additional wind additive is required to the final approach speed. The pilot monitoring 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 15 speed may cause flap load relief activation (as installed) 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 verifying a normal pitch attitude and descent rate is 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. 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.

See Note in this section regarding false glide slope capture while Intercepting Glide Slope from Above.

Below 1,500 feet radio altitude, the flare mode is armed. The FLARE annunciation indicates the second autopilot is fully engaged. As the lowest weather minimums are directly related to the system status, both pilots must observe the FLARE annunciation.

Check that the A/P disengage warning light on each instrument panel is extinguished at 500 feet.

During an autoland with crosswind conditions, the airplane will touchdown in a crab. After touchdown, the rudder must be applied to maintain runway centerline. The autopilots must be disengaged immediately after touchdown. The control wheel should be turned into the wind as the autopilots are disengaged. The A/T disengages automatically two seconds after touchdown.

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

Intercepting Glide Slope from Above

Normally the ILS profile is depicted with the airplane intercepting the glide slope from below in a level flight attitude. However, there are occasions when flight crews are cleared for an ILS approach when they are above the G/S. In this case, there should be an attempt to capture the G/S prior to the FAF. The map display can be used to maintain awareness of distance to go to the final approach fix. The use of autopilot is also recommended.

Note: Before intercepting the G/S from above, the flight crew must ensure that the localizer is captured before descending below the cleared altitude or the FAF altitude.

Note: In some instances, when intercepting the G/S from well above a 3 degree G.S, a false G/S capture can result in an unexpected rapid pitch-up command which can lead to a rapid loss of airspeed.

For airplanes equipped with the SP-77 autopilot, the following technique will help the crew intercept the G/S safely and establish stabilized approach criteria by 1,000 feet AFE:

- select AUTO APP and verify that localizer capture has occurred (green VOR/LOC light illuminated)
- establish final landing configuration
- use CWS pitch to establish a sink rate of 1000 to 1500 fpm to achieve G/S capture (verify green GLIDE SLOPE light is illuminated) and be stabilized for the approach by 1000 feet AFE.

For airplanes equipped with the SP-177 autopilot, the following technique will help the crew intercept the G/S safely and establish stabilized approach criteria by 1,000 feet AFE:

- select APP on the MCP and verify that the G/S is armed
- establish final landing configuration and set the MCP altitude no lower than 1,000 feet AFE
- select the V/S mode and set -1000 to -1500 fpm to achieve G/S capture (verify green GS flight mode accunciations) and be stabilized for the approach by 1000 feet AFE. Use of the green altitude range arc may assist in establishing the correct rate of descent.

Monitor the rate of descent and airspeed to avoid exceeding flap placard speeds and flap load relief activation. After G/S capture monitor G/S deviation. After G/S capture, continue with normal procedures. Comply with the recommendations on the use of speedbrakes found in chapter 4 of this manual.

Note: If the G/S is not captured or the approach not stabilized by 1000 feet AFE, initiate a go-around. Because of G/S capture criteria, the G/S should be captured and stabilized approach criteria should be established by 1000 feet AFE, even in VMC conditions. See the section titled Stabilized Approach Recommendations earlier in this chapter for more information on stabilized approach criteria.

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 15 at flaps 15 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. Do the Landing checklist.

Decision Altitude/Height - DA(H)

The pilot monitoring 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, if any of the above requirements are not met, immediately execute the missed approach procedure. When visual contact with the runway is established, maintain the glide path to the flare. Do not descend below the glide path.

Raw Data - (No Flight Director)

Raw data approaches are normally used during training to improve the instrument scanflow. If a raw data approach is required during normal operations, refer to the DDG or airline equivalent for the possibility of increased landing minima.

ILS navigation signals are displayed on the ADI. Set the NAV switches so that ILS navigation signals are displayed on the HSI. Course deviation displays on the HSI indicate 2 dot deviation from the ILS center beam.

Use the HSI as the primary navigation instrument during a raw data ILS approach. Maneuvering the airplane to place the symbolic airplane on the center of the HSI will center the course deviation bar. The course deviation bar represents the ILS localizer after the front course is selected.

During initial course intercept, crosscheck the magnetic bearing information on the RMI or RDMI (as installed). As the course deviation bar starts to center, turn the airplane to keep the nose of the symbolic airplane pointed at the top of the course deviation bar. This technique will provide a smooth intercept and rollout on course. In a crosswind it will be necessary to adjust the heading into the wind. The drift angle pointer (as installed) on the HSI may be used to maintain the localizer.

Large bank angles will rarely be 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 15 and decelerate to flaps 15 speed. This may be done in steps, pausing at intermediate settings so that large trim changes are not required at once. 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 of the MCP. 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 good speed control during the glide slope intercept phase of the approach. The rate of descent will vary 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 (SP-77) or TO/GA (SP-177) is selected. Refer to Go–Around and Missed Approach - All Approaches, this chapter.

AFDS Autoland Capabilities (SP-177 Autopilot)

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

Note: For autoland use flaps 30 or 40.

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 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, vehicle and aircraft operation are restricted in these critical areas any time the weather is reported less than 800 foot ceiling and/or visibility is less than 2 statute miles.

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 statute miles visibility. As a result, ILS beam bends may occur because of vehicle or aircraft interference. Sudden and unexpected flight control movements may occur at a very low altitude or during the landing 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.

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 (SP-77), 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 may require (depending upon the criteria of the applicable regulatory authority) 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.

For airplanes equipped with the SP-177 autopilot, Category III operations using autoland systems typically reach a DH of 50 ft. when approaching the threshold. In this instance, criteria requires that the runway environment be clearly visible. If not, execute an immediate missed approach.

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 FCOM.

Transition to Manual Approach or Landing (SP-177)

A transition from an AFDS approach to a manual approach can be accomplished anytime during the ILS approach. However pilots should be aware that when performing a dual autopilot approach, the stabilizer is automatically trimmed an additional amount nose up below 400 feet RA. If the autopilots are subsequently disengaged, forward control column force may be required to hold the desired pitch attitude.

Note: If the autopilots are disengaged below 400 feet RA during a dual channel approach, be alert for a mistrim condition.

AFDS System Configuration

Appendix A.2.5

System requirements described in this section do not include all of the systems and equipment required for each type of operation. Reference the applicable AFM or operating regulations for specific systems and equipment needed for Category II and Category III operations.

More detailed information concerning Category II and Category III operational requirements can be found in FAA advisory circulars or similar documents from other regulatory agencies.

CAT II Operations

Category II approaches may be conducted using the autopilot, or flight director only, with two engines. Airplanes equipped the SP-177 may also use dual autopilots. For single autopilot operation, the autopilot must be disengaged no lower than the minimum altitude listed in the Limitations Chapter of the FCOM. The autothrottles should be disconnected when the autopilot is disengaged.

CAT III Operations (SP-177)

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 landing and be prepared to take over manually, if required.

AFDS Faults

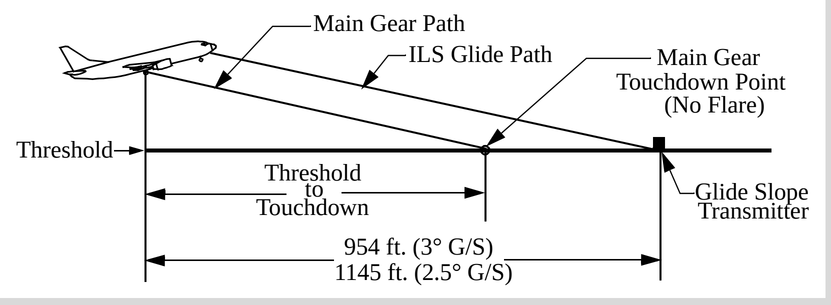
Appendix A.2.5

Faults can occur at any point during an AFDS approach. 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 Autopilot/Autothrottle indicators, Approach Progress Display or Flight Mode Annunciations (as installed) and master caution system.

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 knots 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.



737 Model	Flaps 30		Main Gear over Threshold		Threshold to Main Gear Touchdown Point - No Flare (feet)
	Glide Path (degrees)	Airplane Body Attitude (degrees)	Pilot Eye Height (feet)	Main Gear Height (feet)	
- 200	2.5	5.4	49	31	709
	3.0	4.9	49	31	590
- 200 Adv	2.5	4.4	49	32	728
	3.0	3.9	49	32	606

Non-Normal Operations

This section describes pilot techniques associated with engine inoperative ILS 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 single autopilot may be used. Weather minima for an ILS approach with one engine inoperative are specified in the applicable AFM and/or the operator's Operations Specification or equivalent.

Note: For airplanes equipped with the SP-177 autopilot, the airplane has been demonstrated to meet the criteria for flight director or single autopilot operation to Category I minimums with an engine initially inoperative if the airplane is trimmed for the condition. The use of dual autopilots with an engine inoperative is not authorized.

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 during the entire approach. A centered control wheel indicates proper trim.

Note: For airplanes equipped with the SP-177 autopilot, 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 15, set final approach speed, and decelerate.

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

Engine Inoperative, Rudder Trim - All Instrument Approaches

The pilot must use rudder pedal pressure to control yaw, followed by rudder trim to maintain an in-trim condition during all approaches. Manually centering the rudder trim prior to thrust reduction for landing is normally unnecessary.

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 PM 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.

It may not be advisable to center the rudder trim due to crew workload and the possibility of a missed approach. 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, the decision to continue the approach or execute a go-around should be made immediately. If the approach is continued, retract the flaps to 15 and adjust thrust on the operating engine. Speed should be increased to 15 knots over the previously set flaps 30 or 40 VREF. This sets a command speed that is equal to at least VREF for flaps 15. Wind additives should be added as needed, if time and conditions permit.

If a go-around is required, follow the Go-Around and Missed Approach procedures except use flaps 15 initially if trailing edge flaps are at 30 or 40. Subsequent flap retraction should be made at a safe altitude and in level flight or a shallow climb.

Non - ILS Instrument Approaches

Non-ILS approaches are defined as:

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

Non-ILS approaches are normally flown using the CWS pitch mode (SP-77) or the V/S pitch mode (SP-177). The use of LVL CHG is not recommended after the FAF. Recommended roll modes are provided in the applicable FCOM 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-ILS approaches and landings. Many of these could have been prevented by the use of Constant Descent Final Approach (CDFA) methods. Traditional methods of flying non-ILS approaches involve use of CWS pitch mode (SP-77) or setting a vertical speed on final approach (SP-177), 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 CDFA. These methods provide a constant angle approach, which reduces exposure to crew error and CFIT accidents. These methods also make it much easier for the crew to achieve a stabilized approach to a landing once suitable visual reference to the runway environment has been established.

A typical Non - ILS Instrument Approach as illustrated, assumes all preparations for the approach; such as review of the approach procedure and setting of minima and radio tuning have been completed. The procedures illustrated focus generally on crew actions and avionics systems information. The flight pattern may be modified to suit local traffic and air traffic requirements.

The following discussions assume a straight-in instrument approach is being flown. For airplanes equipped with a SP-77 autopilot system, a circling approach may be flown following an instrument approach using CWS pitch mode provided the altitude alert controller is set in accordance with the circling approach procedure. For airplanes equipped with a SP-177 autopilot system, a circling approach may be flown following an instrument approach using V/S provided the MCP altitude is set in accordance with the circling approach procedure.

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 and does not take advantage of the 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: The autopilot should remain engaged until suitable visual reference has been established.

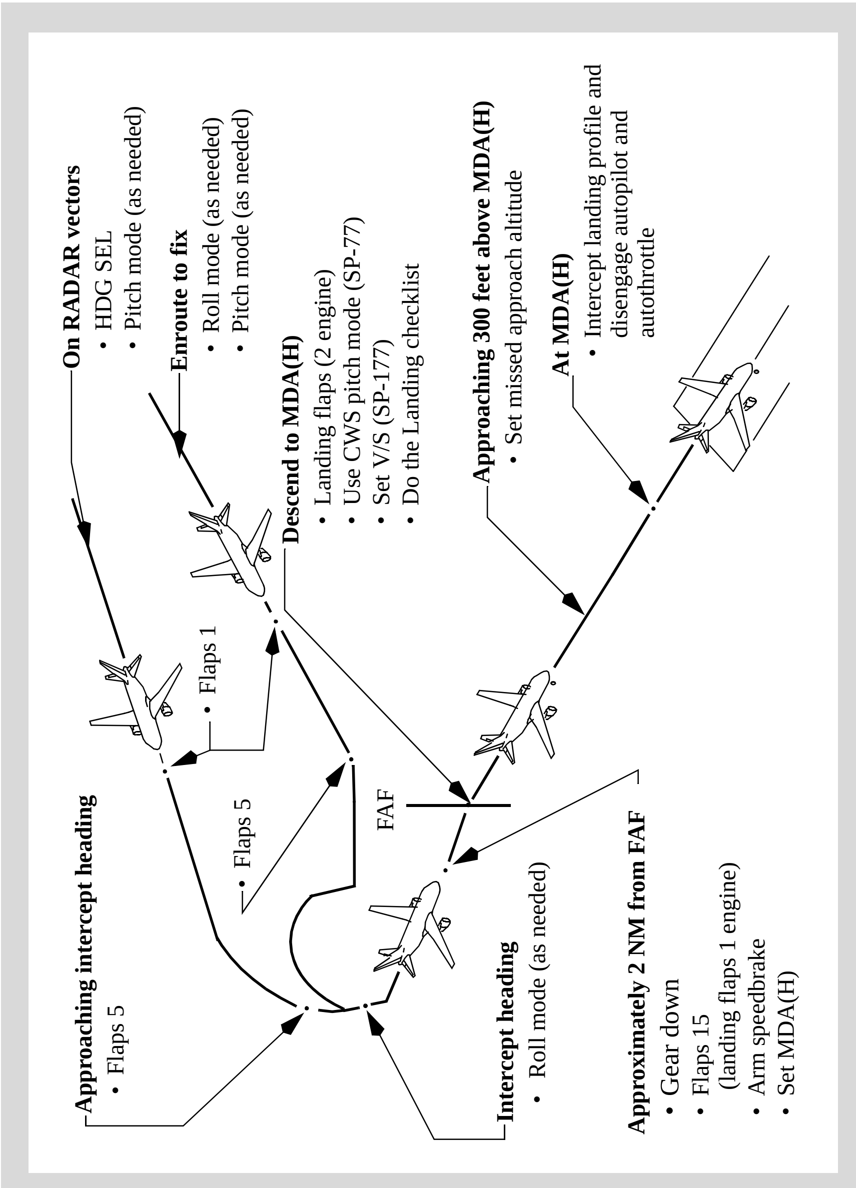
Raw Data Monitoring Requirements

Raw data monitoring is required for all instrument approaches.

Non - ILS Approach - One Engine Inoperative

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

Non-ILS Instrument Approach



Approach Preparations

Tune and identify appropriate navaids. Use MDA(H) for the approach minimum altitude. When using an MDA(H), the crew may wish to set the barometric minimums selector at MDA(H) + 50 feet. Initiating a missed approach approximately 50 feet above the MDA(H) may be necessary to avoid descending below the MDA(H) during the missed approach. This technique is an acceptable means of complying with the MDA(H) during constant angle non-ILS approaches where a level off at MDA(H) is not planned.

Procedure Turn and Initial Approach

Cross the procedure turn fix at flaps 5 and flaps 5 maneuver airspeed.

Final Approach

Approaching intercept heading, select flaps 5. When established on an intercept heading, select appropriate roll mode. Approaching the FAF (approximately 2 NM), set the altitude alert controller (SP-77) or the MCP altitude window (SP-177) to the first intermediate altitude constraint, or MDA + 50 feet if no altitude constraint exists. Select gear down, flaps 15, arm the speedbrake and adjust speed.

Note: If desired altitude is not at an even 100 foot increment, set the altitude alert controller (SP-77) or the MCP altitude window (SP-177) to the nearest 100 foot increment above the altitude constraint or MDA(H).

When initiating descent to MDA(H), select landing flaps, slow to final approach speed and do 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 FCOM procedure.

At or after the FAF, use CWS pitch mode (SP-77) or V/S mode (SP-177) 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.

A technique that may be used to achieve a constant angle path that arrives at MDA(H) at or near the VDP is to use 300 feet per mile for a 3° path. Determine the desired HAA which corresponds to the distance in NM from the runway end using the following table. The PM 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. There should be no level flight segment at minimums.

	Distance Remaining to the Runway (NM)									
	10	9	8	7	6	5	4	3	2	1
HAT (ft.)	3000	2700	2400	2100	1800	1500	1200	900	600	300

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.

For airplanes equipped with the SP-77 autopilot, approximately 300 feet above the MDA(H), select the missed approach altitude. Leaving the MDA(H), be prepared to disengage the autopilot in accordance with regulatory requirements. Disengage the autopilot and complete the landing.

For airplanes equipped with the SP-177 autopilot, approximately 300 feet above the MDA(H), select the missed approach altitude. Leaving the MDA(H), be prepared to disengage the autopilot in accordance with regulatory requirements. Disconnect the autothrottle when disengaging the autopilot. Turn both F/Ds OFF, then place both F/Ds ON. This eliminates unwanted commands for both pilots and allows F/D guidance in the event of a go-around. Complete the landing.

Minimum Descent Altitude/Height (MDA(H))

The pilot monitoring 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.

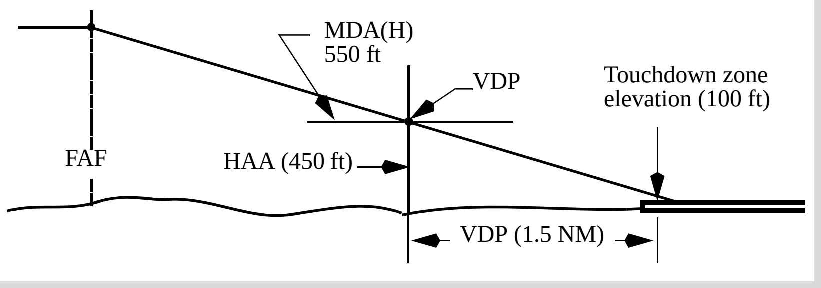
When suitable visual reference is established, maintain the descent path to the flare. Do not descend below the visual glide path.

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.



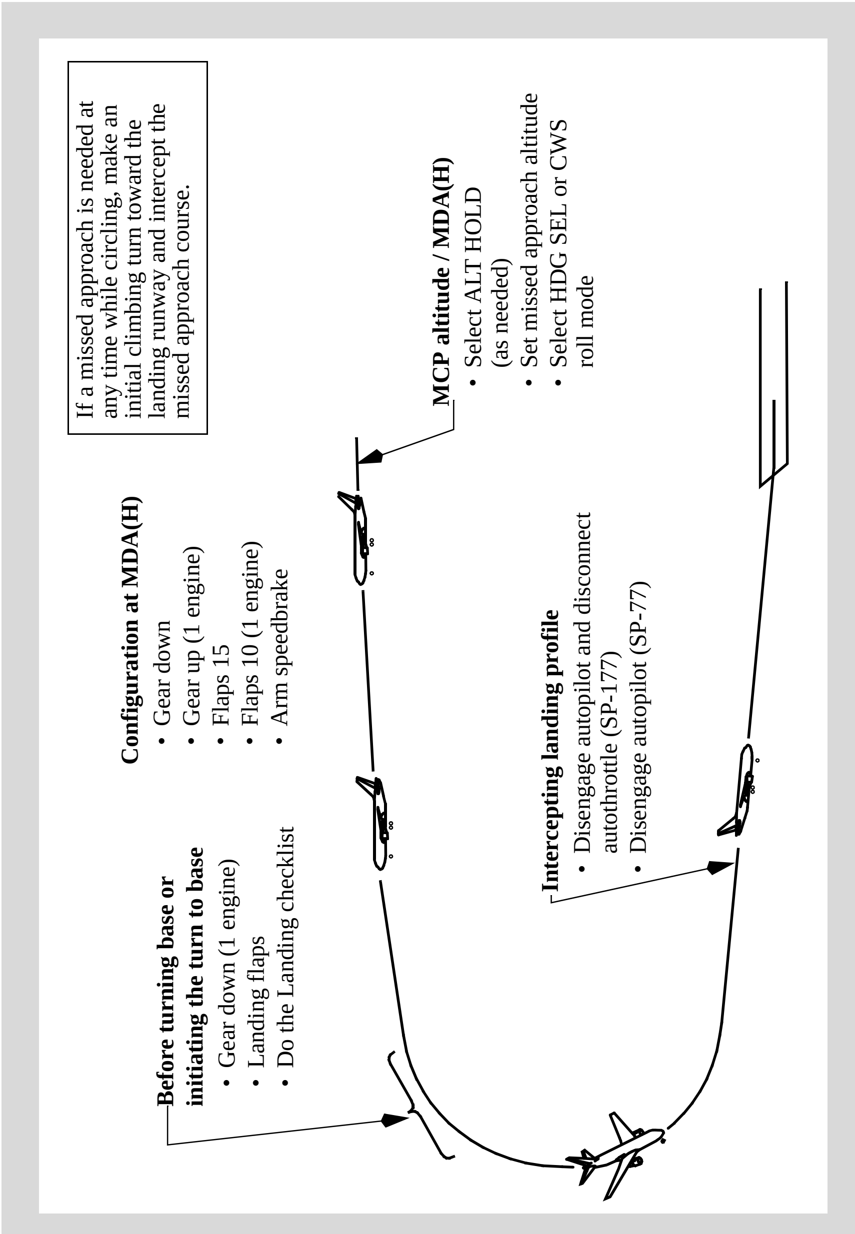
Most VDPs are between 1 and 2 NM from the runway. The following table provides more examples.

HAA (feet)	300	400	450	500	600	700
VDP Distance, NM	1.0	1.3	1.5	1.7	2.0	2.3

Missed Approach - Non-ILS

Refer to Go-Around and Missed Approach - All Approaches, this chapter.

Circling Approach



Circling Approach - General

The circling approach should be flown with landing gear down, flaps 15, and at flaps 15 maneuver speed. Use the weather minima associated with the anticipated circling speed.

The circling approach may be flown following any instrument approach procedure. During the instrument approach, use the V/S mode to descend to the circling MDA(H). Use of the Auto Approach mode (SP-77) or APP mode (SP-177) for descent to a circling approach is not recommended for several reasons:

- the autopilot does not level off at the altitude set in the altitude alert controller (SP-77) or MCP altitude window (SP-177)
- exiting the Auto Approach mode (SP-77) or APP mode (SP-177) requires initiating a go-around or disconnecting the autopilot and turning off the flight directors.

Maintain MDA(H) using ALT HOLD mode (SP-77) or using MCP altitude ALT HOLD mode (SP-177). Use HDG SEL or CWS roll mode for the maneuvering portion of the circling approach. If circling from an ILS approach, fly the ILS in VOR/LOC and CWS pitch (SP-77) or V/S (SP-177) modes.

Note: If the MDA does not end in “00”, set the altitude alert controller (SP-77) or the MCP altitude (SP-177) to the nearest 100 feet above the MDA(H) and circle at MCP altitude.

When in altitude hold (SP-77) or altitude hold at MCP altitude (SP-177) at MDA(H) and before commencing the circling maneuver, set the missed approach altitude.

Before turning base or when initiating the turn to base leg, select landing flaps and begin decelerating to the approach speed plus wind additive. 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. Do the landing checklist. Do not descend below MDA(H) until intercepting the visual profile to the landing runway.

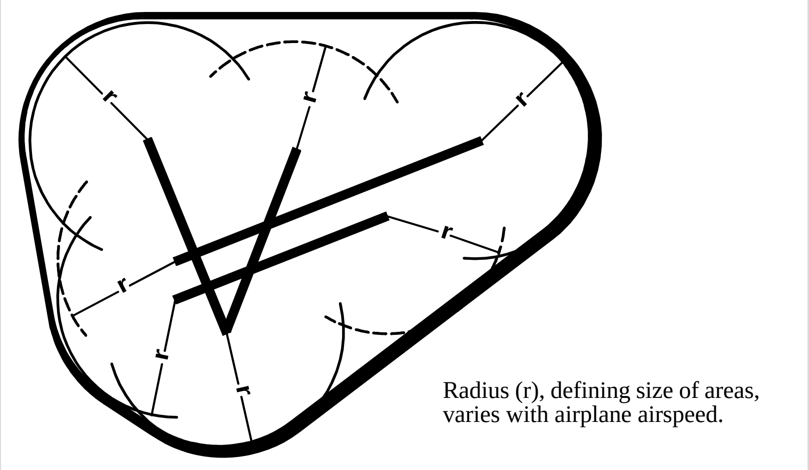
For airplanes equipped with the SP-77 autopilot, leaving the MDA(H), disengage the autopilot and turn both F/Ds OFF.

For airplanes equipped with the SP-177 autopilot, when intercepting the visual profile, disengage the autopilot, disconnect the autothrottle and continue the approach manually. At this point in the approach, the pilot's attention should be focused on flying the visual profile rather than attempting to set the MCP to allow continued use of the autopilot. After intercepting the visual profile, cycle both F/D to OFF, then to ON. This eliminates unwanted commands for both pilots and allows F/D guidance in the event of a go-around. Complete the landing.

Note: For airplanes equipped with the SP-177 autopilot, if a go-around is selected with either flight director switch in the OFF position, the flight director pitch or roll command bar on the corresponding side will 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 the maximum IAS during the circling approach and are depicted in the table following the figure.



FAA	
Maximum IAS	**Circling Area Radius (r) from Threshold**
140 Kts	1.7 NM
165 Kts	2.3 NM

ICAO	
Maximum IAS	**Circling Area Radius (r) from Threshold**
180 Kts	4.2 NM
205 Kts	5.28 NM

Note: 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.

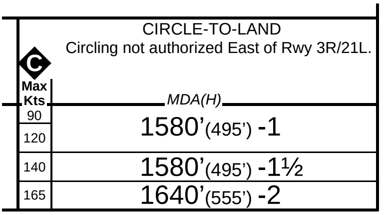
FAA Expanded Circling Maneuvering Airspace Radius

The FAA has modified the criteria for circling approach areas via TERPS. Circling approach areas for approach procedures developed beginning in 2013 use the radius distances (in NM) as depicted in the following table. These distances, dependent on aircraft category, are also based on the circling altitude which accounts for the true airspeed increase with altitude.

Circling MDA in feet MSL	Circling Area Radius (r) from Threshold (NM)	
	Cat C Max 140 KIAS	**Cat D Max 165 KIAS**
1,000 or less	2.7	3.6
1,001 to 3,000	2.8	3.7
3,001 to 5,000	2.9	3.8
5,001 to 7,000	3.0	4.0
7,001 to 9,000	3.2	4.2
9,000 and above	3.3	4.4

Effect on Charts

Charts where the new criteria have been applied can be identified by the "Inverse C" icon in the CIRCLE-TO-LAND minima box as shown in the following table.



It will take the FAA a number of years to update existing instrument approaches to the new criteria and apply the larger circling area dimensions. Circling minima not identified by the "Inverse C" icon continue to use the older circling area dimensions defined by the smaller radii. On these approaches, pilots must ensure that they do not base their circling maneuver on the larger airspace afforded by the new TERPS criteria and risk exceeding the circling protected airspace during the circling maneuver.

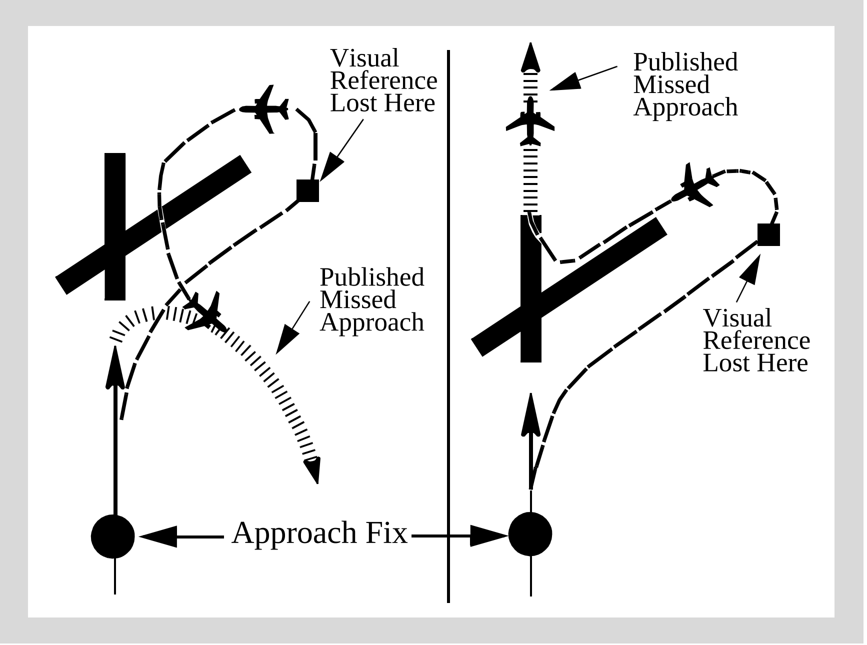
Circling Approach - One Engine Inoperative

If a circling approach is anticipated, maintain gear up, flaps 10, and flaps 10 maneuver speed from the final approach fix until just before turning base. As an option, use flaps 5, and flaps 5 maneuver speed as the approach flaps setting for the circling approach. Before turning base or when initiating the turn to base leg, select gear down and flaps 15 and begin reducing speed to VREF 15 + wind additive. Do not descend below MDA until intercepting the visual profile.

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. Continue the turn until established on an intercept heading to the missed approach course corresponding to the instrument approach procedure just flown. Maintain the missed approach flap setting until close-in maneuvering is completed.

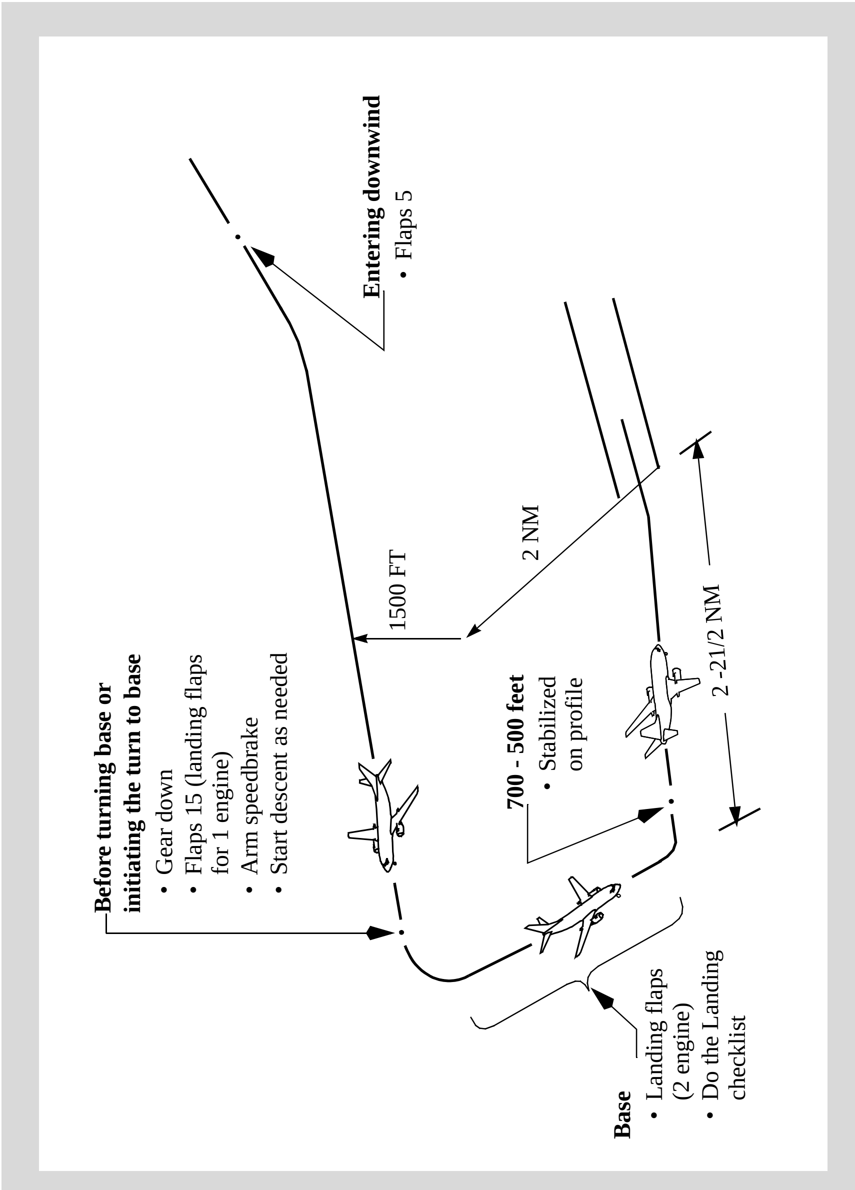
Different patterns may be required to become established on the prescribed missed approach course. This depends on airplane position at the time the missed approach is started. The following figure illustrates the maneuvering that may be required. This ensures the airplane remains within the circling 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 1/2° 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 1,500 feet above the runway elevation and enter downwind with flaps 5 at flaps 5 maneuver speed. Maintain a track parallel to the landing runway approximately 2 NM abeam.

Before turning base or initiating the turn to base, extend the landing gear, select flaps 15, arm the speedbrake, and slow to flaps 15 maneuver speed or approach speed plus wind additive if landing at flaps 15. If the approach pattern must be extended, delay lowering gear and selecting flaps 15 until approaching the normal visual approach profile. Turning base leg, adjust thrust as required while descending at approximately 600-700 fpm.

Extend landing flaps before turning final. Allow the speed to decrease to the proper final approach speed and trim the airplane. Do the Landing checklist. When established in the landing configuration, maneuvering to final approach may be accomplished at final approach speed (VREF plus wind additive).

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 AFE for each NM 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.

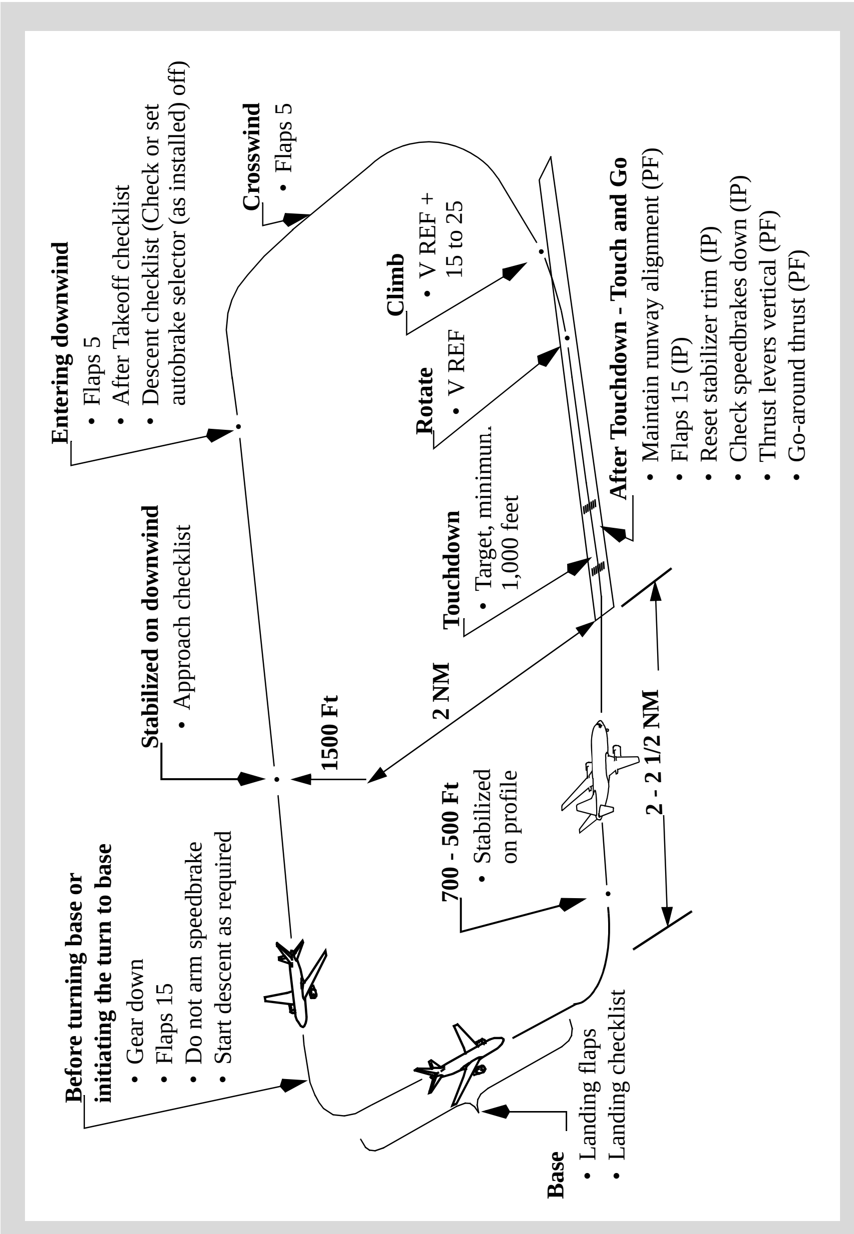
With one engine inoperative, the rudder trim may be centered before landing. This allows most of the rudder pedal pressure to be removed when the thrust of the operating engine is retarded to idle at touchdown.

Full rudder authority and rudder pedal steering capability are not affected by rudder trim. 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 (as installed) OFF.

Landing

The trainee should do a normal final approach and landing. After touchdown, the instructor selects flaps 15, 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 15 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 configuration warning horn may sound momentarily if the flaps have not retracted to flaps 15 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 before initiating the takeoff, do the following:

- set takeoff flaps
- trim the stabilizer for takeoff
- place speedbrake lever in the down detent
- place autobrake to RTO (as installed)

- check the rudder trim
- set airspeed bugs for the flap setting to be used.

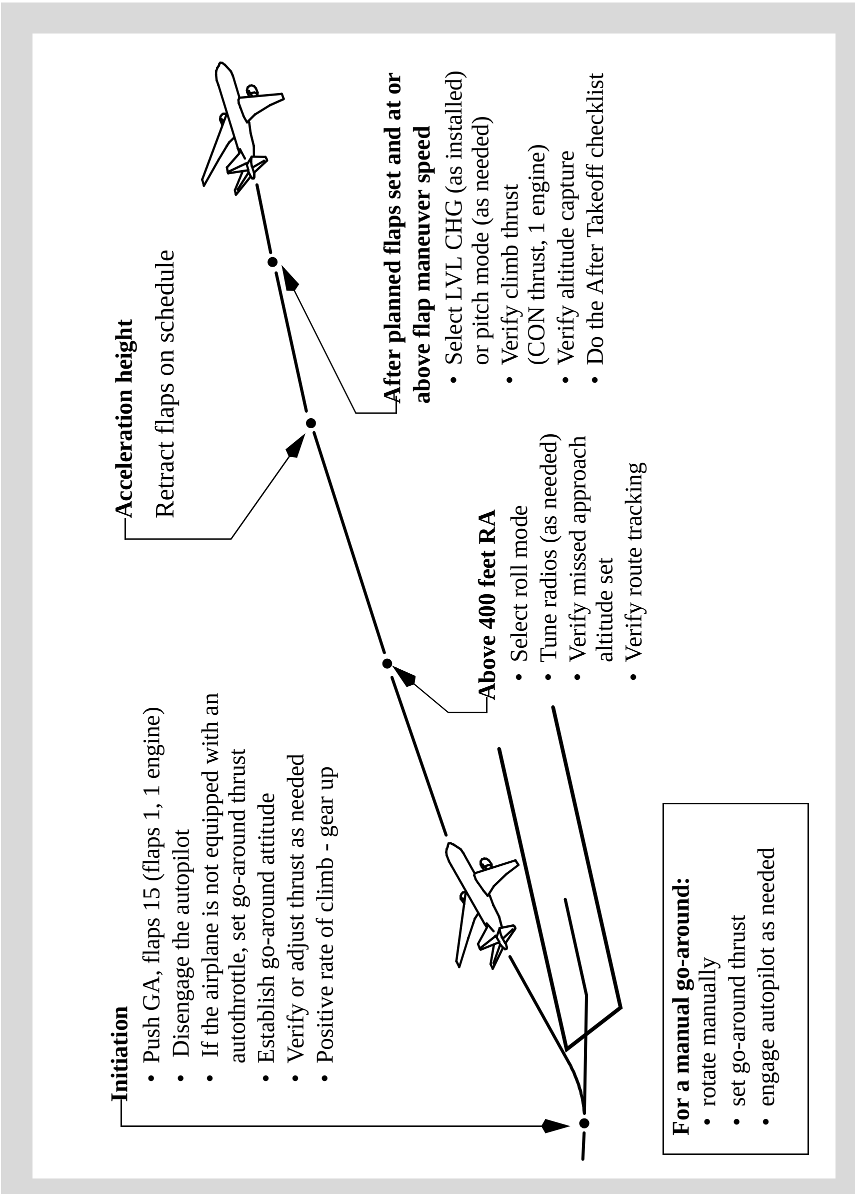
Perform a normal takeoff.

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.

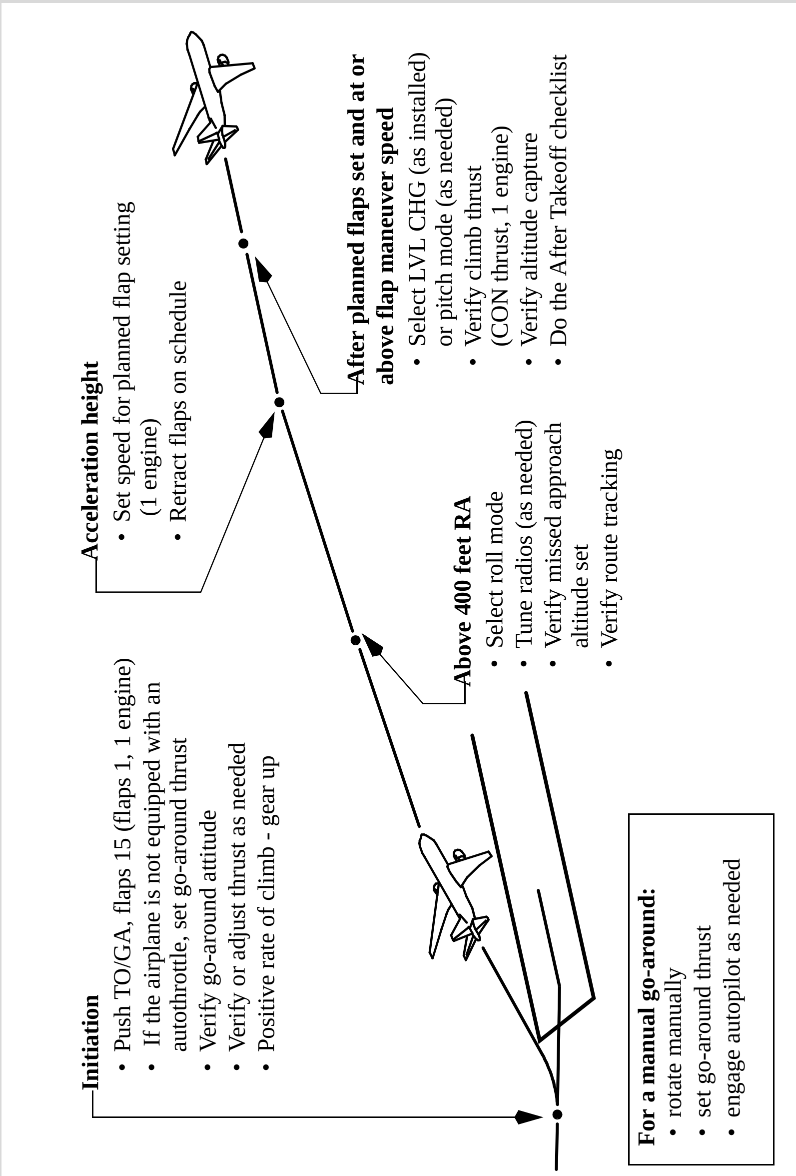
Note: Flying the pattern with the gear extended assists in brake cooling.

Go–Around and Missed Approach - All Approaches

Go-Around and Missed Approach Profile - SP-77 Autopilot



Go-Around and Missed Approach Profile - SP-177 Autopilot



Go–Around and Missed Approach - All Engines Operating

The go-around and missed approach is generally performed in the same manner whether an instrument or visual approach was flown. The go-around and missed approach is flown using the Go-Around and Missed Approach procedure described in the FCOM. The discussion in this section supplements those procedures.

For airplanes equipped with the SP-77 autopilot, if a missed approach is required fly manually or use CWS. When initiating the missed approach, press either GA switch, call for flaps 15, set go-around thrust, and rotate smoothly towards 15° pitch attitude. Then follow flight director commands and retract the landing gear after a positive rate of climb is indicated on the altimeter. Readjust pitch as necessary for the continuation of the go-around.

Note: For airplanes equipped with the SP-77 autopilot, following a non-ILS approach, flight director commands are available only when GA is manually selected on the flight director mode selector.

For airplanes equipped with the SP-177 autopilot, if a missed approach is required following a dual autopilot approach with FLARE arm annunciated, leave the autopilots engaged. Push either TO/GA switch, call for flaps 15, 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. For some airplanes equipped with the SP-177 autopilot, pressing either TO/GA switch once commands full go-around EPR limit. For other airplanes equipped with the SP-177 autopilot, pressing either TO/GA switch once commands thrust sufficient for a 2,000 fpm climb rate. After reaching reduced go-around thrust, pressing either TO/GA switch a second time commands full go-around ERP limit.

For airplanes equipped with the SP-177 autopilot, if a missed approach is required following a single autopilot or manual instrument approach, or a visual approach, push either TO/GA switch, call for flaps 15, ensure/set go-around thrust, and rotate smoothly toward 15° pitch attitude. Follow flight director commands and retract the landing gear after a positive rate of climb is indicated on the altimeter.

Note: When performing a normal approach using flaps 15 for landing, if a go-around is required use flaps 15 for go-around. Authorized operators with appropriate performance data available, use flaps 1 for go-around if required for performance. When using flaps 1 for go-around, limit bank angle to 15° when airspeed is less than VREF 15 + 15 knots.

For airplanes equipped with the SP-177 autopilot, 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.

For airplanes equipped with the SP-77 autopilot, the GA pitch mode commands a fixed go-around attitude of 14°. The GA roll mode commands wings level. Above 400 feet AGL, select a roll mode as appropriate.

For airplanes equipped with the SP-177 autopilot, the TO/GA pitch mode initially commands a go-around attitude and then transitions to speed as the rate of climb increases. Command speed automatically moves to a target airspeed for the existing flap position. The TO/GA roll mode commands wings level. 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 acceleration for flap retraction.

Note: For airplanes equipped with the SP-177 autopilot, pitch and roll modes cannot be engaged until above 400 feet AGL.

Note: For airplanes equipped with the SP-177 autopilot, when accomplishing a missed approach from a dual-autopilot approach, initial selection of a 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, do the missed approach procedure through gear up before initiating the turn. Delay further flap retraction until initial maneuvering is complete and a safe altitude and appropriate speed are attained.

For airplanes equipped with the SP-177 autopilot, command speed automatically increases to maneuver speed for the existing flap position. Retract flaps on the normal flap/speed schedule. When the flaps are retracted and the airspeed approaches maneuver speed, select LVL CHG and ensure climb thrust is set. Verify the airplane levels off at selected altitude and proper speed is maintained.

Low Altitude Level Off - Low Gross Weight

When accomplishing a low altitude level off following a go-around at a low gross weight, the crew should consider the following factors:

- if full go-around thrust is used, altitude capture can occur just after the go-around is initiated due to the proximity of the level off altitude and the high climb rate of the airplane
- the autopilot control laws limit F/D and autopilot pitch commands for passenger comfort
- there may not be enough altitude below the intended level off altitude to complete the normal capture profile and an overshoot may occur unless crew action is taken.

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

- if full go-around thrust is used, reduce to climb thrust earlier than normal
- disconnect the autopilot and complete the level off manually if there is a possibility of an overshoot
- for airplanes equipped with the SP-177 autopilot:
  - use the autothrottle
  - on some airplanes, pressing either TO/GA switch once commands full go-around EPR limit
  - on some airplanes, pressing either TO/GA switch once commands thrust sufficient for a 2,000 fpm climb rate. After reaching reduced go-around thrust, pressing either TO/GA switch signals the A/T to advance to full go-around ERP limit
  - if the autothrottle is not available, be prepared to use manual thrust control as needed to manage speed and prevent flap overspeed.

Go-Around after Touchdown

If a go-around is initiated before touchdown and touchdown occurs, continue with normal go-around procedures.

If a go-around is initiated after touchdown but before thrust reverser selection, auto speedbrakes retract and autobrakes disarm as thrust levers are advanced.

Once reverse thrust is initiated following touchdown, 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.

For airplanes equipped with the SP-177 autopilot, if a go-around is initiated before touchdown and touchdown occurs, the F/D go-around mode will continue to provide go-around guidance commands throughout the maneuver. If a go-around is initiated after touchdown, the F/D go-around mode will not be available until go-around is selected after becoming airborne.

Go–Around and Missed Approach - One Engine Inoperative

If a missed approach is accomplished from a flaps 15 approach, use flaps 1 for the go-around flap setting. 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 airplanes equipped with the SP-77 autopilot, the initial pitch attitude is 12° to 13°. The command airspeed bug should remain at the final approach speed until a safe height is attained. Accelerate to flap retraction speed. Retract flaps at flaps 1 maneuver speed. When the flaps are up and the airspeed is flaps up maneuver speed, select maximum continuous thrust. At level off altitude manually reduce thrust to control speed.

For airplanes equipped with the SP-177 autopilot, after TO/GA is engaged, the AFDS initially commands a go-around attitude, then transitions to maintain command speed as the rate of climb increases. The MCP command airspeed bug should remain at the final approach speed until a safe height is attained. Accelerate to flap retraction speed by repositioning the MCP command airspeed bug to flaps up maneuver speed. Retract flaps at flaps 1 maneuver speed. When the flaps are up and the airspeed is flaps up maneuver speed, select LVL CHG and maximum continuous thrust. At level off altitude manually reduce thrust to control speed.

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.

Engine Failure During Go–Around and Missed Approach

If an engine fails during go-around, perform normal Go-Around and Missed Approach procedures. Verify maximum go-around thrust is set. Maintain flaps 15, VREF 30 or 40 + wind additive (5 knots minimum) speed and limit bank angle to 15° until initial maneuvering is complete and a safe altitude is reached.

For airplanes equipped with the SP-77 autopilot, accelerate to flap retraction speed by adjusting pitch. Retract flaps on the normal flap/speed schedule.

For airplanes equipped with the SP-177 autopilot, accelerate to flap retraction speed by positioning the command speed to the maneuver speed for the desired flap setting and adjusting pitch. Retract flaps on the normal flap/speed schedule.

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.

Visual Approach Slope Indicator (VASI/T - VASI)

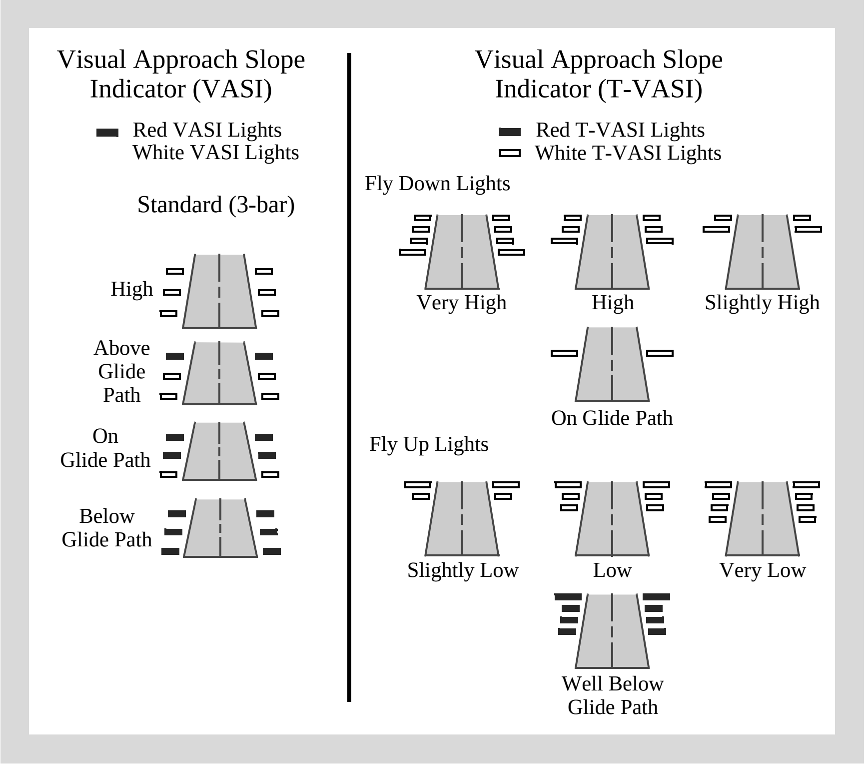
The VASI is a system of lights arranged to provide visual descent guidance information during the approach. All VASI systems are visual projections of the approach path normally aligned to intersect the runway at a point 1,000 or 1,800 feet beyond the threshold. Flying the VASI glide slope to touchdown is the same as selecting a visual aim point on the runway adjacent to the VASI installation.

When using a two-bar VASI, the difference between the eye reference path and the gear path results in a normal approach and threshold height. It provides useful information in alerting the crew to low profile situations.

Some airports have three-bar VASI which provides two visual glide paths. The additional light bar is located upwind from a standard two-bar installation. When the airplane is on the glide path, the pilot sees the one white bar and two red bars. Three-bar VASI may be safely used with respect to threshold height, but may result in landing further down the runway.

For a T-VASI, flying the approach with one additional white fly down light visible provides additional wheel clearance.

Three Bar VASI/T - VASI



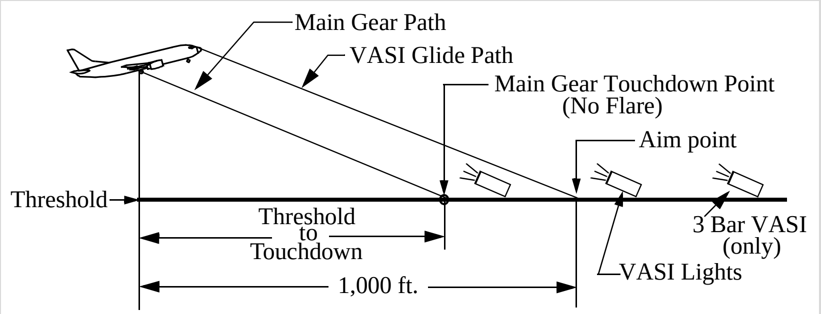
VASI Landing Geometry

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.

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 and Flaps 40, VREF (for the flap setting used) + 5 knots and should be reduced by 1° for each 5 knots above this speed.
- pilot eye height is measured when the main gear is over the threshold.



737 Model	Flaps 30		Main Gear over Threshold		Threshold to Main Gear Touchdown Point - No Flare (feet)
	Visual Glide Path (degrees)	Airplane Body Attitude (degrees)	Pilot Eye Height (feet)	Main Gear Height (feet)	
-200	3.0	4.9	50	35	660
-200 Adv	3.0	3.9	50	35	673

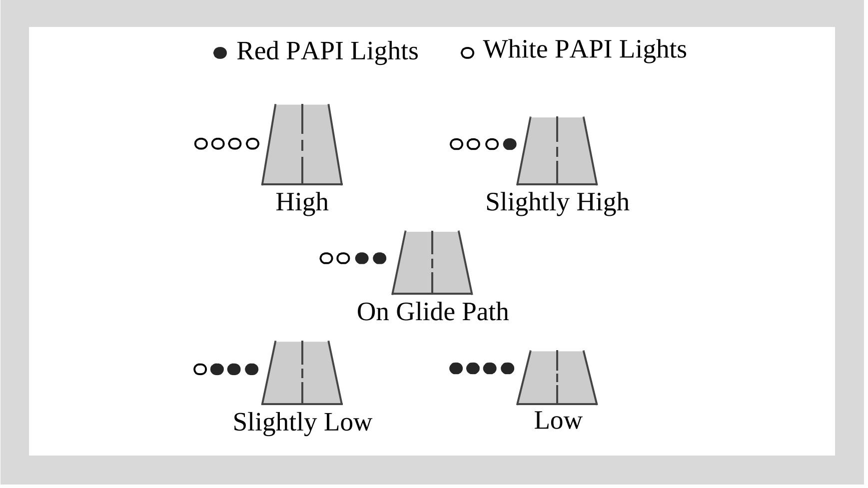
737 Model	Flaps 40		Main Gear over Threshold		Threshold to Main Gear Touchdown Point - No Flare (feet)
	Visual Glide Path (degrees)	Airplane Body Attitude (degrees)	Pilot Eye Height (feet)	Main Gear Height (feet)	
-200	3.0	2.3	50	36	693
-200 Adv	3.0	1.7	50	37	700

Precision Approach Path Indicator

The Precision Approach Path Indicator (PAPI) uses lights which are normally on the left side of the runway. They are similar to the VASI, but are installed in a single row of light units.

When the 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 beyond the threshold.

PAPI Landing Geometry



Landing Geometry

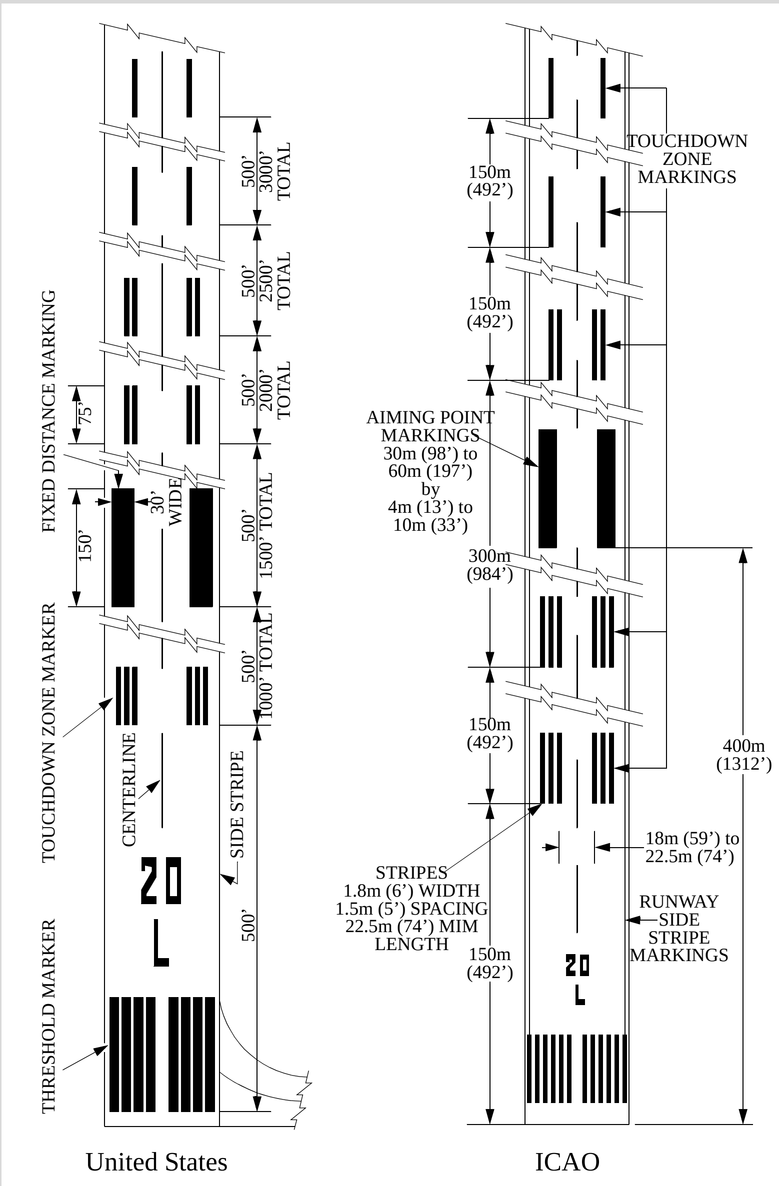
Visual Aim Point

During visual approaches many techniques and methods are used to ensure main landing gear touchdown at the desired point on the runway. One of the most common methods used is to aim at the desired gear touchdown point on the runway, then adjust the final approach glide path until the selected point appears stationary in relation to the airplane (the point does not move up or down in the pilot's field of view during the approach).

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.

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. The radio altimeter should be used to assist the pilot in judging terrain clearance, threshold height and flare initiation height

Flare and Touchdown

The techniques discussed here are applicable to all landings including one engine inoperative landings, crosswind landings and landings on slippery runways. Unless an unexpected or sudden event occurs, such as windshear or collision avoidance situation, it is not appropriate to use sudden, violent or abrupt control inputs during landing. Begin with a stabilized approach on speed, in trim and on glide path.

Note: When a manual landing is planned from an approach with the autopilot connected, the transition to manual flight should be planned early enough to allow the pilot time to establish airplane control before beginning the flare. The PF should consider disengaging the autopilot and disconnecting the autothrottle 1 to 2 NM before the threshold, or approximately 300 to 600 feet above field elevation.

When the threshold passes under the 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. A smooth thrust 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. Ideally, main gear touchdown should occur simultaneously with thrust levers reaching idle.

Avoid rapid control column movements during the flare. If the flare is too abrupt and thrust is excessive near touchdown, the airplane tends to float in ground effect. Do not allow the airplane to float or attempt to hold it off. Fly the airplane onto the runway at the desired touchdown point and at the desired airspeed.

Note: Do not trim during the flare. Trimming in the flare increases the possibility of a tailstrike.

Prolonged flare increases airplane pitch attitude 2° to 3°. When prolonged flare is coupled with a misjudged height above the runway, a tail strike is possible. Do not prolong the flare in an attempt to achieve a perfectly smooth touchdown. A smooth touchdown is not the criterion for a safe landing.

Typically, the pitch attitude increases slightly during the actual landing, but avoid over-rotating. Do not increase the pitch attitude, trim, or hold the nose wheel off the runway after landing. This could lead to a tail strike.

Airspeed Control

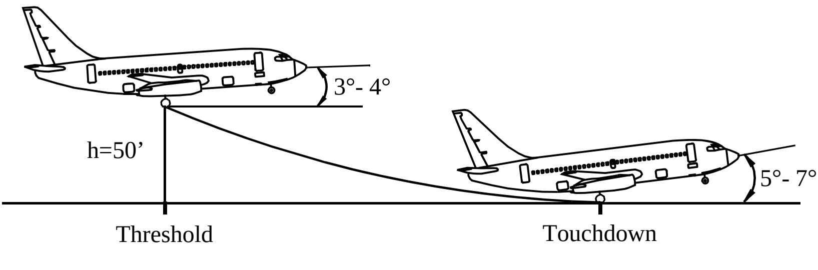
For airplanes equipped with the SP-177 autopilot, during an autoland, the autothrottle retards the thrust so as to reach idle at touchdown. The 5 knot additive is bled off during the flare.

If the autothrottle (as installed) is disconnected, or is planned to be disconnected prior to landing, maintain VREF plus the wind additive until approaching the flare. The steady headwind additive is bled off before touchdown while the gust correction is maintained to touchdown. Plan to touchdown at VREF plus the gust correction. With proper airspeed control and thrust management, touchdown should occur at no less than VREF - 5 knots.

Landing Flare Profile

The following diagram uses these conditions:

- 3° approach glide path
- flare distance is approximately 1,000 to 2,000 feet beyond the threshold
- typical landing flare times range from 4 to 8 seconds and are a function of the approach speed
- airplane body attitudes are based upon typical landing weights, flaps 30, VREF 30 + 5 (approach) and VREF 30 + 0 (touchdown), and should be reduced by 1° for each 5 knots above this speed.

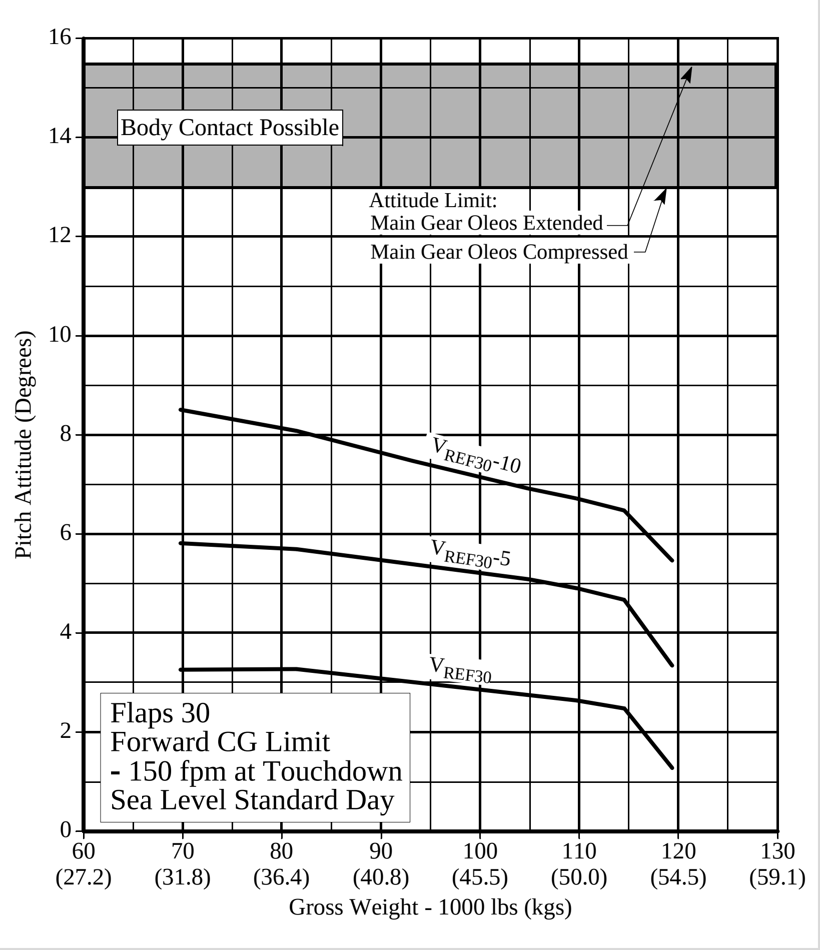


Normal Touchdown Attitude

The following figures illustrate the effect of airspeed on airplane attitude at touchdown. They show airplane attitude at a normal touchdown speed (VREF to VREF - 5 knots) for flaps 30 and flaps 40. The figures also show that touchdown at a speed below normal touchdown speed, in this case VREF - 10 knots, seriously reduces aft fuselage-runway clearance.

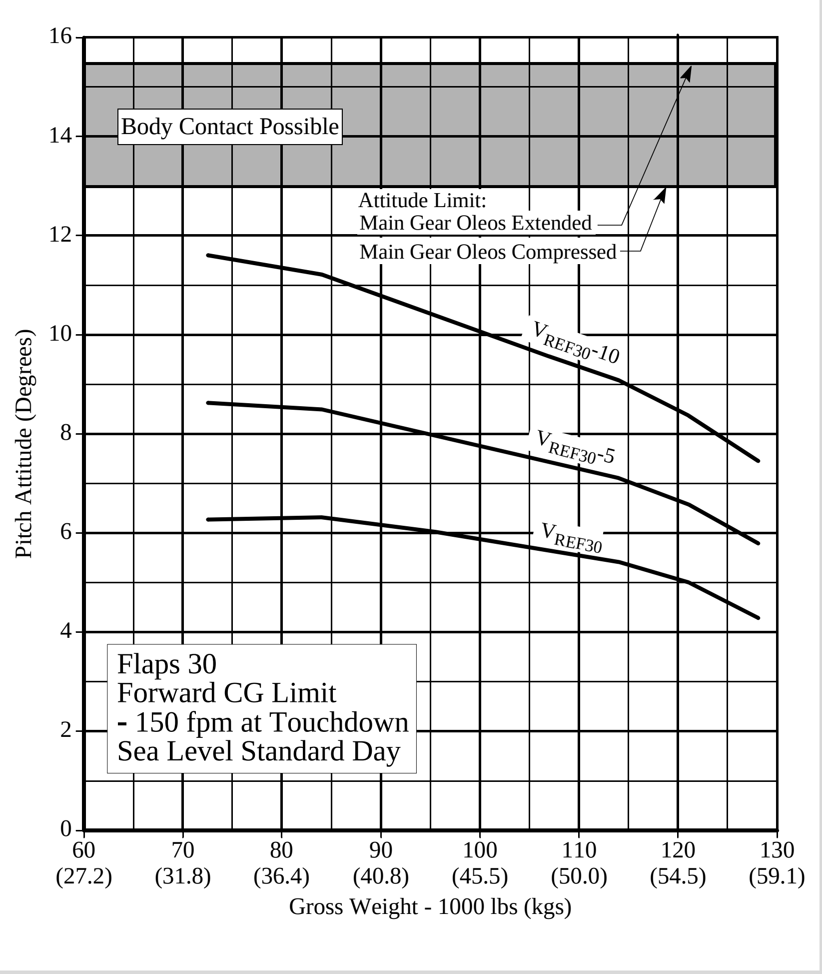
Touchdown Body Attitudes

737-200



Touchdown Body Attitudes

737-200A



Pitch and Roll Limit Conditions

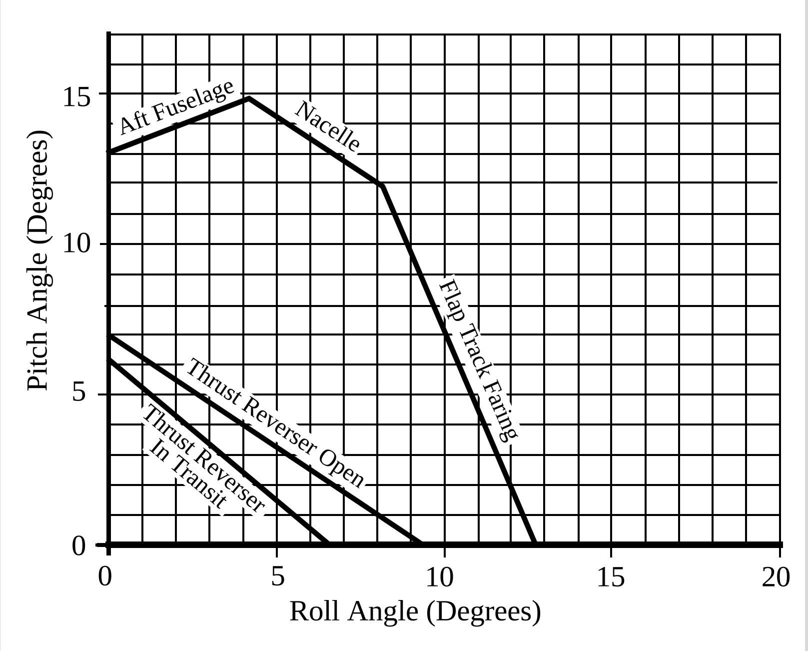
The Ground Contact Angles - Normal Landing figure illustrates body roll/pitch angles at which the airplane structure contacts the runway.

Note: The following figure is based on a rigid wing, however, dynamic maneuvering can reduce this envelope due to structural flexing of the airframe. Therefore, body roll/pitch angles within the envelope shown on the figures can result in airplane structure contacting the runway.

Ground Contact Angles - Normal Landing

Conditions

- Pitch about main gear centerline
- Roll about main gear outside tire
- Static strut compression
- Valid for all flap detents
- Valid for all control surface positions



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. During the resultant bounce, if the thrust levers are then retarded to idle, automatic speedbrake deployment can occur resulting in a loss of lift and nose up pitching moment which can result in a tail strike or hard landing on a subsequent touchdown.

Rejected Landing

A rejected landing maneuver is trained and evaluated by some operators and regulatory agencies. Although the FCOM/QRH does not contain a procedure or maneuver titled Rejected Landing, the requirements of this maneuver can be accomplished by doing the Go-Around Procedure if it is initiated before touchdown. Refer to Chapter 5, Go-Around after Touchdown, for more information on this subject.

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 nose wheels smoothly onto the runway without delay. Control column movement forward of neutral should not be required. Do not attempt to hold the nose wheels off the runway. Holding the nose up after touchdown for aerodynamic braking is not an effective braking technique and results in high nose gear sink rates upon brake application and reduced braking effectiveness.

To avoid possible airplane structural damage, do not make large nose down control column movements before the nose wheels are lowered to the runway.

To avoid the risk of 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 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 PM. This improves the crew’s situational awareness of the position of the spoilers during landing and builds good habit patterns which can prevent failure to observe a malfunctioned or disarmed spoiler system.

Directional Control and Braking after Touchdown

If the nose wheel is not promptly lowered to the runway, braking and steering capabilities are significantly degraded and no drag benefit is gained. Rudder control is effective to approximately 60 knots. Rudder pedal steering is sufficient for maintaining directional control during the rollout. Do not use the nose wheel steering wheel until reaching taxi speed. In a crosswind, displace the control wheel into the wind to maintain wings level which aids directional control. Perform the landing roll procedure immediately after touchdown. Any delay markedly increases the stopping distance.

Stopping distance varies with wind conditions and any deviation from recommended approach speeds.

Factors Affecting Landing Distance

Advisory information for normal and non-normal configuration landing distances is contained in the PI chapter of the FCOM. 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.

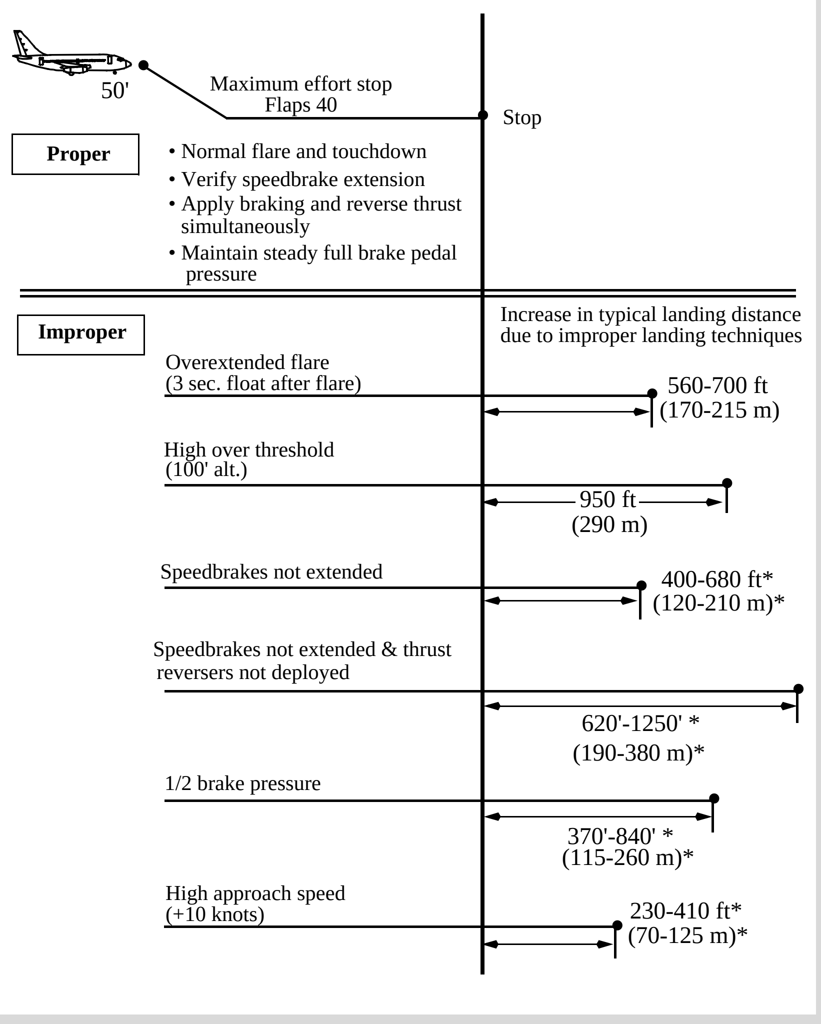
Floating above the runway before touchdown must be avoided because it uses a large portion of the available runway. The airplane should be landed as near the normal touchdown point as possible. Deceleration rate on the runway is approximately three times greater than in the air.

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.

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.

Factors Affecting Landing Distance (Typical)

The following diagram show typical increases in landing distance due to improper landing techniques compared to the proper (baseline) condition. These data are based on dry runway, sea level, standard day conditions with landing weights up to the maximum landing weight. Data exclude wet or contamination effects. When increased landing distance is shown as a range, it reflects variations in airplane weight and model variants (if applicable). These calculations are intended for training discussion purposes only.



Non-Normal Landing Distance

Because of higher approach speeds and the possible degraded capability of deceleration devices (spoiler, brakes, reversers) associated with the non-normal landing condition, the actual landing distance is increased. The Non-Normal Configuration Landing Distance table in the appropriate PI chapter of the FCOM shows VREF and landing distances for various non-normal landing configurations and runway conditions.

Slippery Runway Landing Performance

Appendix A.2.6

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 FCOM. 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 FCOM 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.

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).

- 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.

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 (as installed)

Use of the autobrake system is recommend whenever the runway is limited, when using higher than normal approach speeds, landing on slippery runways, or landing in a crosswind.

For normal operation of the autobrake system select a deceleration setting.

Settings include:

- MAX: Used when minimum stopping distance is required. Should be used for wet or slippery runways. Deceleration rate is less than that produced by full manual braking
- MED (2 or 3, as installed): Should be used when landing rollout distance is limited
- MIN (1, as installed): This setting provides a moderate deceleration suitable for all routine operations.

Experience with various runway conditions and the related airplane handling characteristics provide initial guidance for the level of deceleration to be selected.

Immediate initiation of reverse thrust at main gear touchdown and full reverse thrust allow the autobrake system to reduce brake pressure to the minimum level. Since the autobrake system senses deceleration and modulates brake pressure accordingly, the proper application of reverse thrust results in reduced braking for a large portion of the landing roll.

The importance of establishing the desired reverse thrust level as soon as possible after touchdown cannot be overemphasized. This minimizes brake temperatures and tire and brake wear and reduces stopping distance on very slippery runways.

The use of minimum reverse thrust as compared to maximum reverse thrust can double the brake energy requirements and result in brake temperatures much higher than normal.

After touchdown, crewmembers should be alert for autobrake disengagement annunciations. The PM should notify the PF anytime the autobrakes disengage.

If stopping distance is not assured with autobrakes engaged, the PF should immediately apply manual braking sufficient to assure deceleration to a safe taxi speed within the remaining runway.

A table in the PI section of the FCOM shows the relative stopping capabilities of the available autobrake selections.

Transition to Manual Braking

The speed at which the transition from autobrakes to manual braking is made depends upon airplane deceleration rate, runway conditions and stopping requirements. Normally the speedbrakes remain deployed until taxi speed, but may be stowed earlier if stopping distance within the remaining runway is assured. When transitioning to manual braking, use reverse thrust as required until taxi speed. The use of speedbrakes and reverse thrust is especially important when nearing the end of the runway where rubber deposits affect stopping ability.

When transitioning from the autobrake system to manual braking, the PF should notify the PM. Techniques for release of autobrakes can affect passenger comfort and stopping distance. These techniques are:

- stow the speed brake handle. When stopping distance within the remaining runway is assured, this method provides a smooth transition to manual braking, is effective before or after thrust reversers are stowed, and is less dependent on manual braking technique
- smoothly apply 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
- manually position the autobrake selector off (normally done by the PM at the direction of the PF).

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. 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 are extended before applying the brakes
- initiate wheel braking using very light pedal pressure and increase pressure as ground speed decreases.
- apply steady pressure.

When the aitiskid system is inoperative, the NNC tells the flight crew that they should not pump the brakes. This is because each time the brakes are released, the required stopping distance is increased. Also, each time the brakes are reapplied, the probability of a skid is increased.

Flight testing has demonstrated that braking effectiveness on a wet grooved runway is similar to that of a dry runway. However, caution must be exercised when braking on any wet, ungrooved portions of the runway with antiskid inoperative to avoid tire failure.

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 FCOM.

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 FCOM/QRH should be used to identify potential overheat situations.

Close adherence to recommended landing roll procedures ensures minimum brake temperature build up.

Minimum Brake Heating

Consider using the following technique if landing overweight or other factors exist that may lead to excessive brake temperatures. A normal landing, at weights up to maximum landing weight, does not require special landing techniques.

Note: Autolands are not recommended for overweight landings.

To minimize brake temperature build-up, use the following landing techniques:

- select the longest runway available but avoid landing downwind
- use the largest available landing flap setting
- use an autobrake setting, consistent with reported runway conditions, that will result in the use of all available runway length. A stopping distance safety margin should be used in accordance with airline policy. Although the autobrakes initially increase brake temperature, the brake contribution is minimized after reverser deployment
- ensure all of the headwind correction is bled off prior to touchdown to avoid landing with excessive airspeed
- use a normal gear touchdown aim point
- do not allow the airplane to float
- ensure the spoilers deploy immediately after touchdown
- select maximum reverse thrust as soon as possible after main gear touchdown. Do not wait for nose gear touchdown. The intention is to use reverse thrust as the major force that stops the airplane. The use of maximum reverse thrust further minimizes brake heating
- as soon as stopping is assured in the remaining runway, turn the autobrakes off and continue slowing the airplane with reverse thrust
- if stopping in the remaining runway is in doubt, continue use of autobrakes or take over manually and apply up to maximum braking as needed
- consider extending the landing gear early to provide maximum brake cooling as needed.

Reverse Thrust Operation

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 is most effective at high speeds.

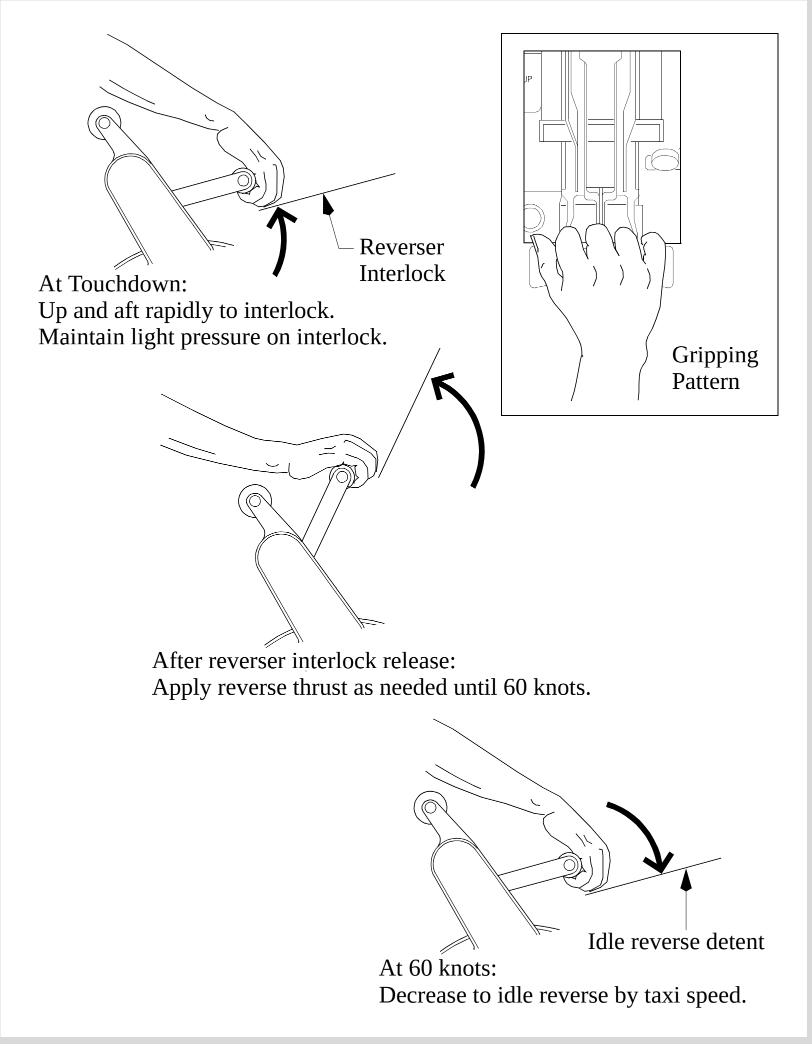
After touchdown, with the thrust levers at idle, rapidly raise the reverse thrust levers up and aft to the interlock position, then to the number 2 reverse thrust detent. Conditions permitting, limit reverse thrust to the number 2 detent. The PM should monitor engine operating limits and call out any engine operational limits being approached or exceeded, any thrust reverser failure, or any other abnormalities.

Maintain reverse thrust as required, 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. Reverse thrust is reduced to idle between 60 knots and taxi speed to prevent engine exhaust re-ingestion and to reduce the risk of FOD. It also helps the pilot maintain directional control in the event a reverser becomes inoperative.

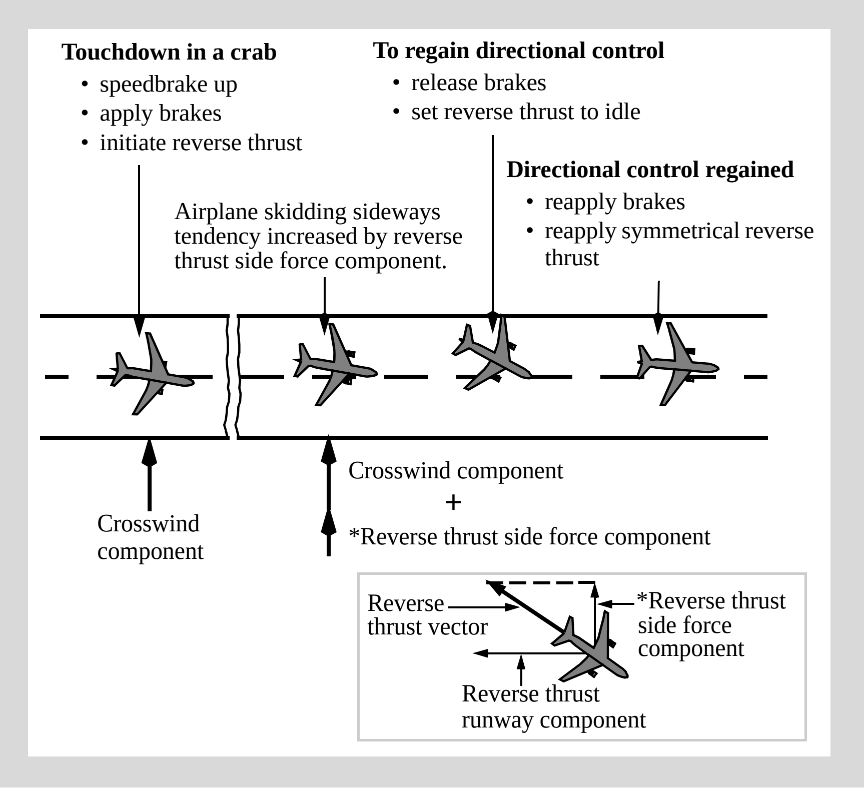
Note: If an engine surges during reverse thrust operation, quickly select reverse idle on both engines.

The PM should call out 60 knots to assist the PF in scheduling the reverse thrust. The PM should also call out any inadvertent selection of forward thrust as reverse thrust is cancelled.

Reverse Thrust Operations



Reverse Thrust and Crosswind (All Engines)



This figure shows a directional control problem during a landing rollout on a slippery runway with a crosswind. As the 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. Also, high braking forces reduce the capability of the tires to corner.

To correct back to the centerline, release the brakes and reduce reverse thrust to reverse idle. Releasing the brakes increases the tire-cornering capability and contributes to maintaining or regaining directional control. Setting reverse idle reduces the reverse thrust side force component without the requirement to go through a full reverser actuation cycle. Use rudder pedal steering and differential braking as required, to prevent over correcting past the runway centerline. When directional control is regained and the airplane is correcting toward the runway centerline, apply maximum braking and symmetrical reverse thrust to stop the airplane.

Note: Use of this technique increases the required landing distance.

Reverse Thrust - Engine Inoperative

Asymmetrical reverse thrust may be used with one engine inoperative. Use normal reverse thrust procedures and techniques with the operating engine. If directional control becomes a problem during deceleration, return the thrust lever to the reverse idle detent.

Crosswind Landings

The crosswind guidelines shown below were derived through flight test data, engineering analysis and flight simulator evaluations. These crosswind guidelines are based on steady wind (no gust) conditions and include all engines operating and engine inoperative. Gust effects were evaluated and tend to increase pilot workload without significantly affecting the recommended guidelines.

Landing Crosswind Guidelines

Appendix A.2.6

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. These guidelines assume adverse airplane loading and proper pilot technique.

Runway Condition	Crosswind Component (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 with crosswinds components in excess of 13 knots at flaps 15, 16 knots at flaps 30, or 18 knots at flaps 40. 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 de-crab technique (with removal of crab in flare), touchdown in a crab, 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 airplane 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 airplane with the extended runway centerline so that main gear touchdown occurs on the runway centerline.

The initial phase of the approach to landing is flown using the crab method to correct for drift. Prior to the flare the 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.

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 30 or 40 landings at all gross weights. However, wet or slippery runway field length requirements should be verified from the landing distance charts in the PI chapter of the FCOM. Brake energy limits will not be exceeded for flaps 30 or 40 landings at all gross weights.

Note: Use of flaps 30 rather than flaps 40 is recommended to provide increased margin to flap placard speed.

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 15 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.

Autobrake (as installed) stopping distance guidance is contained in the PI section of the FCOM. 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 (SP-177)

Overweight autolands are not recommend. 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.

Maneuvers — Chapter 7
Table of Contents — Section TOC

Preface

This chapter outlines the recommended operating practices and techniques used during maneuvers in both the training and operational environment. 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.

Maneuvering for events such as Approach to Stall or Stall Recovery, Terrain Avoidance, Traffic Avoidance, Upset Recovery, or Windshear may result in deviation from the ATC clearance. The crew should expeditiously return to the applicable ATC clearance immediately following such maneuvering unless otherwise directed.

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 disengaged. 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 maneuver 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 an engine inoperative and gain familiarization with rudder control requirements.

	Condition One	**Condition Two**
Airspeed	flaps up maneuver speed	V2
Landing Gear	Up	Down
Flaps	Up	15
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 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.

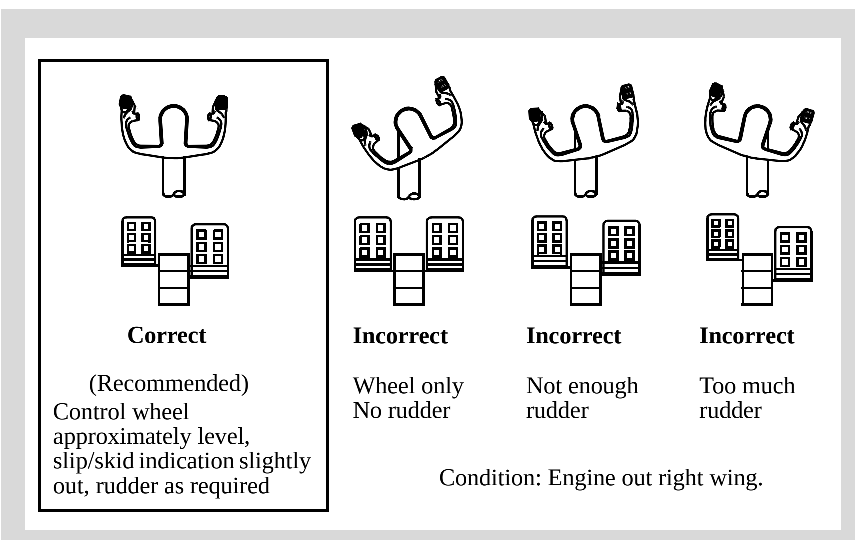
When the rudder is trimmed to level the control wheel, the airplane maintains heading. A small amount of bank toward the operating engine may be noticeable on the bank indicator. The slip/skid indicator is displaced slightly toward the operating engine.

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: For airplanes equipped with the SP-177 autopilot, the autothrottle should not be used with an engine inoperative.

High Altitude Maneuvering, “G” Buffet

Airplane buffet reached as a result of airplane 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 0.80M. Induce “g” buffet by smoothly increasing the bank angle until the buffet is noticeable. Increase the rate of descent while increasing the bank angle to maintain airspeed. Do not exceed 45° of bank. If buffet does not occur by 45° of bank, increase control column back pressure until buffet occurs. When buffet is felt, relax back pressure and smoothly roll out to straight and level. Notice that the controls are fully effective at all times.

Rapid Descent

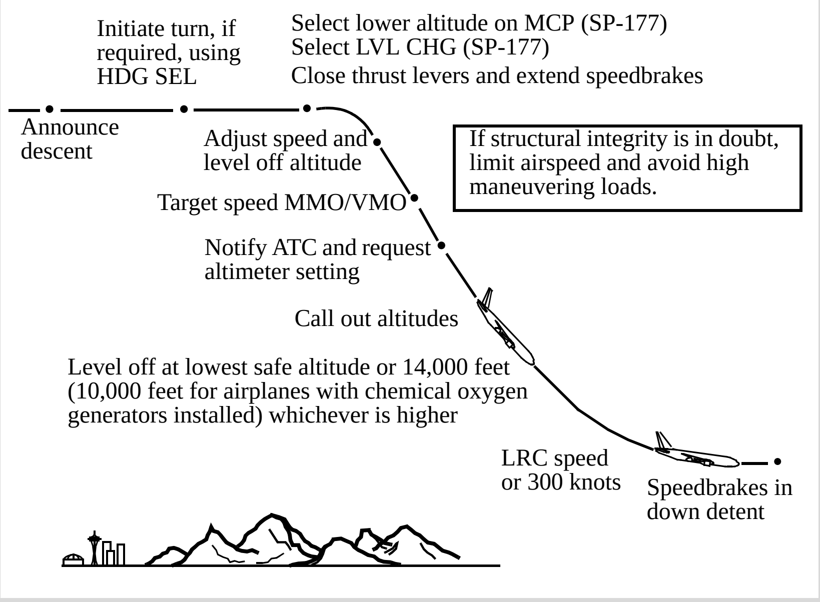
Appendix A.2.6

This section addresses basic techniques and procedures for a rapid descent. Some routes over mountainous terrain require careful operator planning to include carrying additional oxygen, special procedures, higher initial level off altitudes, and emergency routes in the event a depressurization is experienced. These requirements are normally addressed in an approved company route manual or other document that addresses route specific depressurization procedures.

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: For airplanes equipped with the SP-77 autopilot, use of the autopilot in the CWS pitch mode is recommended.

Note: For airplanes equipped with the SP-177 autopilot, use of the autopilot in the LVL CHG mode 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 descents are normally made with the landing gear up.

The PM checks the lowest safe altitude, notifies ATC, and obtains an altimeter setting (QNH). Both pilots should verify that all memory items have been accomplished and call out any items not completed. The PM calls out 2,000 feet and 1,000 feet above the level off altitude.

Level off at the lowest safe altitude or 14,000 feet (10,000 feet for airplanes with chemical oxygen generators installed), whichever is higher. Lowest safe altitude is the Minimum Enroute Altitude (MEA), Minimum Off Route Altitude (MORA), or any other altitude based on terrain clearance, navigation aid reception, or other appropriate criteria.

If severe turbulent air is encountered or expected, reduce to turbulent air penetration speed.

Autopilot Entry and Level Off

Level Change (LVL CHG) (SP-177)

Because of airspeed and altitude protection and reduced crew workload, use of the autopilot with LVL CHG mode is the recommended technique for rapid descents. Use of the V/S mode is not recommended.

Initiate a turn, if required, using HDG SEL. Set a lower altitude in the altitude window. Select LVL CHG, close the thrust lever and smoothly extend the speedbrakes. 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 needed.

When descending at speeds near VMO/MMO with the autopilot engaged, short-term airspeed increases above VMO/MMO may occur. These are most often due to wind and temperature changes. These short-term increases are acceptable for this maneuver and the autopilot should adjust the pitch to correct the airspeed to below VMO/MMO. Do not disconnect the autopilot unless autopilot operation is clearly unacceptable. Any airspeed above VMO/MMO should be documented in the airplane logbook.

Note: For more complete information on recommendations if VMO/MMO is exceeded, see the section titled "Overspeed" in Chapter 8 of this manual.

When approaching the target altitude, ensure the altitude is set in the MCP altitude select window, and the command speed is set to LRC or approximately 300 knots before level-off is initiated. This aids in a smooth transition to level flight. When the speedbrakes are retracted during altitude capture near VMO/MMO, a momentary overspeed condition may occur. To avoid this condition, smoothly and slowly retract the speedbrakes to allow the autopilot sufficient time to adjust the pitch attitude to maintain the airspeed within limits.

Control Wheel Steering

Control Wheel Steering (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, monitor the airspeed display and bank angle to ensure that at least minimum maneuver speed is maintained when turning.

To manually fly the maneuver, disconnect the autothrottles and retard thrust levers to idle. Smoothly extend the speedbrakes, disengage the autopilot and smoothly lower the nose to initial descent attitude (approximately 10° 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.

Landing Gear Extended Descent

The rapid descent is normally made with the landing gear up. However, when structural integrity is in doubt and airspeed must be limited, extension of the landing gear may provide a more satisfactory rate of descent.

If the landing gear is to be used during the descent, comply with the landing gear placard speeds.

After Level Off

Recheck the pressurization system and evaluate the situation. Do not remove the crew oxygen masks if cabin altitude remains above 10,000 feet.

Note: Determine the new course of action based on weather, oxygen, fuel remaining, medical condition of crew and passengers, and available airports. Obtain a new ATC clearance.

Approach to Stall or Stall

An approach to a stall is a controlled flight maneuver; a stall is an out-of-control, but recoverable, condition. However, the recovery maneuver is the same for either an approach to a stall or a fully developed stall.

Most approach to stall incidents have occurred where there was altitude available for recovery. The incidents that progressed into accidents often occurred because the crew failed to make a positive recovery when the stall warning occurred, the condition progressed to a full stall, and the airplane impacted the ground in a stalled condition. For this reason, emphasis has shifted from a recovery with minimum loss of altitude to reducing the angle of attack below the wing stalling angle to complete a positive and efficient recovery.

A stall warning should be readily identifiable by the pilot, either by initial buffet or an artificial indication (stick shaker). During the initial stages of a stall, local airflow separation results in buffeting (initial buffet), giving a natural warning of an approach to stall. At cruise Mach speed, stick shaker activation occurs just after reaching initial buffet. Recovery from an approach to stall should be initiated at the earliest recognizable stall warning, either initial buffet or stick shaker.

An airplane may be stalled in any attitude (nose high, nose low, high or low angle of bank) or any airspeed (turning, accelerated stall). It is not always intuitively obvious that the airplane is stalled.

An airplane stall is characterized by one or more of the following conditions:

- stall warning
- buffeting, which could be heavy
- lack of pitch authority
- lack of roll control
- inability to arrest descent rate.

Approach to Stall or Stall Recovery

To initiate the recovery, the angle of attack must be reduced below the wing stalling angle. Smoothly apply nose down elevator to reduce the angle of attack until the wings are unstalled (buffet or stick shaker stops). Nose down stabilizer trim may be needed if the control column does not provide the needed response.

Note: With high thrust engines, low airspeed coupled with high thrust settings may result in a condition where elevator authority is not adequate. This is because airplanes with underwing-mounted engines have a nose-up pitch moment relative to increased thrust.

Application of forward control column (as much as full forward may be required) and the use of some nose-down stabilizer trim should provide sufficient elevator control to produce a nose-down pitch rate. It may be difficult to know how much stabilizer trim to use, and care must be taken to avoid using too much. Pilots should not fly the 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. The use of too much trim may result in the loss of control or high structural loads.

Continue the recovery by rolling in the shortest direction to wings level, as needed. If an attempt is made to roll to wings level before the wings are unstalled, the ailerons and spoilers are ineffective. Unloading the wing by maintaining continuous nose-down elevator pressure keeps the wing angle of attack low making the normal roll controls more effective. After the stall is broken, normal roll controls, up to full deflection of ailerons and spoilers, may be used to roll in the shortest direction to wings level, if needed. The use of rudder is normally not needed.

The Approach to Stall or Stall Recovery maneuver calls for the crew to advance the thrust levers as needed. Under certain conditions, where high thrust settings are already applied such as during takeoff or go-around, it may be necessary to reduce thrust in order to prevent the angle of attack from continuing to increase. This is because airplanes with underwing-mounted engines have a nose-up pitch moment relative to increased thrust.

Note: Use care during recovery from a nose low attitude after the buffet and/or stick shaker have stopped. If the pull up is too aggressive, a "secondary" stall or sustained stick shaker may result.

In extreme cases where the application of forward control column coupled with some nose-down stabilizer trim and a thrust reduction do not stop an increasing pitch rate in a nose high situation, rolling the airplane to a bank angle that starts the nose down may be effective. If normal roll control is ineffective, careful rudder input in the direction of the desired roll may be required. Bank angles of about 45°, up to a maximum of 60°, could be needed. Too much rudder applied too quickly or held too long may result in loss of lateral and directional control.

Do not change gear or flap configuration during the recovery, unless a stall warning indication is encountered during liftoff and the flaps were inadvertently positioned up for takeoff. In this case, extend flaps 1 as directed in the Approach to Stall or Stall Recovery maneuver. Extending or retracting the flaps during the recovery at other times results in an increased altitude loss.

High Altitude Recovery

At higher altitudes, normally above 20,000 feet, the airplane becomes increasingly thrust limited. If an approach to stall indication is experienced, nose down elevator and stabilizer trim is required to initiate a descent. This is because when the airplane is thrust limited, altitude needs to be traded for airspeed. Therefore a recovery at high altitude results in a greater altitude loss than a recovery at low altitudes.

Approach to Stall or Stall Recovery Training

The objective of the approach to stall or stall recovery training is to familiarize the pilot with the stall warning and correct recovery techniques. Recent safety studies have shown that an increasing number of stall related accidents have occurred during the maneuvering and approach phases of flight. In an effort to reduce this trend, training emphasis has shifted to performing stall or stall recovery exercises in these phases of flight.

Approach to Stall or Stall Recovery training maneuvers should be done under simulated instrument conditions with the autopilot engaged. Exercises include:

- level off
- turning base
- ILS final approach.

Initial Conditions

Set the command speed in accordance with normal procedures for the phase of flight. During the level off exercise, the speedbrake remains extended until retracted during the Approach to Stall or Stall Recovery maneuver. After the initial conditions are established, the instructor initiates each exercise by disconnecting the autothrottle (as installed) and placing the thrust levers to idle.

Initial Buffet-Stick Shaker

The autopilot slowly establishes a pitch attitude by using stabilizer trim and/or elevator position to induce the stall buffet or stick shaker.

During the initial stages of the stall, local airflow separation results in buffeting giving a natural warning of an approach to stall. A stall warning should be readily identifiable by the pilot, either by initial buffet indication or an artificial indication (stick shaker).

Effect of Flaps

Flaps are used to increase low speed performance capability. The leading edge devices ensure that the inboard wing stalls before the outboard wing. This causes the nose of the airplane to pitch down at the onset of the stall.

Effect of Speedbrakes

For any given airspeed, the angle of attack is higher with the speedbrakes up. This increases initial buffet speed and stick shaker speed but has less effect on the actual stall speed.

Recovery

Recovery from an approach to stall should be initiated at the earliest recognizable stall warning, either initial buffet or stick shaker. Initiate the Approach to Stall or Stall Recovery maneuver as published in the QRH.

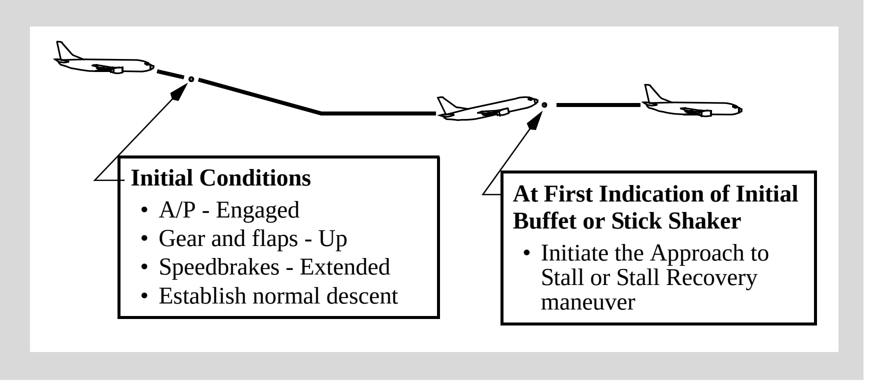
Apply nose down elevator and, if needed, nose down stabilizer trim to reduce the angle of attack. Thrust is increased as needed to accelerate. Subsequently the stall buffet and the stick shaker will stop. Maintain lateral control with ailerons.

Do not use flight director commands during the recovery. Flight director commands are not designed to provide guidance that leads to a recovery from an approach to stall or stall.

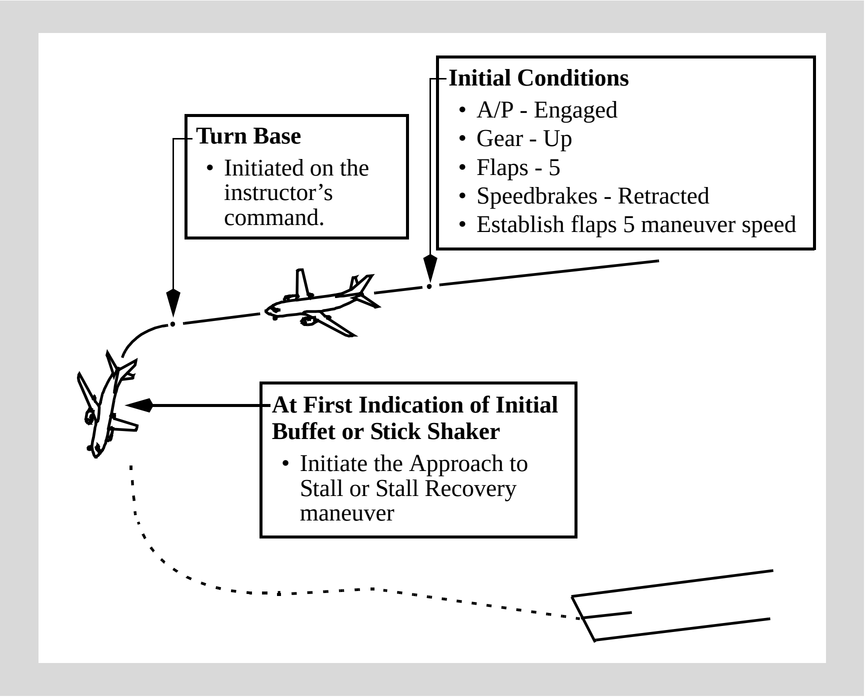
Approach to Stall Recovery Exercises

The following exercises are intended for simulator training only.

Level Off

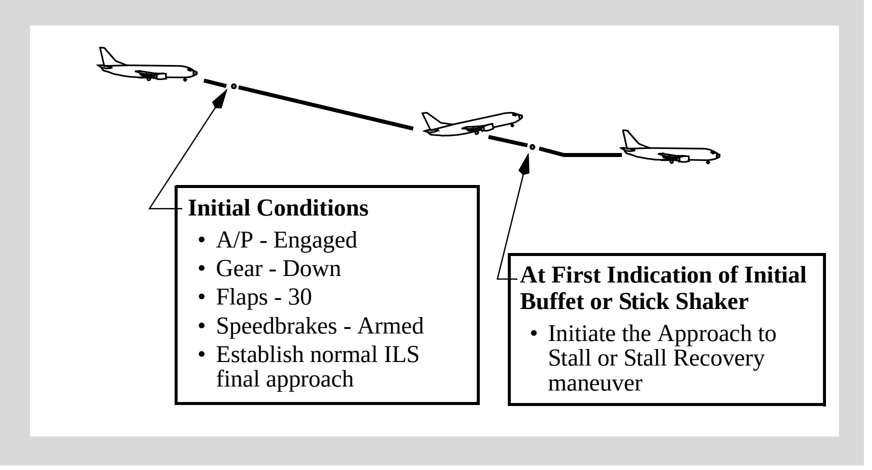


Turning Base



Note: The instructor commands initiation of the turn to base when the airspeed is at flaps 5 maneuver speed. This ensures the initial buffet or stick shaker occurs during the turn.

ILS Final Approach



Note: If during the ILS final approach exercises the decision is made to go-around, the Approach to Stall or Stall Recovery maneuver must be completed before the go-around is initiated.

Completion of the Recovery

Upon completion of the maneuver, recover to the command speed, adjust thrust as needed, and follow previous instructions (e.g. heading, altitude). Re-engage the autopilot and autothrottle (as installed) in accordance with normal procedures.

Stick Shaker and Stall Speeds

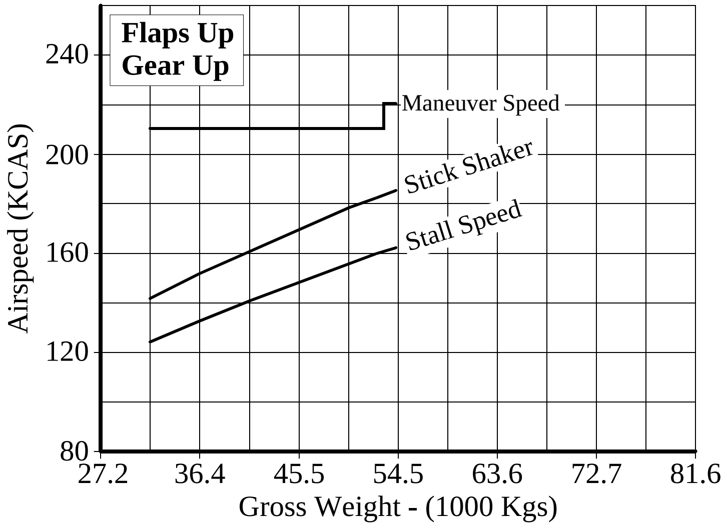
The following figures depict stick shaker and stall speeds at various gross weights and flap settings. This data is presented for training purposes only.

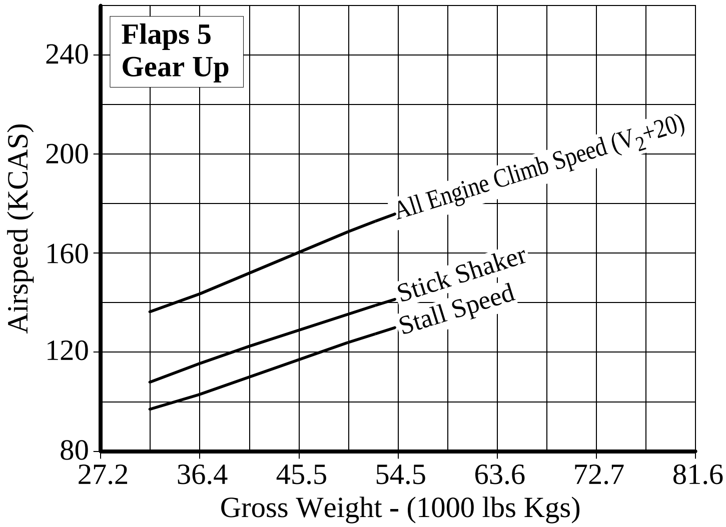
Conditions

- 10,000 ft Altitude
- Idle Thrust
- Forward CG

Stick Shaker and Stall Speeds - Kilograms

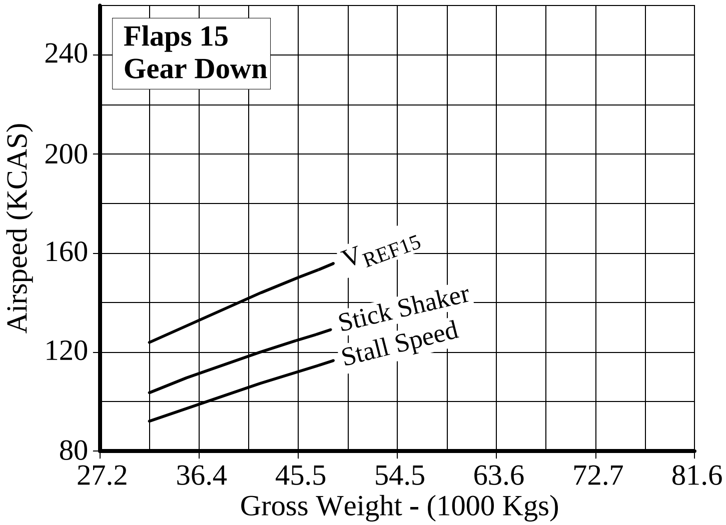
737-200

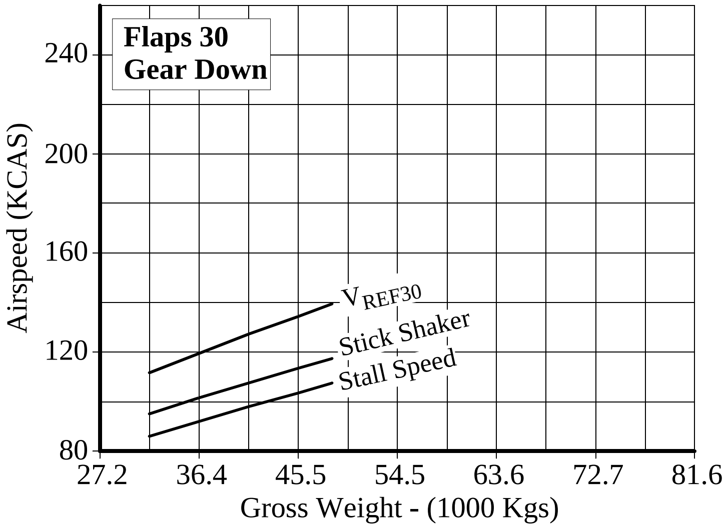




Stick Shaker and Stall Speeds - Kilograms

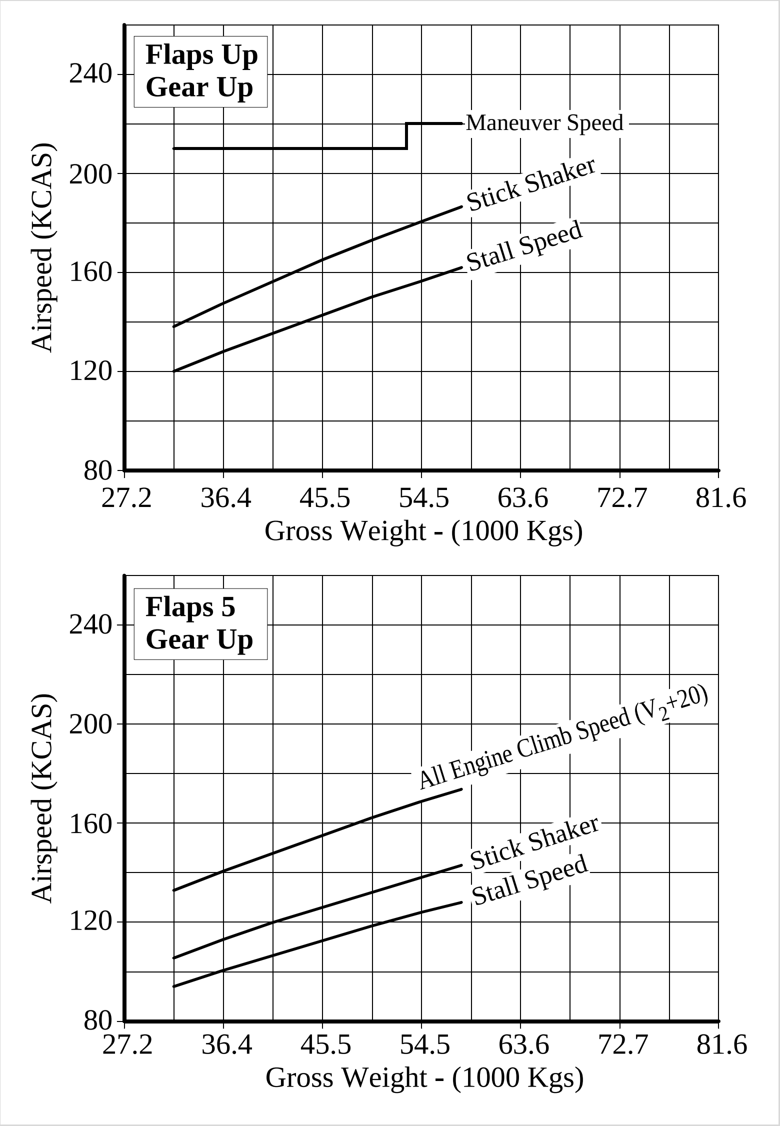
737-200





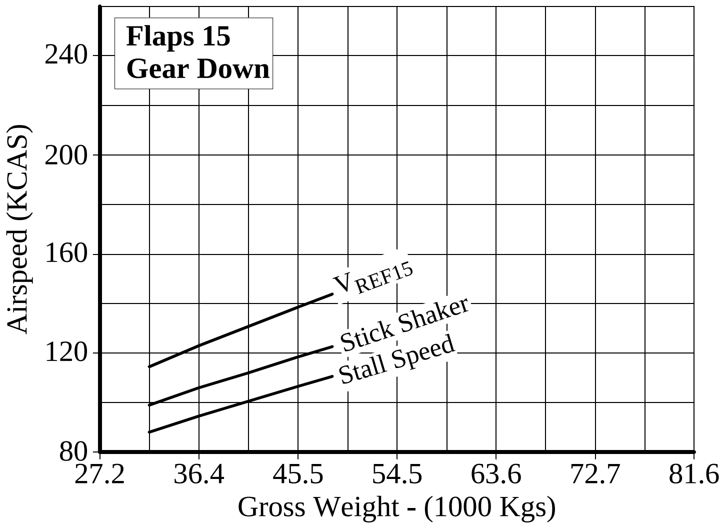
Stick Shaker and Stall Speeds - Kilograms

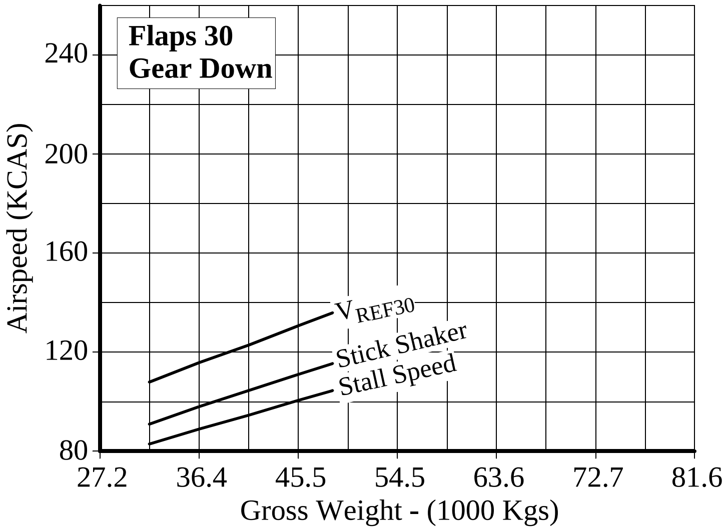
737-200A



Stick Shaker and Stall Speeds - Kilograms

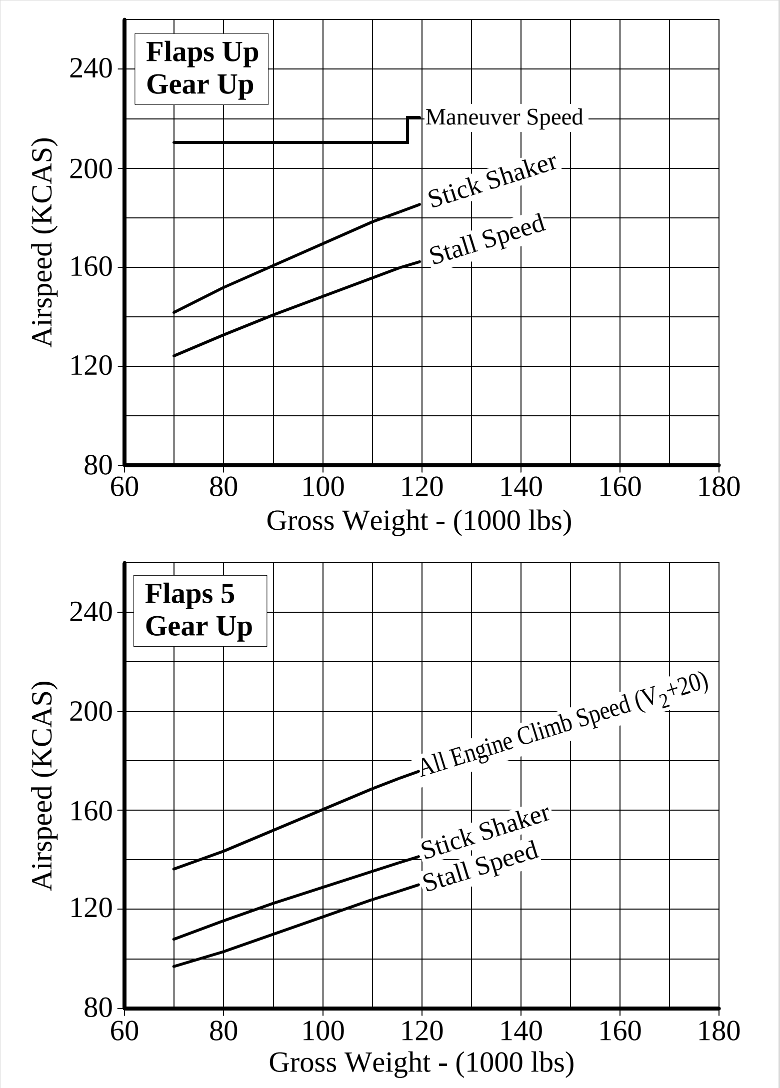
737-200A





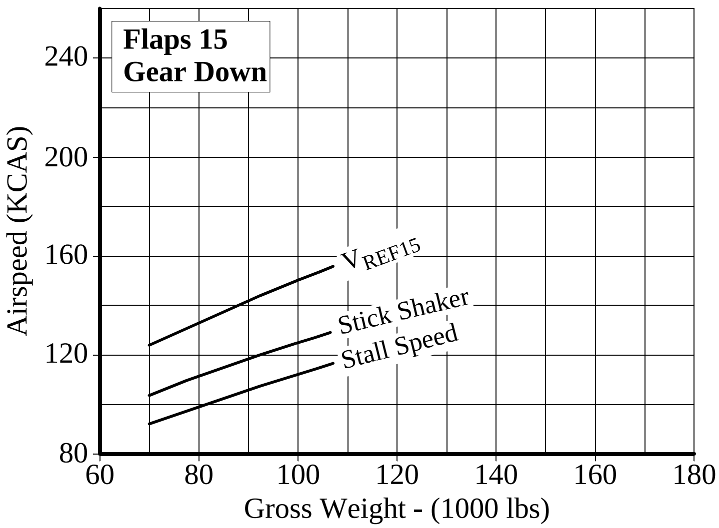
Stick Shaker and Stall Speeds - Pounds

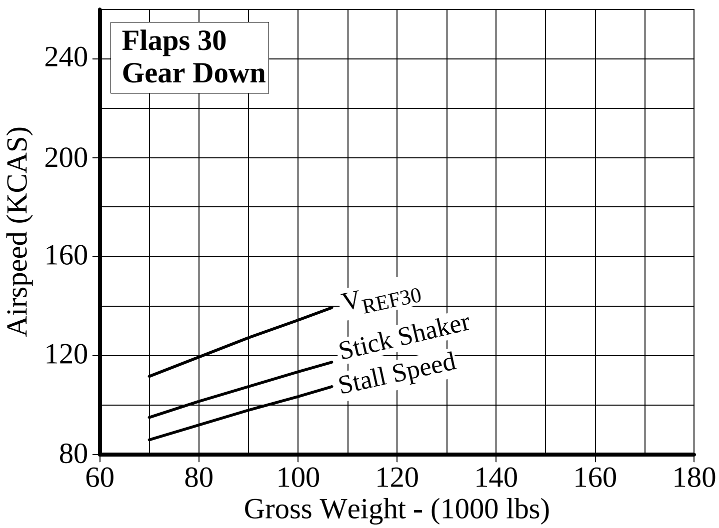
737-200



Stick Shaker and Stall Speeds - Pounds

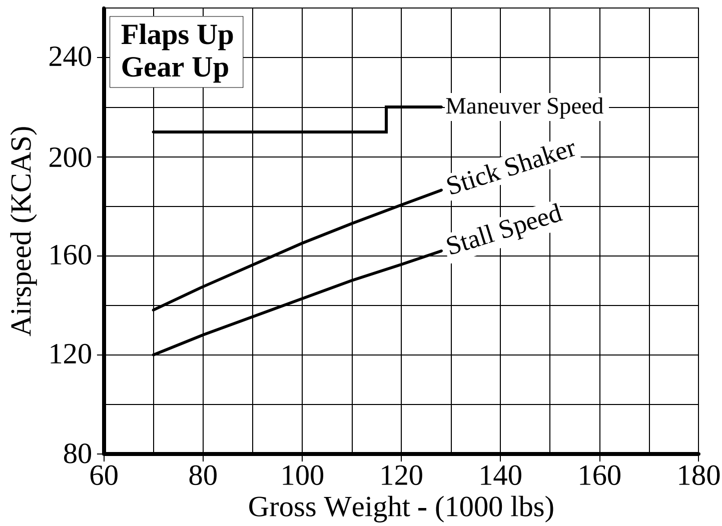
737-200

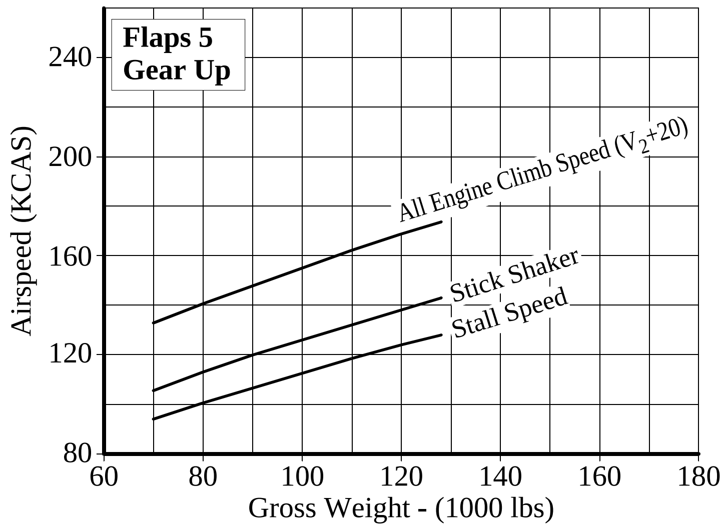




Stick Shaker and Stall Speeds - Pounds

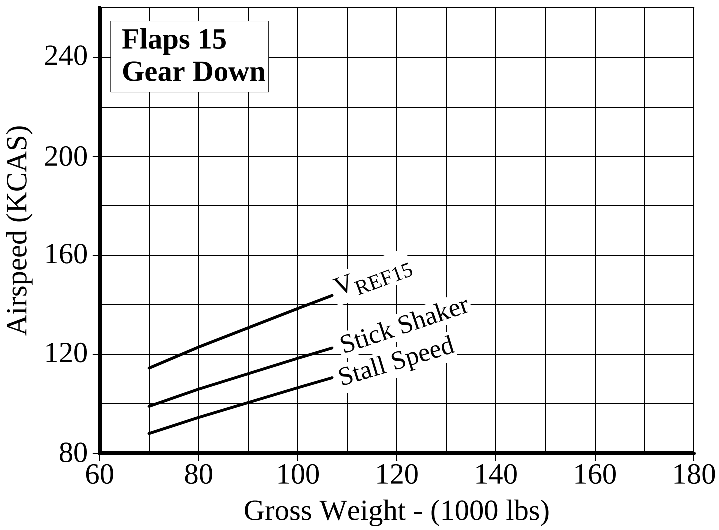
737-200A

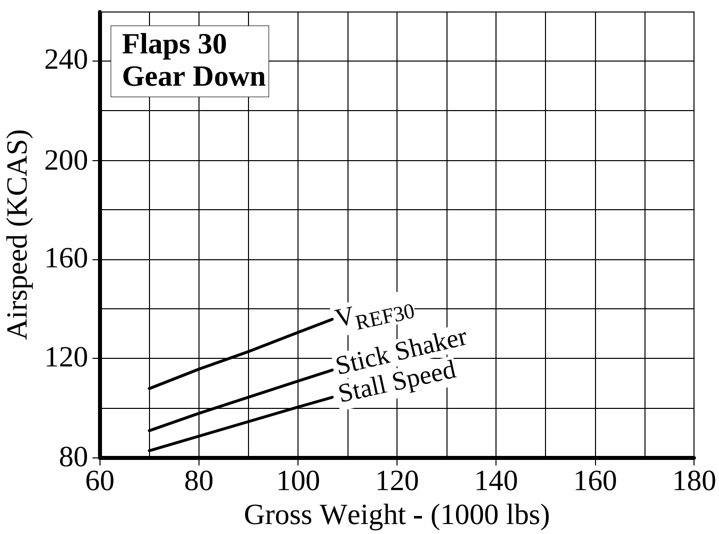




Stick Shaker and Stall Speeds - Pounds

737-200A





Steep Turns

The objective of the steep turn maneuver is to familiarize the pilot with airplane handling characteristics beyond 35° of bank and improve the instrument crosscheck. During training, 45° of bank is used for this maneuver. It is not intended that the pilot should ever be required to bank greater than 25° to 30° in any normal or non-normal condition.

Note: Stabilizer trim is not recommended during the steep turn maneuver because of increased workload during roll out.

Entry

Stabilize airspeed at 250 knots on heading and altitude. Use a normal turn entry. An increase in pitch is required as the bank angle is increased to maintain constant altitude. An increase in thrust is required to maintain constant airspeed.

During Turn

Pitch and thrust control are the same as for a normal turn; however, larger pitch adjustments are required for a given altitude deviation. Varying the angle of bank while turning makes pitch control more difficult. If altitude loss becomes excessive, reduce the angle of bank as 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 Director Indicator (ADI)

The ADI has cyclical precession in pitch during steep turns. Although the actual airplane pitch attitude remains constant in a perfect steep turn, the instrument indication of pitch attitude slowly varies throughout the turn. Do not rely upon it for pitch attitude other than for small corrections based on short period observations.

Vertical Speed Indicator

The vertical speed indicator interprets a change of acceleration as a change to vertical speed. Rapid increase in “g” forces as a steep turn is entered causes a transient display of approximately 200 FPM climb, even though the airplane is maintaining altitude perfectly. A 200 FPM descent appears because of the reduction in “g” force during a fast rollout. The VSI gives correct indications only during periods of steady “g” force.

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. An increase in thrust is required as bank angle increases.

Note: If the airspeed cursor is set to 250 knots on the airspeed indicator, the airspeed fast/slow indicator (as installed) on the ADI indicates thrust change required.

Rollout

Roll out at the same rate as used during normal turns. Normally rollout should begin 15° to 20° prior to the desired heading. A decrease in pitch is required as the bank angle is decreased to maintain constant altitude. An decrease in thrust is required to maintain constant airspeed.

Terrain Avoidance

The Ground Proximity Warning System (GPWS) PULL UP Warning occurs when an unsafe closure rate is detected with terrain below 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.

Engine Overboost

A significant thrust overboost capability exists which could be used in emergency situations. This overboost capability should only be considered when ground contact is imminent. Overboosting the engines when the situation is not sufficiently serious unnecessarily shortens engine life and increases the potential for engine failure. In an emergency situation “firewalling the thrust levers” should be considered. This condition could result in an EGT or N1 exceedance. Land at the nearest suitable airport.

Traffic Alert and Collision Avoidance System

The Traffic Alert and Collision Avoidance System (TCAS) (as installed) 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.

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

A Traffic Advisory (TA) occurs when nearby traffic meets system minimum separation criteria, and is indicated aurally and visually on the TCAS traffic display. A goal of the TA is to alert the pilot of the possibility of an RA. If a TA is received, immediately accomplish the Traffic Avoidance maneuver 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 the existing vertical speed is within 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. If a RA is received, immediately accomplish the Traffic Avoidance maneuver in the QRH.

Resolution advisories are known to occur more frequently at locations where traffic frequently converges. This is especially true in RVSM airspace. Climb or descent profiles should not be modified in anticipation of avoiding an RA unless specifically requested by ATC.

RA maneuvers require only small pitch attitude changes which should be accomplished smoothly and without delay. Properly executed, the RA maneuver is mild and does not require large or abrupt control movements. Remember that the passengers and flight attendants may not all be seated during this maneuver. The flight director is not affected by TCAS guidance. Therefore, when complying with an RA, flight director commands may be followed only if they result in a vertical speed that satisfies the RA command.

There have been reports of some flight crews responding incorrectly to the RA “Adjust Vertical Speed Adjust” (AVSA) (as installed) by increasing rather than decreasing vertical speed. Flight crews should be aware that an AVSA always requires a reduction in vertical speed. Follow QRH procedures and comply with the RA commanded vertical speed.

During the RA maneuver, the aircrew attempts to establish visual contact with the target. However, visual perception of the encounter can be misleading, particularly at night. The traffic acquired visually may not be the same traffic causing the RA.

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 any of the following conditions:

- pitch attitude greater than 25° nose up
- pitch attitude greater than 10° nose down
- bank angle greater than 45°
- 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
- high bank angles
- nose high, high bank angles
- nose low, high bank angles

Note: Higher than normal control forces may be required to control the airplane attitude when recovering from upset situations. Be prepared to use a firm and continuous force on the control column and control wheel to complete the recovery.

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° 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 g and 1 g. If altitude permits, flight tests have determined that an effective way to achieve a nose-down pitch rate is to reduce some thrust.

If normal pitch control inputs do not stop an increasing pitch rate, rolling the airplane to a bank angle that starts the nose down should work. Bank angles of about 45°, up to a maximum of 60°, could be needed. Unloading the wing by maintaining continuous nose-down elevator pressure keeps the wing angle of attack as low as possible, making the normal roll controls as effective as possible. With airspeed as low as stick shaker onset, normal roll controls - up to full deflection of ailerons and spoilers - may be used. The rolling maneuver changes the pitch rate into a turning maneuver, allowing the pitch to decrease. Finally, if normal pitch control then roll control is ineffective, careful rudder input in the direction of the desired roll may be required to induce a rolling maneuver for recovery.

Only a small amount of rudder is needed. Too much rudder applied too quickly or held too long may result in loss of lateral and directional control. Because of the low energy condition, pilots should exercise caution when applying rudder.

The reduced pitch attitude allows airspeed to increase, thereby improving elevator and aileron control effectiveness. After the pitch attitude and airspeed return to a desired range the pilot can reduce angle of bank with normal lateral flight controls and return the airplane to normal flight.

Nose Low, Wings Level

In a situation where the airplane pitch attitude is unintentionally more than 10° nose low and going lower, the airspeed is increasing rapidly. A pilot would likely reduce thrust and extend the speedbrakes. Thrust reduction causes an additional nose-down pitching moment. Speedbrake extension causes a nose-up pitching moment, an increase in drag, and a decrease in lift for the same angle of attack. At airspeeds well above VMO/MMO, the ability to command a nose-up pitch rate with elevator may be reduced because of the extreme aerodynamic loads on the elevator.

Again, it is necessary to maneuver the 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°, it is possible to experience bank angles greater than 90°.

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°, level flight cannot be maintained within AFM load factor limits. In high bank angle increasing airspeed situations, the primary objective is to maneuver the lift of the 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° 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°. This also reduces wing angle of attack to improve roll capability. Full aileron and spoiler input should be used if necessary to smoothly establish a recovery roll rate toward the nearest horizon. It is important to not increase g force or use nose-up elevator or stabilizer until approaching wings level. The pilot should also extend the speedbrakes as needed.

Upset Recovery Techniques

It is possible to consolidate and incorporate recovery techniques into two basic scenarios, nose high and nose low, and to acknowledge the potential for high bank angles in each scenario described above. Other crew actions such as recognizing the upset, reducing automation, and completing the recovery are included in these techniques. The recommended techniques provide a logical progression for recovering an 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.

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 FCOM. For specific crew actions for recovery, see the Maneuvers section in the QRH.

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Non–Normal Operations Chapter 8

Preface

This chapter describes pilot techniques associated with accomplishing selected Non-Normal Checklists (NNCs) and provides guidance for situations beyond the scope of 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 Instructions, Non-Normal Checklists), 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 that the Pilot Flying (PF) fly the airplane while the Pilot Monitoring (PM) accomplishes the NNC. Maximum use of the autoflight system is recommended to reduce crew workload
- ANALYZE THE SITUATION: NNCs should be accomplished only after the malfunctioning system has been positively identified. Review all caution and warning lights to positively identify the malfunctioning system(s).

Note: Pilots should don oxygen masks and establish crew communications anytime oxygen deprivation or air contamination is suspected, even though an associated warning has not occurred.

- TAKE THE PROPER ACTION: Although some in-flight non-normal situations require immediate corrective action, difficulties can be compounded by the rate the PF issues commands and the speed of execution by the PM. Commands must be clear and concise, allowing time for acknowledgment of each command prior to issuing further commands. The PF must exercise positive control by allowing time for acknowledgment and execution. The other crewmembers must be certain their reports to the PF are clear and concise, neither exaggerating nor understating the nature of the non-normal situation. This eliminates confusion and ensures efficient, effective, and expeditious handling of the non-normal situation
- EVALUATE THE NEED TO LAND: If the NNC directs the crew to plan to land at the nearest suitable airport, or if the situation is so identified in the QRH section CI.2, (Checklist Instructions, Non-Normal Checklists), diversion to the nearest airport where a safe landing can be accomplished is required. If the NNC or the Checklist Introduction do not direct landing at the nearest suitable airport, the pilot must determine if continued flight to destination may compromise safety.

Troubleshooting

Troubleshooting can be defined as:

- taking steps beyond a published NNC in an effort to improve or correct a non-normal condition
- initiating an annunciated checklist without a light, alert, or other indication to improve or correct a perceived non-normal condition
- initiating diagnostic actions.

Examples of troubleshooting are:

- attempting to reset a system by cycling a system control or circuit breaker when not directed by the NNC
- using maintenance-level information to diagnose or take action
- using switches or controls intended only for maintenance.

Troubleshooting beyond checklist directed actions is rarely helpful and has caused further loss of system function or failure. In some cases, accidents and incidents have resulted. The crew should consider additional actions beyond the checklist only when completion of the published checklist steps clearly results in an unacceptable situation. In the case of airplane controllability problems when a safe landing is considered unlikely, airplane handling evaluations with gear, flaps or speedbrakes extended may be appropriate. In the case of jammed flight controls, do not attempt troubleshooting beyond the actions directed in the NNC unless the airplane cannot be safely landed with the existing condition. Always comply with NNC actions to the extent possible.

Crew distraction, caused by preoccupation with troubleshooting, has been a key factor in several fuel starvation and CFIT accidents. Boeing recommends completion of the NNC as published whenever possible, in particular for flight control malfunctions that are addressed by a NNC. Guidance for situations beyond the scope of the non-normal checklist is provided later in this chapter.

Approach and Landing

When a non-normal situation occurs, a rushed approach can often complicate the situation. Unless circumstances require an immediate landing, complete all corrective actions before beginning the final approach.

For some non-normal situations, the possibility of higher airspeed on approach, longer landing distance, a different flare profile or a different landing technique should be considered.

Plan an extended straight-in approach with time allocated for the completion of any lengthy NNC steps such as the use of alternate flap or landing gear extension systems. Arm autobrakes (as installed) and speedbrakes unless precluded by the NNC.

Note: The use of autobrakes (as installed) is recommended because maximum autobraking may be more effective than maximum manual braking due to timely application upon touchdown and symmetrical braking. However, the Advisory Information in the PI chapter of the FCOM provides Non-Normal Configuration Landing Distance data based on the use of maximum manual braking. When used properly, maximum manual braking provides the shortest stopping distance.

Fly a normal glide path and attempt to land in the normal touchdown zone. After landing, use available deceleration measures to bring the airplane to a complete stop on the runway. The captain must determine if an immediate evacuation should be accomplished or if the airplane can be safely taxied off the runway.

Landing at the Nearest Suitable Airport

Appendix A.2.6

"Plan to land at the nearest suitable airport" is a phrase used in the QRH. This section explains the basis for that statement and how it is applied.

In a non-normal situation, the pilot-in-command, having the authority and responsibility for operation and safety of the flight, must make the decision to continue the flight as planned or divert. In an emergency situation, this authority may include necessary deviations from any regulation to meet the emergency. In all cases, the pilot-in-command is expected to take a safe course of action.

The QRH assists flight crews in the decision making process by indicating those situations where “landing at the nearest suitable airport” is required. These situations are described in the Checklist Instructions or the individual NNC.

The regulations regarding an engine failure are specific. Most regulatory agencies specify that the pilot-in-command of a twin engine airplane that has an engine failure or engine shutdown shall land at the nearest suitable airport at which a safe landing can be made.

A suitable airport is defined by the operating authority for the operator based on 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 an engine failure), the guidance material also typically specifies that 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 evacuation. This may dictate landing at the nearest airport appropriate for the airplane type, rather than at the nearest suitable airport normally used for the route segment where the incident occurs.

Air Systems

Cabin Altitude Warning

There have been several reports of cabin altitude warning alerts caused by improperly configured engine bleed air and air conditioning pack switches. This condition is often the result of crews failing to reconfigure switches following a no engine bleed takeoff. Additionally, there have been reports of crews delaying their response to the cabin altitude warning alert because it was confused with the takeoff configuration warning horn.

In order to address the problem of incorrectly positioning switches that affect pressurization, the normal takeoff procedure has been modified to direct the crew to set or verify the correct position of the engine bleed air and air conditioning pack switches after flap retraction is complete. Engine bleeds and air conditioning packs have also been included as specific items in the After Takeoff normal checklist. Additionally, when doing a no engine bleed takeoff, reference to the No Engine Bleed Takeoff supplementary procedure, in conjunction with good crew coordination, reduces the possibility of crew errors.

On airplanes without the takeoff configuration and cabin altitude warning lights installed, confusion sometimes occurs between the cabin altitude warning horn and the takeoff configuration warning horn. This confusion can be resolved if the crew remembers that the takeoff configuration warning horn is only armed when the airplane is on the ground to indicate that the takeoff configuration is not correct for takeoff. If this horn is activated in flight, it indicates that the cabin altitude has reached 10,000 feet. In this case, the crew should immediately initiate the Cabin Altitude Warning or Rapid Depressurization NNC.

On airplanes with the takeoff configuration and cabin altitude warning lights installed, the TAKEOFF CONFIG light illuminates on the ground, when the takeoff configuration is not correct for takeoff. In flight, the CABIN ALTITUDE light illuminates when the cabin altitude is at or above 10,000 feet. In this case, the crew should immediately initiate the Cabin Altitude Warning or Rapid Depressurization NNC.

Ditching

Send Distress Signals

Transmit Mayday, current position, course, speed, altitude, situation, intention, time and position of intended touchdown, and type of aircraft using existing air-to-ground frequency. Set transponder code 7700 and, if practical, determine the course to the nearest ship or landfall.

Advise Crew and Passengers

Alert the crew and the passengers to prepare for ditching. Assign life raft positions (as installed) and order all loose equipment in the aircraft secured. Put on life vests, shoulder harnesses, and seat belts. Do not inflate life vests until after exiting the 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 having them report to the flight deck in person to ensure passenger cabin preparations for ditching are complete.

Ditching Final

Transmit final position. Select flaps 40 or landing flaps appropriate for the existing conditions.

Advise the cabin crew of imminent touchdown. On final approach announce ditching is imminent and advise crew and passengers to brace for 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 deploy slides/rafts. Evacuate as soon as possible, ensuring all passengers are out of the airplane.

Note: 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.

Engines, APU

Engine Failure vs Engine Fire After Takeoff

The NNC 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 NNC memory items. Due to asymmetric thrust considerations, Boeing recommends that the PF retard the affected thrust lever after the PM confirms that the PF has identified the correct engine. Reference items should be accomplished on a non-interfering basis with other normal duties after the flaps have been retracted and conditions permit.

Engine Tailpipe Fire

Engine tailpipe fires are typically caused by engine control malfunctions that result in the ignition of pooled fuel. These fires can be damaging to the engine and have caused unplanned passenger evacuations.

If a tailpipe fire is reported, the crew should accomplish the NNC without delay. Flight crews should consider the following when dealing with this situation:

- motoring the engine is the primary means of extinguishing the fire
- to prevent an inappropriate evacuation, flight attendants should be notified without significant delay
- communications with ramp personnel and the tower are important to determine the status of the tailpipe fire and to request fire extinguishing assistance
- the engine fire checklist is inappropriate because the engine fire extinguishing agent is not effective against a fire inside the tailpipe.

Loss of Engine Thrust Control

Engine response to a loss of control varies from engine to engine. Malfunctions have occurred in-flight and on the ground. The major challenge the flight crew faces when responding to this malfunction is recognizing the condition and determining which engine has malfunctioned. The Engine Limit/Surge/Stall NNC is written to include this malfunction. This condition can occur during any phase of flight.

Failure of engine or fuel control system components or loss of thrust lever position feedback has caused loss of engine thrust control. Engine thrust 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 or the response is abnormal.

Since recognition may be difficult, if a loss of engine thrust control is suspected, the flight crew should continue the takeoff or remain airborne until the NNC can be accomplished. This helps with directional control and may preclude an inadvertent shutdown of the wrong engine. In some conditions, such as during low speed ground operations, immediate engine shutdown may be necessary to maintain directional control.

High Engine 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 normally lower vibration levels. Vibration will likely become imperceptible as airspeed is further reduced during approach.

The impact of a vibrating environment on human performance is dependent on a number of factors, including the orientation of the vibration relative to the body. People working in a vibrating environment may find relief by leaning forward or backward, standing, or otherwise changing their body position.

Once airframe vibration has been reduced to acceptable levels, the crew must evaluate the situation and determine a new course of action based on weather, fuel remaining, and available airports.

Recommended Technique for an In-Flight Engine Shutdown

Appendix A.2.7

Any time an engine shutdown is required in flight, good crew coordination is essential. Airplane incidents have turned into airplane accidents as a result of the flight crew shutting down the incorrect engine.

When the flight path is under complete control, the crew should proceed with a deliberate, systematic process that identifies the correct engine and ensures that the operating engine is not shut down. Do not rush through the shutdown checklist, even for a fire indication. The following technique is an example that could be used:

When an engine shutdown is required, the PF disconnects the A/T (as installed). The PF then verbally coordinates confirmation of the affected engine with the PM and then slowly retards the thrust lever of the engine that will be shutdown.

Coordinate activation of the start lever as follows:

- PM places a hand on and verbally identifies the start lever for the engine that will be shutdown
- PF verbally confirms that the PM has identified the correct start lever
- PM moves the start lever to cutoff.

If the NNC requires activation of the engine fire switch, coordinate as follows:

- PM places a hand on and verbally identifies the engine fire switch for the engine that is shutdown
- PF verbally confirms that the PM has identified the correct engine fire switch
- PM pulls the engine fire switch.

Bird Strikes

Experience shows that bird strikes are common in aviation. Most bird strikes occur at very low altitudes, below 500 feet AGL. This section deals with bird strikes that affect the engines.

Recent studies of engine bird strikes reveal that approximately 50% of engine bird strikes damage the engine(s). The risk of engine damage increases proportionally with the size of the bird and with increased engine thrust settings. When an engine bird strike damages the engine, the most common indications are significant vibrations due to fan blade damage and an EGT increase.

Note: After any bird strike, the engines should be inspected by maintenance.

Preventative Strategies

Airports are responsible for bird control and should provide adequate wildlife control measures. If large birds or flocks of birds are reported or observed near the runway, the crew should consider:

- delaying the takeoff or landing when fuel permits. Advise the tower and wait for airport action before continuing
- takeoff or land on another runway that is free of bird activity, if available.

To prevent or reduce the consequences of a bird strike, the crew should:

- discuss bird strikes during takeoff and approach briefings when operating at airports with known or suspected bird activity.
- be extremely vigilant if birds are reported on final approach
- if birds are expected on final approach, plan additional landing distance to account for the possibility of no thrust reverser use if a bird strike occurs.

Note: The use of weather radar to scare the birds has not been proven effective.

Crew Actions for a Bird Strike During Takeoff

If a bird strike occurs during takeoff, the decision to continue or reject the takeoff is made using the criteria found in the Rejected Takeoff maneuver of the QRH.

If a bird strike occurs above 80 knots and prior to V1, and there is no immediate evidence of engine failure (e.g. failure, fire, power loss, or surge/stall), the preferred option is to continue with the take off followed by an immediate return, if required.

Crew Actions for a Bird Strike During Approach or Landing

If the landing is assured, continuing the approach to landing is the preferred option. If more birds are encountered, fly through the bird flock and land. Maintain as low a thrust setting as possible.

If engine ingestion is suspected, limit reverse thrust on landing to the amount needed to stop on the runway. Reverse thrust may increase engine damage, especially when engine vibration or high EGT is indicated.

Evacuation

If an evacuation is planned and time permits, a thorough briefing and preparation of the crew and passengers improves the chances of a successful evacuation. Flight deck preparations should include a review of pertinent checklists and any other actions to be accomplished. Appropriate use of autobrakes (as installed) should be discussed. If evacuating due to fire in windy conditions, consider positioning the airplane so the fire is on the downwind side.

Notify cabin crew of possible adverse conditions at the affected exits. The availability of various exits may differ for each situation. Crewmembers must make the decision as to which exits are usable for the circumstances.

For unplanned evacuations, the captain needs to analyze the situation carefully before initiating an evacuation order. Quick actions in a calm and methodical manner improve the chances of a successful evacuation.

Method of Evacuation

When there is a need to evacuate passengers and crew, the captain has to choose between commanding an emergency evacuation using the emergency escape slides or less urgent means such as deplaning using stairs, jetways, or other means. All available sources of information should be used to determine the safest course of action including reports from the cabin crew, other aircraft, and air traffic control. The captain must then determine the best means of evacuation by carefully considering all factors. These include, but are not limited to:

- the urgency of the situation, including the possibility of significant injury or loss of life if a significant delay occurs
- the type of threat to the airplane, including structural damage, fire, reported bomb on board, etc.
- the possibility of fire spreading rapidly from spilled fuel or other flammable materials
- the extent of damage to the airplane
- the possibility of passenger injury during an emergency evacuation using the escape slides.

If in doubt, the crew should consider an emergency evacuation using the escape slides.

If there is a need to deplane passengers, but circumstances are not urgent and the captain determines that the Evacuation NNC is not needed, the normal shutdown procedure should be completed before deplaning the passengers.

Discharging Fire Bottles during an Evacuation

The evacuation NNC specifies discharge of the engine or APU fire bottles if an engine or APU fire warning light is illuminated. However, evacuation situations can present possibilities regarding the potential for fire that are beyond the scope of the NNC and may not activate an engine or APU fire warning. The crew should consider the following when deciding whether to discharge one or more fire bottles into the engines and/or APU:

- if an engine fire warning light is not illuminated, but a fire indication exists or a fire is reported in or near an engine, discharge both available fire bottles into the affected engine
- if the APU fire warning light is not illuminated, but a fire indication exists or a fire is reported in or near the APU, discharge the APU bottle
- the discharged halon agent is designed to extinguish a fire and has very little or no fire prevention capability in the engine nacelles. Halon dissipates quickly into the atmosphere
- there is no reason to discharge the engine or APU fire bottles for evacuations not involving fire indications existing or reported in or near an engine or APU, e.g., cargo fire, security or bomb threat, etc.

Flight Controls

Leading Edge or Trailing Edge Device Malfunctions

Leading edge or trailing edge device malfunctions can occur during extension or retraction. This section discusses all flaps up and partial or asymmetrical leading/trailing edge device malfunctions for landings.

All Flaps Up Landing

The probability of both leading and trailing edge devices failing to extend is remote. If an all 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 maneuver speed. Establish final approximately 10 NM from the runway. This allows time to extend the gear and decelerate to the target speed while in level flight and complete all required checklists. Maintain no slower than flaps up maneuver 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. Before intercepting the descent profile, decrease airspeed to command speed and maintain this speed until the landing is assured.

The normal rate of descent on final is approximately 900 fpm due to the higher ground speed. Final approach body attitude is approximately 1° - 2° higher than a flaps 30 approach. Do not make a flat approach (shallow glide path angle) or aim for the threshold of the runway. Use a normal aim point approximately 1,000 feet down the runway.

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.

For airplanes equipped with the SP-177 autopilot, use manual control of thrust levers. Due to automatic speed protection, autothrottle use may result in higher than desired speed on final. Do not use autoland.

Note: Use of the autopilot during approach phase is acceptable.

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 an 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 needed to achieve touchdown at the desired point and to lower the nose wheels to the runway. After lowering the nose wheels to the runway, hold light forward control column pressure and expeditiously accomplish the landing roll procedure. Full reverse thrust is needed for a longer period of time.

Use of autobrakes (as installed) is recommended. Autobrake setting should be consistent with runway length. 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 (as installed) 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 Flaps Transit - Landing

If an asymmetrical or skewed leading edge device condition occurs, use the LEADING EDGE FLAPS TRANSIT NNC to determine the flap setting and VREF for approach. VREF provides 15° bank angle maneuver capability and allows 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 15, a landing gear configuration warning occurs.

Trailing Edge Flap Asymmetry - Landing

If an uncommanded roll occurs when the flaps change position, or the left and right flap indications disagree, use the Trailing Edge Flap Asymmetry NNC to configure the airplane for approach and landing. If a trailing edge flap asymmetry exists, full maneuver capability exists even if the asymmetry occurred with flaps just out of the full up position.

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 an 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 15, a landing gear configuration warning occurs.

Flap Extension using the Alternate System

When extending the flaps using the alternate system, the recommended method for setting command speed differs from the method used during normal flap extension. Since the flaps extend more slowly when using the alternate system, it is recommended that the crew delay setting the new command speed until the flaps reach the selected position. This method may prevent the crew from inadvertently getting into a low airspeed condition if attention to airspeed is diverted while accomplishing other duties.

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 disengagement
- autopilot that cannot be engaged
- undershoot or overshoot of an altitude during autopilot level-off
- higher than normal control forces required during speed or configuration changes.

If any jammed flight control condition exists, both pilots should apply force to try to either clear the jam or activate the override feature. There should be no concern about damaging the flight control mechanism by applying too much force to either clear a jammed flight control or activate an override feature. Maximum force may result in some flight control surface movement with a jammed flight control. If the jam clears, both pilot’s flight controls are available.

Note: If a control is jammed due to ice accumulation, the jam may clear when moving to a warmer temperature.

Note: There is an override feature for the control wheel.

If the jam does not clear, activation of an override feature allows a flight control surface to be moved independent of the jammed control. Applying force to the non-jammed flight control activates the override feature. When enough force is applied, the jammed control is overridden allowing the non-jammed control to operate. To identify the non-jammed flight control, apply force to each flight control individually. The flight control that results in the greatest airplane control is the non-jammed control.

Note: The pilot of the non-jammed control should be the pilot flying for the remainder of the flight.

The non-jammed control requires a normal force, plus an additional override force to move the flight control surface. For example, if a force of 10 lbs (4 kgs) is normally needed to move the surface, and 50 lbs (23 kgs) of force is needed to activate the override, a total force of 60 lbs (27 kgs) is needed to move the control surface while in override. Response is slower than normal with a jammed flight control; however, sufficient response is available for airplane 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 airplane control and landing.

Trim Inputs

If a jammed flight control condition exists, use manual inputs from other control surfaces to counter pressures and maintain a neutral flight control condition. The following table provides trim inputs that may be used to counter jammed flight control conditions.

Jammed Control Surface	Manual Trim Inputs
Elevator	Stabilizer
Aileron	Rudder
Rudder	Aileron

Note: Asymmetric engine thrust may aid roll and directional control.

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.

Stabilizer Trim Inoperative

The stabilizer trim may become inoperative for number of reasons. The most common reason is a failed stabilizer motor. This failure mode causes a loss of electric trim through both the autopilot and control wheel switches, but manual trim is still available using the trim wheels. This failure mode is addressed using the Stabilizer Trim Inoperative NNC.

Other, less common failure modes that are also addressed using the Stabilizer Trim Inoperative NNC include:

- a lodged or stuck stabilizer motor. This failure mode causes a loss of electric trim through both the autopilot and control wheel switches, but manual trim is still available using the trim wheels by overriding autopilot and main electric trim brake systems. The effort needed to manually rotate the trim wheels in this condition is higher than normal
- a lodged or stuck stabilizer actuator. This failure mode causes a loss of electric trim through both the autopilot and control wheel switches and a loss of manual trim. The result is a stabilizer that cannot be trimmed. Flight tests have demonstrated the airplane can be flown and landed safely with stabilizer trim inoperative
  - a lodged or stuck stabilizer actuator can be the result of ice on the jackscrew. If the crew suspects that the failure could be due to ice accumulation, descend to a warmer temperature and try again.

Runaway Stabilizer

Hold the control column firmly to maintain the desired pitch attitude. If uncommanded trim motion continues, the stabilizer trim commands are interrupted when the control column is displaced in the opposite direction.

Manual Stabilizer Trim

If manual stabilizer trim is necessary, ensure both stabilizer trim cutout switches are in CUTOUT prior to extending the manual trim wheel handles.

Excessive airloads on the stabilizer may require effort by both pilots to correct the mis-trim. In extreme cases it may be necessary to aerodynamically relieve the airloads to allow manual trimming. Accelerate or decelerate towards the in-trim speed while attempting to trim manually.

Anticipate the trim changes required for the approach. Configure the airplane early in the approach. When reaching the landing configuration, maintain as constant a trim setting as possible. If a go-around is required, anticipate the trim changes as airspeed increases.

Flight Control Low Pressure - Rudder Pressure Reducer

In the event the System A flight control LOW PRESSURE light illuminates, the Flight Control Low Pressure NNC should normally be accomplished. However, if this light illuminates at 700 feet radio altitude because the rudder pressure reducer failed to transition to normal pressure, the flight crew should continue to land. With the System A rudder pressure at low pressure, sufficient rudder control is available to handle crosswinds up to the crosswind landing guidelines provided in Chapter 6. In the event of a go-around, the Flight Control Low Pressure NNC should then be accomplished prior to landing. Autopilot autoland operations are not affected by the System A flight control LOW PRESSURE light illuminated due to the rudder pressure reducer at low pressure.

Standby Rudder On (As Installed)

The STANDBY RUDDER ON light illuminates any time the standby rudder PCU is operating. If this light illuminates independent of crew action or a hydraulic system malfunction, either of two conditions may have occurred. The most probable cause is a force fight monitor malfunction inadvertently activating the standby pump and powering the standby PCU. In this case, three PCU control valves power the rudder and full rudder inputs should be avoided to prevent applying excessive loads on the rudder. The NNC is written for this condition. The second cause may be because of a pressure difference between the two main PCU control valves indicating a jammed condition. This condition does not require a NNC because satisfactory rudder operation is available using the standby rudder PCU.

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, pressure trapped within the system reacts unpredictably. The pressure may increase through expansion, decrease through contraction, or remain constant. In all cases, the airspeed indications would be abnormal. This could mean increasing indicated airspeed in climb, decreasing indicated airspeed in descent, or unpredictable indicated airspeed in cruise.

Increased reliance on automation has de-emphasized the practice of setting known pitch attitudes and thrust settings. However, should an airspeed unreliable incident occur, the flight crew should be familiar with the approximate pitch attitude and thrust setting for each phase of flight. This familiarity can be gained by noting the pitch attitude and thrust setting occasionally during normal flight. Any significant change in body attitude from the attitude normally required to maintain a particular airspeed or Mach number should alert the flight crew to a potential airspeed problem.

If abnormal airspeed is recognized, immediately set the memorized target pitch attitude and thrust setting for the aircraft configuration. When airplane control is established, accomplish the Airspeed Unreliable NNC. The crew should alert ATC if unable to maintain assigned altitude or if altitude indications are unreliable.

Memory items for target pitch and thrust must be accomplished as soon as it is suspected that airspeed indications are incorrect. The intent of having memorized pitch and thrust settings is to quickly put the airplane in a safe regime until the Airspeed Unreliable checklist can be referenced. The following assumptions and requirements were used in developing these memory items:

- The memorized settings are calculated to work for all model/engine combinations, at all weights and at all altitudes.
- The flaps up settings will be sufficient such that the actual airspeed remains above stick shaker and below overspeed.
- The flaps extended settings will be sufficient such that the actual airspeed remains above stick shaker and below the flap placard limit.
- The settings are biased toward a higher airspeed as it is better to be at a high energy state than a low energy state.

- These memorized settings are to allow time to stabilize the airplane, remain within the flight envelope without overspeed or stall, and then continue with reference to the checklist.
- Settings are provided for flight with and without flaps extended. The crew should use the setting for the condition they are in to keep the airplane safe while accessing the checklist.

The memorized pitch and thrust setting for the current configuration (flaps extended/flaps up) should be applied immediately with the following considerations:

- The flaps extended pitch and thrust settings will result in a climb.
- The flaps up pitch and thrust settings will result in a slight climb at light weights and low altitudes, and a slight descent at heavy weights and high altitudes.
- At light weight and low altitude, the true airspeed will be higher than normal, but within the flight envelope. At heavy weight and high altitude, the same settings will result in airspeed lower than normal cruise but within the flight envelope.
- The goal of these pitch and power settings is to maintain the airplane safely within the flight envelope, not to maintain a specific climb or level flight.
- The current flap position should be maintained until the memory pitch and thrust settings have been set and the airplane stabilized. If further flap extension/flap retraction is required refer to PI-QRH Airspeed Unreliable table.

In order to determine if a reliable source of indicated airspeed is available, the Airspeed Unreliable checklist says "When in trim and stabilized, cross check the captain, first officer and standby airspeed indicators." The intent of this statement is for the pilot flying to set the pitch attitude and thrust setting from the PI-QRH Flight With Unreliable Airspeed table and allow the airplane to stabilize before comparing the airspeed indications to those shown in the table.

The airplane is considered stabilized when the thrust and pitch have been set, and the pitch is trimmed with no further trim movement needed to maintain the pitch setting. This is not an instantaneous process, and must be complete before comparing indicated and expected airspeeds for accurate results.

If it is determined that none of the airspeed indicators are reliable, the PI-QRH tables should be used for the remainder of the flight. Flight crews need to ensure they are using the table and values appropriate for phase of flight and airplane configuration.

- When changing phase of flight or airplane configuration, make initial thrust change, set pitch attitude, configure the airplane as neeeded, then recheck thrust and pitch, and trim as needed. Do not change configuration until the airplane is trimmed and stabilized.

If the flight crew is aware of the problem, flight without the benefit of valid airspeed information can be safely conducted and should present little difficulty. Early recognition of erroneous airspeed indications requires familiarity with the interrelationship of attitude, thrust setting, and airspeed. A delay in recognition could result in loss of airplane control.

Ground speed information is available from the FMC and on the instrument displays (as installed). These indications can be used as a crosscheck. 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 maneuver speed or approach speed for the existing airplane configuration.

Descent

Idle thrust descents to 10,000 feet can be made by flying body attitude and checking rate of descent in the QRH/PI tables. At 2,000 feet above the selected level off altitude, reduce rate of descent to 1,000 FPM. On reaching the selected altitude, establish pitch 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 the QRH 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.

Pitch and Thrust Reference for Airspeed Unreliable

The following table provides pitch and thrust settings calculated to work for all model/engine combinations, at all weights and at all altitudes.

	Flaps Extended		Flaps Up	
Model	**Pitch Attitude (degrees)**	**Thrust (N1)**	**Pitch Attitude (degrees)**	**Thrust (N1)**
737	10	80	4	75

Fuel

Fuel Balance

The primary purpose for fuel balance limitations on Boeing airplanes is for the structural life of the airframe and landing gear and not for controllability. A reduction in structural life of the airframe or landing gear can be caused by frequently operating with out-of-limit fuel balance conditions. Lateral control is not significantly affected when operating with fuel beyond normal balance limits.

The fuel balance limit also indicates that imbalances beyond the current state may result in increased trim drag and higher fuel consumption. The Fuel Balancing supplementary procedure should be accomplished when the fuel balance limit is reached.

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 unexpectedly coming from the tank with the lowest quantity.

Fuel Balancing Considerations

The crew should consider the following when performing fuel balancing procedures:

- use of the Fuel Balancing Supplementary Procedure in conjunction with good crew coordination reduces the possibility of crew errors
- routine fuel balancing when not near the imbalance limit increases the possibility of crew errors and does not significantly improve fuel consumption
- during critical phases of flight, fuel balancing should be delayed until workload permits. This reduces the possibility of crew errors and allows crew attention to be focused on flight path control
- fuel imbalances that occur during approach need not be addressed if the reason for the imbalance is obvious (e.g. engine failure or thrust asymmetry, etc.).

Fuel Leak

Any time an unexpected fuel quantity indication or imbalance condition is experienced, a fuel leak should be considered as a possible cause. Maintaining a fuel log and comparing actual fuel burn to the flight plan fuel burn can help the pilot recognize a fuel leak.

Significant fuel leaks, although fairly rare, are difficult to detect. The Engine Fuel Leak NNC assumes the leak is between the front spar and the engine. This is the most common type of fuel leak since fuel lines are exposed in the strut. Most other fuel lines, such as a crossfeed manifold, are contained within the tanks. A significant fuel leak directly from a tank to the outside is very rare due to the substantial wing structure that forms the tanks.

There is no specific fuel leak annunciation on the flight deck. A leak must be detected by discrepancies in the fuel log, by visual confirmation, or by some annunciation that occurs because of a leak. Any unexpected change in fuel quantity or fuel balance should alert the crew to the possibility of a leak. If a leak is suspected, it is imperative to follow the NNC.

The NNC leads the crew through steps to determine if the fuel leak is from the strut or engine area. If an engine fuel leak is confirmed, the NNC directs the crew to shutdown the affected engine. There are two reasons for the shutdown. The first is to close the spar valve, which stops the leak. This prevents the loss of fuel which could result in a low fuel state. The second reason is that the fire potential is increased when fuel is leaking around the engine. The risk of fire increases further when the thrust reverser is used during landing. The thrust reverser significantly changes the flow of air around the engine which can disperse fuel over a wider area.

Low Fuel

A low fuel condition exists when the indicated fuel quantity in either main tank is 1,000 pounds/453 kilograms of fuel or less.

Approach and Landing

In a low fuel condition, the clean configuration should be maintained as long as possible during the descent and approach to conserve fuel. However, initiate configuration changes early enough to provide a smooth, slow deceleration to final approach speed to prevent fuel from running forward in the tanks.

A normal landing configuration and airspeed appropriate for the wind conditions are recommended.

Runway conditions permitting, heavy braking and high levels of reverse thrust should be avoided to prevent uncovering all fuel pumps and possible engine flameout during landing roll.

Go-Around

If a go-around is necessary, apply thrust slowly and smoothly and maintain the minimum nose-up body attitude required for a safe climb gradient. Avoid rapid acceleration of the airplane. If any wing tank fuel pump low pressure light illuminates, do not turn the fuel pump switches off.

Hydraulics

Proper planning of the approach is important. Consideration should be given to the effect the inoperative system(s) has on crosswind capabilities, autoflight, stabilizer trim, control response, control feel, reverse thrust, stopping distance, go-around configuration and performance required to reach an alternate airfield.

Hydraulic System(s) Inoperative - Landing

If the landing gear is extended using manual gear extension, the gear cannot be raised. Trailing edge flaps can be extended or retracted using the alternate (electric) system. However, the rate of flap travel is significantly reduced. Leading edge devices can also be extended using the alternate system, but they cannot be retracted.

Flaps 15 is used to improve go-around capabilities. 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.

If nose wheel steering is inoperative and any crosswind exists, consideration should be given to landing on a runway where braking action is reported as good or better. Braking action becomes the primary means of directional control below approximately 60 knots where the rudder becomes less effective. If controllability is satisfactory, taxi clear of the runway using differential thrust and brakes. Continued taxi with nose wheel steering inoperative is not recommended due to airplane control difficulties and heat buildup in the brakes.

Manual Reversion

With both hydraulic systems A and B inoperative, the ailerons and elevator are controlled manually. A noticeable dead band will be observed in both of these controls. High control forces are required for turns and the control wheel must be forcibly returned to the aileron neutral position.

Both electric and manual trim are still functional. Do not overtrim. The airplane should be trimmed slightly nose up and a light forward pressure held on the control column to minimize the effects of the elevator dead band.

The rudder is powered by the standby hydraulic system. Caution must be exercised to not overcontrol the rudder.

Fly a long straight-in approach. Keep thrust changes small and slow to allow for pitch trim changes. Landing configuration and approach airspeed should be established on the runway centerline so that only a slight reduction in thrust is required to achieve the landing profile. Do not make a flat approach. Anticipate the airplane will tend to pitch down as thrust is reduced for touchdown. To help reduce the pitch down tendency, trim slightly nose up on approach and initiate the flare at a higher than normal altitude. Although trimming during the flare is not normally recommended, the high control column forces required during landing in this situation can be reduced by adding a small amount of nose up trim during the flare.

After touchdown, thrust reverser operation is slow. Apply steady brake pressure since only accumulator pressure is available. Do not apply excessive forward pressure to the control column. Excessive forward pressure without the speedbrakes deployed can result in less weight on the main gear and reduced braking capability.

Do not attempt to taxi the airplane after stopping because the accumulator pressure may be depleted or close to being depleted.

If a go-around is required, apply thrust smoothly and in coordination with stabilizer trim. Rapid thrust application results in nose-up pitch forces.

Landing Gear

Landing Gear Lever Jammed in the Up Position

The landing gear could be jammed in the UP position due to a mechanical jam of the landing gear handle, or if the landing gear selector valve is stuck in the up position. Either condition results in the landing gear remaining pressurized in the UP position.

The LANDING GEAR LEVER JAMMED IN THE UP POSITION NNC has the crew attempt to bypass the solenoid linkage by pulling the landing gear override trigger. If the landing gear cannot be extended due to a mechanical jam of the landing gear handle, this may allow the crew to resolve the jam without having to depressurize hydraulic system A. If this action does not result in the landing gear lever moving to the DN position and all landing gear indicating down and locked, the landing gear is most likely jammed in the UP position because the landing gear selector valve is stuck in the up position. In this case, the checklist directs the crew to completely depressurize hydraulic system A to release the uplocks and allow the gears to extend.

Fully depressurizing hydraulic system A may require 10-15 minutes to complete because hydraulic system pressure must be bled off as each gear is extended. If sufficient fuel is not available to complete the NNC, a gear up or partial gear landing is preferable to running out of fuel while attempting to extend the gear. This NNC should not be performed if one or more gear is extended.

Tire Failure during or after Takeoff

If the crew suspects a tire failure during takeoff, the Air Traffic Service facility serving the departing airport should be advised of the potential for tire pieces remaining on the runway. The crew should consider continuing to the destination unless there is an indication that other damage has occurred (non-normal engine indications, engine vibrations, hydraulic system failures or leaks, etc.).

Continuing to the destination will allow the airplane weight to be reduced normally, and provide the crew an opportunity to plan and coordinate their arrival and landing when the workload is low.

Considerations in selecting a landing airport include, but are not limited to:

- sufficient runway length and acceptable surface conditions to account for the possible loss of braking effectiveness
- sufficient runway width to account for possible directional control difficulties
- altitude and temperature conditions that could result in high ground speeds on touchdown and adverse taxi conditions
- runway selection options regarding "taxi-in" distance after landing
- availability of operator maintenance personnel to meet the aircraft after landing to inspect the wheels, tires, and brakes before continued taxi
- availability of support facilities should the airplane need repair.

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 for directional control. With a single tire failure, towing is not necessary unless unusual vibration is noticed or other failures have occurred.

In the case of a flat nose wheel tire, slowly and gently lower the nose wheels to the runway while braking lightly. Runway length permitting, use idle reverse thrust. Autobrakes (as installed) 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 a main tire has failed, slowly and gently lower the nose wheels to the runway and do not use autobrakes (as installed). Differential braking may be required to steer the airplane. Use idle or higher reverse thrust as needed to stop the airplane.

Note: Extended taxi distances or fast taxi speeds can cause a significant increases in temperature on the remaining tires.

Partial or Gear Up Landing

Land on all available gear. The landing gear absorbs the initial shock and delays touchdown of airplane body parts. Recycling the landing gear in an attempt to extend the remaining gear is not recommended. A gear up or partial gear landing is preferable to running out of fuel while attempting to solve a gear problem.

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

If time and conditions permit, reduce weight as much as possible by burning off fuel to attain the slowest possible touchdown speed.

At the captain’s command, advise the crew and the passengers of the situation, as needed. Coordinate with all ground emergency facilities. For example, fire trucks normally operate on a common VHF frequency with the airplane and can advise the crew of the airplane condition during the landing. Advise the cabin crew to perform emergency landing procedures and to brief passengers on evacuation procedures.

The NNC instructs the crew to inhibit the ground proximity system as needed to prevent nuisance warnings when close to the ground with the gear retracted.

For landing in any gear configuration, establish approach speed early and maintain a normal rate of descent.

Landing Techniques

Attempt to keep the airplane on the runway to minimize airplane damage and aid in evacuation. After touchdown lower the nose gently before losing elevator effectiveness. Use all aerodynamic capability to maintain directional control on the runway. At touchdown speed, the rudder has sufficient authority to provide directional control in most configurations. At speeds below 60 knots, use nose wheel/rudder pedal steering, if available, and differential braking as needed.

Use of Speedbrakes

During a partial gear or gear up landing, speedbrakes should be extended only when stopping distance is critical. Extending the speedbrakes before all gear, or the nose or the engine nacelle in the case of a gear that does not extend, have contacted the runway may compromise controllability of the airplane.

Extending the speedbrakes after a complete touchdown also creates a risk of not being able to stow the speedbrakes after the airplane has come to a rest. If this is the case, there would be an increase in the probability of injuring passengers if the over wing exits are used for evacuation.

When landing with any gear that indicates up or partially extended, attempt to fly the area with the unsafe indication smoothly to the runway at the lowest speed possible, but before losing flight control effectiveness. A smooth touchdown at a low speed helps to reduce airplane damage and offers a better chance of keeping the airplane on the runway. Since the airplane is easier to control before body parts make ground contact, delay extending the speedbrakes until after the nose and both sides of the airplane have completed touchdown. If the speedbrakes are deployed before all areas have made contact with the runway, the airplane will complete touchdown sooner and at a higher speed.

Some crews or operators may elect to avoid the use of speedbrakes during any landing with a partial gear indication. However, most partial gear indications are the result of an indicator malfunction rather than an actual gear up condition. If the crew elects not to use speedbrakes during landing, be aware that stopping distance may rapidly become critical if all gear remain extended throughout touchdown and rollout.

Use of Reverse Thrust

During a partial gear or gear up landing, an engine making ground contact could suffer sufficient damage such that the thrust reverser mechanism may not operate. Selecting reverse thrust with any gear not extended may produce an additional asymmetric condition that makes directional control more difficult. Reverse thrust should be used only when stopping distance is critical.

If reverse thrust is needed, keep in mind that the airplane is easier to control before body parts make ground contact. If the thrust reversers are deployed before all gear, or the nose or the engine nacelle in the case of a gear that does not extend, have made contact with the runway, the airplane will complete touchdown sooner and at a higher speed.

After Stop

Accomplish an evacuation, if needed.

Partial or Gear Up Combinations

Both Main Gear Extended with Nose Gear Up

Land in the center of the runway. After touchdown lower the nose gently before losing elevator effectiveness.

Nose Gear Only Extended

Land in the center of the runway. Use normal approach and flare attitudes maintaining back pressure on the control column until ground contact. The engines contact the ground prior to the nose gear.

One Main Gear Extended and Nose Gear Extended

Land the airplane on the side of the runway that corresponds to the extended main gear down. At touchdown, maintain wings level as long as possible. Use rudder and nose wheel steering for directional control. After all gear, or the engine nacelle where the gear is not extended, have made contact with the runway, braking on the side opposite the unsupported wing should be used as needed to keep the airplane rolling straight.

One Main Gear Only Extended

Land the airplane on the side of the runway that corresponds to the extended main gear down. At touchdown, maintain wings level as long as possible. Use rudder for directional control. After all gear, or the nose or the engine nacelle in the case of gear that do not extend, have made contact with the runway, braking on the side opposite the unsupported wing should be used as needed to keep the airplane rolling straight.

All Gear Up or Partially Extended

Land in the center of the runway. The engines contact the ground first. There is adequate rudder available to maintain directional control during the initial portion of the ground slide. Attempt to maintain the centerline while rudder control is available.

Overspeed

VMO/MMO is the airplane maximum certified operating speed and should not be exceeded intentionally. However, crews can occasionally experience an inadvertent overspeed. For example, during cruise at high altitude, wind speed or direction changes may lead to overspeed events. Also, some windshears and wave activity speed changes are beyond the capability of the autothrottle system (as installed) to prevent short term overspeeds. Airplanes have been flight tested beyond VMO/MMO to ensure smooth pilot inputs will return the airplane safely to the normal flight envelope.

When encountering an inadvertent overspeed condition, crews should leave the autopilot engaged unless it is apparent that the autopilot is not correcting the overspeed. However, if manual inputs are required, disengage the autopilot. Be aware that disengaging the autopilot to avoid or reduce the severity of an inadvertent overspeed may result in an abrupt pitch change.

When correcting an overspeed during cruise at high altitude, avoid reducing thrust to idle which results in slow engine acceleration back to cruise thrust and may result in over-controlling the airspeed or a loss of altitude. If autothrottle (as installed) corrections are not satisfactory, deploying partial speedbrakes slowly can assist in reducing speed and avoiding the need for idle thrust. When the airspeed is below VMO/MMO, retract the speedbrakes at the same rate as they were deployed.

For airplanes equipped with the SP-177 autopilot, during climb or descent, if LVL CHG pitch control is not correcting the overspeed satisfactorily, switching to the V/S mode temporarily may be helpful in controlling speed. In the V/S mode, the selected vertical speed can be adjusted slightly to increase the pitch attitude to help correct the overspeed. As soon as the speed is below VMO/MMO, LVL CHG may be re-selected.

Note: Anytime VMO/MMO is exceeded, the maximum airspeed should be noted in the flight log.

Tail Strike

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

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

Takeoff Risk Factors

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

Mistrimmed Stabilizer

This usually results from using erroneous takeoff data, e.g., the wrong weights, or an incorrect center of gravity (CG). In addition, sometimes accurate information is 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 airplane can assist in approximating numbers that are reasonable.

Rotation at Improper Speed

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

Trimming during Rotation

Trimming the stabilizer during rotation may contribute to a tail strike. The pilot flying may easily lose the feel of the elevator while the trim is running which may result in an excessive rotation rate.

Excessive Rotation Rate

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 (SP-177)

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°. 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 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. See the section titled “Stabilized Approach Recommendations” in chapter 5 of this manual for more detailed information the stabilized approach.

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.

Mishandling of Crosswinds

When the airplane is placed in a sideslip attitude to compensate for the wind effects, this cross-control maneuver reduces lift, increases drag, and may increase the rate of descent. If the airplane then descends into a turbulent surface layer, particularly if the wind is shifting toward the tail, the stage is set for tail strike.

The combined effects of high closure rate, shifting winds with the potential for a quartering tail wind, can result in a sudden drop in wind velocity commonly found below 100 feet. Combining this with turbulence can make the timing of the flare very difficult. The pilot flying can best handle the situation by using additional thrust, if needed, and by using an appropriate pitch change to keep the descent rate stable until initiation of the flare. Flight crews should clearly understand the criteria for initiating a go-around and plan to use this 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 (as installed) 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.

Warning Systems

If an unexpected landing gear configuration or GPWS alert occurs, the flight crew must ensure the proper configuration for the phase of flight. Time may be required in order to assess the situation, take corrective action and resolve the discrepancy. Flight path control and monitoring of instruments must never be compromised.

Note: If the warning occurs during the approach phase, a go-around may be necessary, followed by holding or additional maneuvering.

Wheel Well Fire

Prompt execution of the Wheel Well Fire NNC 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.

For airplanes equipped with the SP-77 autopilot, a rapid way to reduce airspeed during a climb or descent is to set altitude hold and reduce thrust as the airplane levels off to fly approximately 250 knots.

Note: For airplanes equipped with the SP-177 autopilot, to avoid unintended deceleration below the new target airspeed, the autothrottle should remain engaged.

For airplanes equipped with the SP-177 autopilot, a rapid way to reduce airspeed during a climb or descent is to select altitude hold and set approximately 250 knots. This technique results in the autothrottle reverting to the SPD mode and provides a more rapid speed reduction than using LVL CHG.

Note: Additionally, thrust levers may be reduced to idle and/or speedbrakes may be used to expedite deceleration.

If the pitch mode is LVL CHG and the crew wishes to remain in that mode, simply set approximately 250 knots. This technique does not result in as rapid a speed reduction as reverting to the SPD mode, but allows the crew to remain in the pitch mode in use.

Windows

Window Damage

To do the Window Damage NNC, the flight crew may need to determine if the inner pane of the affected window is cracked or shattered. This can be done by placing the point of an object such as a pencil on the crack, and then moving the head while focusing on the point of the object. If the crack appears to move relative to the point of the object, the crack is not in the inner pane. If the crack does not appear to move relative to the point of the object, the crack is in the inner pane. A crack in the inner pane may also be detected by running a fingernail across the window’s surface.

On window 4, these checks will not aid in determining if a middle or outer pane is cracked or shattered. Since it is unlikely that the crew can tell whether a window 4 middle or outer pane is cracked or shattered, the checklist directs action based on a middle pane cracked or shattered.

On window 1, 2, 3 heated, and 5, if the flight crew is uncertain which pane is cracked or shattered, assume that the inner pane is cracked or shattered and continue with the checklist.

If both forward windows delaminate or forward vision is unsatisfactory, accomplish an ILS autoland, if available.

Flight with the Side Window(s) Open

The inadvertent opening of an unlatched flight deck window by air loads during the takeoff roll is not considered an event that warrants a high speed RTO. Although the resulting noise levels may interfere with crew communications, it is safer to continue the takeoff and close the window after becoming airborne and the flight path is under control. The flight may be continued once the window is closed and locked and pressurization is normal. If the window is damaged and will not close, return to the departure airport.

If needed, the windows may be opened in-flight after depressurizing the airplane. It is recommended that the airplane be slowed since the noise levels increase at higher airspeed. Maneuver speed for the current flap setting is a good target speed. Intentions should be briefed and ATC notified prior to opening the window as the noise level can be high and make communications difficult, even at slow speeds. However, there is very little turbulence on the flight deck. 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 NNCs 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 NNCs to cover all events.

The following guidelines may aid the flight crew in determining the proper course of action should an in-flight event of this type be encountered. Although these guidelines represent what might be called “conventional wisdom”, circumstances determine the course of action which the crew perceives will conclude the flight in the safest manner.

Basic Aerodynamics and Systems Knowledge

Knowledge of basic aerodynamic principles and 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° in the event maneuver capability is in question. Increasing the normal flap/speed maneuver schedule while staying within flap placard limits provides extra stall margin where greater bank angles are necessary
- all Boeing airplanes have the capability to land using any flap position, including flaps up. Use proper maneuver and final approach speeds and ensure adequate runway is available to stop the 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 NNC. 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.

Checklists with Memory Steps

After flight path control has been established, do the memory steps of appropriate NNCs. The emphasis at this point should be on containment of the problem. Reference steps are initiated after the airplane flight path and configuration are properly established.

Complete all applicable NNCs prior to beginning final approach. Exercise common sense and caution when accomplishing multiple NNCs with conflicting 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. Make configuration and airspeed changes slowly until a damage assessment and airplane handling evaluation have been done and it is certain that lower airspeeds can be safely used. In addition, limit bank angle to 15° and avoid large or rapid changes in engine thrust and airspeed that might adversely affect controllability. If possible, conduct the damage assessment and handling evaluation at an altitude that provides a safe margin for recovery should flight path control be inadvertently compromised. It is necessary for the flight crew to use good judgment in consideration of the existing conditions and circumstances to determine an appropriate altitude for this evaluation.

The evaluation should start with an examination of flight deck indications to assess damage. Consideration should be given to the potential cumulative effect of the damage. A thorough understanding of 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 inform them of the situation and use them as a potential source of information. In addition to current and forecast weather, and airfield conditions, it may be possible to obtain technical information and recommendations from 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. 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 NNC. If stick shaker or initial stall buffet are encountered at or before reaching the associated flap speed, or if a rapid increase in wheel deflection and full rudder deflection are necessary to maintain wings level, increase speed to a safe level and consider this speed to be the minimum approach speed for the established configuration.

After the damage assessment and handling characteristics are evaluated, the crew should formulate a sequential plan for the completion of the flight.

If airplane performance is a concern, use of the alternate flap or gear extension systems may dictate that the check of airplane handling characteristics be done during the actual approach. Configuration changes made by the alternate systems may not be reversible. The crew must exercise extreme caution on final approach with special emphasis on minimum safe speeds and proper airplane configuration. If asymmetrical thrust is being used for roll control or pitch authority is limited, plan to leave thrust on until touchdown.

Landing Airport

The following items should be considered when selecting an airport for landing:

- weather conditions (VMC preferred)
- enroute time
- length of runway available (longest possible runway preferred, wind permitting)
- emergency services available
- flight crew familiarity
- other factors dictated by the specific situation.

Preface

Information contained in this appendix is provided by the operator of organizations that use the 737-200 Flight Crew Training Manual.

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Preface

Recommendations contained in this appendix are provided for the operations staff of operators that use the 737-200 Flight Crew Training Manual. Recommendations are based on Boeing experience, and are intended as guidance for consideration by each operator. Individual operators are responsible for determining the applicability of these recommendations to their operations. Some of these recommendations may need to be coordinated with applicable regulatory agencies.

Operational Philosophy

Events Requiring Maintenance Inspection

FCTM 1.1

Most operators establish procedures or policies to ensure that aircrews document ground or flight events which require a maintenance inspection after flight. Chapter 5 of the Aircraft Maintenance Manual (AMM) refers to such events as "Conditional Inspections". Additional events, that are not listed in chapter 5 but may require maintenance inspection, should also be addressed.

Callouts

FCTM 1.50

Recommended callouts are provided in the interest of good Crew Resource Management. Operators are encouraged to develop their own recommended callouts based upon their fleet configuration. Operators may modify, supplement, or eliminate recommended callouts provided in this manual as they determine best practices for their operational needs. However, procedural callouts found in this list should be accomplished as indicated in the Procedures section of the FCOM.

Cold Temperature Altitude Corrections

FCTM 1.16

Operator coordination with local and en route air traffic control facilities is recommended for each cold weather airport or route in the 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).

Push Back or Towing

FCTM 2.2

The development of specific pushback and towing procedures and policies are recommended which are tailored for specific operations. The flight operations and maintenance departments need to be primary in developing these procedures.

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

Engine Out Taxi

FCTM 2.16

If operator policies, procedures and flight crew familiarization materials are appropriately applied, EOT operations can be conducted safely and should be acceptable to flight crews and regulatory authorities.

Operator policies, procedures and flight crew familiarization materials should include, but not be limited to the following:

- airport layout
- taxiway composition
- taxiway slope
- foreign object damage (FOD)
- airplane system redundancy
- engine warm-up and cool down times
- fuel balancing
- crew workload and heads-down time
- current weather, including temperature and wind
- current taxiway surface conditions

Each operator should establish Standard Operating Procedures (SOP) for EOT operations. These SOPs should provide the flight crew with clear, concise guidance for EOT operations.

Boeing published Flight Operations Technical Bulletins titled “Engine Out Taxi” for the 737CL and 737NG models that are available on MyBoeingFleet. At this time there is no plan to provide a model specific bulletin for the 737-200/-200A. However, the Background Information and the Introduction part of the Engine Out Taxi Flight Operations Technical Bulletins for the 737CL and 737NG models contain information applicable for the 737-200/200A.

Crosswind Takeoff

Takeoff Crosswind Guidelines

FCTM 3.11

Crosswind guidelines are not considered limitations. Crosswind guidelines are provided to assist operators in establishing their own crosswind policies. These guidelines are based upon steady wind (no gust) conditions. Operators need to address the increased workload associated with gusts when developing their own crosswind policies.

Low Visibility Takeoff

FCTM A.3

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

FCTM 3.15

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.

Cruise

ETOPS

ETOPS Requirements and Approval

FCTM 4.11

FAA operators conducting ETOPS are required to comply with FAA regulations and Advisory Circulars. Other regulatory agencies may have different requirements or governing rules.

Operators must have an ETOPS configured airplane, and approved flight operations and maintenance programs in place to support ETOPS. These programs normally ensure that the ETOPS airplane is in compliance with the requirements of the appropriate Configuration, Maintenance and Procedures (CMP) documents. The operator's maintenance department must develop programs which monitor and report reliability of the engines, airframe and ETOPS significant components. The Minimum Equipment List (MEL) and the Dispatch Deviations Guide (DDG) have been expanded to address the improved redundancy levels and the additional equipment unique to ETOPS configured airplanes.

Note: Reference MyBoeingFleet for more information on ETOPS.

Flight and Performance

FCTM 4.11

Critical fuel calculations are part of the ETOPS dispatch process and are not normally calculated by the flight crew. The crew normally receives ETOPS critical fuel information in the Computer Flight Plan (CFP).

Approach

Approach Category

FCTM 1.3

An operator may use a different approach category as determined in coordination with the applicable regulatory authority.

ILS Approach

Low Visibility Approaches

AFDS System Configuration

FCTM 5.21

The airplane equipment needed for Category II and Category III approaches is contained in the AFM. Operators are responsible for reviewing their AFM to determine equipment needed and submit these requirements along with other data to their applicable regulator in order to get approval for Cat II or III operations. Operators who have been approved for Cat II and III operations and have airplanes certified for these operations need to provide this information to their pilots.

More detailed information concerning Category II and Category III operational requirements can be found in FAA advisory circulars or similar documents from other regulatory agencies. The manufactures demonstrated compliance with the airworthiness performance standards does not constitute approval to conduct operations in lower weather minimums.

AFDS Faults

FCTM 5.22

Operators are responsible for reviewing their AFM and FAA advisory circulars or similar documents from other regulatory agencies to establish a pilot response if any of the required airplane equipment fails or the AFDS is degraded during a Category II or Category III approach. However, the requirements in the AFM do not necessarily denote all of the systems and equipment required for the types of operation specified. Applicable regulations may prescribe an operational requirement for additional systems (e.g. autobrake).

The pilot response along with other data should be submitted to the applicable regulator for approval. The operator needs to provide this information to their pilots.

More detailed information concerning Category II and Category III operational requirements can be found in FAA advisory circulars or similar documents from other regulatory agencies. The manufactures demonstrated compliance with the airworthiness performance standards does not constitute approval to conduct operations in lower weather minimums.

Landing Roll

Factors Affecting Landing Distance

Slippery Runway Landing Performance

FCTM 6.17

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 operator to determine operating policies based on the training and operating experience of their flight crews.

Crosswind Landings

Landing Crosswind Guidelines

FCTM 6.26

Crosswind guidelines are not considered limitations. Crosswind guidelines are provided to assist operators in establishing their own crosswind policies. These guidelines are based upon steady wind (no gust) conditions. Operators need to address the increased workload associated with gusts when developing their own crosswind policies.

Rapid Descent

FCTM 7.5

Some routes over mountainous terrain require careful operator planning to include carrying additional oxygen, special procedures, higher initial level off altitudes, and emergency routes in the event a depressurization is experienced. These requirements are normally addressed in an approved company route manual or other document that addresses route specific depressurization procedures.

Non-Normal Situation Guidelines

Landing at the Nearest Suitable Airport

FCTM 8.3

A suitable airport is defined by the operating authority for the operator based on guidance material, but in general must have adequate facilities and meet certain minimum weather and field conditions.

Engines, APU

Recommended Technique for an In-Flight Engine Shutdown

FCTM 8.8

Operators may develop their own crew coordination techniques for an in-flight engine shutdown. This technique should ensure that the objectives stated in the body of this manual are met. The section titled Recommended Technique for an In-Flight Engine Shutdown contains an example that could be used.

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