Boeing 777/787 Operations Manual
BOEING 777/787 FCTM

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0 Contents

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1 Preface

1.1 Model Identification

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

Model
777-200
777-200LR
777-F
777-300ER
787-8
787-9
787-10

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.

777-200 – 777-300ER

If information is applicable to consecutively numbered models, a dash (–) is used in the model designator. For example, if information is applicable to 777-200 and 777-200LR and 777-300 models, but not the 777-300ER, the model designator will show 777-200 – 777-300.

777-200 – 777-300ER

If information is applicable to models that are not consecutively numbered, a comma (,) is used in the model designator. For example, if information is applicable to only 777-200 and 777-300ER models, the model designator will show 777-200, 777-300ER.

787-8 – 787-10

If information is applicable to consecutively numbered models, a dash (–) is used in the model designator. For example, if information is applicable to 787-8 and 787-9 models, but not the 787-10, the model designator will show 787-8 – 787-9.

787-8, 787-10

If information is applicable to models that are not consecutively numbered, a comma (,) is used in the model designator. For example, if information is applicable to only 787-8 and 787-10 models, the model designator will show 787-8, 787-10.

777-200 – 777-300ER

At this time there is no need for a unique model designator for the 777-200ER. All information that is applicable for the 777-200 also applies to the 777-200ER. If in the future, a need for a 777-200ER designator becomes necessary, it will be added.

1.2 Introduction

The Flight Crew Training Manual (FCTM) provides information and recommendations on maneuvers and techniques, developed and recommended by Boeing, and accepted by the FAA for use in flight operations. These maneuvers and techniques are provided as guidance and do not prevent the operator from developing equivalent maneuvers or techniques in accordance with the applicable operating rules. 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 or ECL 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 question about the content or use of this manual can be directed to either of the following via BA Virtual Forums or Discord:

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1.3 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 is at or above the flap 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.

1.4 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
ACT	Active
ADF	Automatic Direction Finder
ADI	Attitude Director Indicator
ADIRU	Air Data Inertial Reference Unit
AFDS	Autopilot Flight Director System
AFE	Above Field Elevation
AFM	Airplane Flight Manual (FAA approved)
AFM - DPI	Airplane Flight Manual - Digital Performance Information
AGL	Above Ground Level
AH	Alert Height
ALT ACQ	Altitude Acquire
ALT HOLD	Altitude Hold
AMM	Aircraft Maintenance Manual
ANP	Actual Navigation Performance
AOA	Angle of Attack

A/P	Autopilot
APU	Auxiliary Power Unit
AR	Authorization Required
ASA	Autoland Status Annunciator
ASI	Airspeed Indicator
ASR	Airport Surveillance Radar
A/T	Autothrottle
ATC	Air Traffic Control
ATM	Assumed Temperature Method
AUPRTA	Airplane Upset Prevention and Recovery Training Aid
B	
BARO	Barometric
B/CRS B/C	Back Course
C	
C	Captain Celsius Center
CAA	Civil Aviation Authority
CDFA	Continuous Descent Final Approach

CDU	Control Display Unit
CFIT	Controlled Flight Into Terrain
CFP	Computer Flight Plan
CFR	Code of Federal Regulations
CG	Center of Gravity
CLB	Climb
CMD	Command
CON	Continuous
CRM	Crew Resource Management
CRT	Cathode Ray Tube
CRZ	Cruise
D	
DA	Decision Altitude
DA(H)	Decision Altitude (Height)
D/D	Direct Descent
DDG	Dispatch Deviations Guide
DES	Descent
DIR	Direct
DME	Distance Measuring Equipment
DU	Display Unit
E	
EADI	Electronic Attitude Director Indicator
EASA	European Aviation Safety Agency
ECL	Electronic Checklist
ECON	Economy

EEC	Electronic Engine Control
EFB	Electronic Flight Bag
EFIS	Electronic Flight Instrument System
EGT	Exhaust Gas Temperature
EHSI	Electronic Horizontal Situation Indicator
EICAS	Engine Indication and Crew Alerting System
ENG OUT	Engine Out
EOT	Engine Out Taxi
EPR	Engine Pressure Ratio
ETA	Estimated Time of Arrival
ETOPS	Extended Operations
EXT	Extend
F	
F	Fahrenheit
FAC	Final Approach Course
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
FLCH	Flight Level Change
FMA	Flight Mode Annunciations
FMC	Flight Management Computer

FMS	Flight Management System
F/O	First Officer
FOD	Foreign Object Damage or Foreign Object Debris
FPA	Flight Path Angle
FPM	Feet Per Minute
FPV	Flight Path Vector
ft	Foot or Feet
G	
g	free fall acceleration of a body
GA	Go-Around
GBAS	Ground-Based Augmentation System
GLS	GBAS Landing System
GNSS	Global Navigation Satellite System
GP	Glide Path
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
G/S	Glide Slope
GS	Ground Speed
H	
HAA	Height Above Airport
HAT	Height Above Touchdown
HDG SEL	Heading Select
HSI	Horizontal Situation Indicator
HUD	Head Up Display

I	
IAF	Initial Approach Fix
IAN	Integrated Approach Navigation
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
IRS	Inertial Reference System
IRU	Inertial Reference Unit
ISA	International Standard Atmosphere
ISFD	Integrated Standby Flight Display
J	
JAA	Joint Aviation Authority
K	
K	Knots
KCAS	Knots Calibrated Airspeed
KGS	Kilograms
KIAS	Knots Indicated Airspeed
L	
LBS	Pounds

LDA	Localizer-type Directional Aid
LDS	Large Display System
LFDS	Large Format Display System
LNAV	Lateral Navigation
LOC	Localizer
LOM	Locator Outer Marker
LRC	Long Range Cruise
LVL CHG	Level Change
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
MFD	Multifunction Display
MKR	Marker
MM	Middle Marker
MMO	Maximum Mach Operating Speed
MOCA	Minimum Obstruction Clearance Altitude
MOD	Modify

MORA	Minimum Off Route Altitude
MSL	Mean Sea Level
N	
NAA	Navigation Aviation Authority
NAT HLA	North Atlantic High Level Airspace
NAV	Navigation
NAV RAD	Navigation Radio
ND	Navigation Display
NM	Nautical Mile(s)
NNC	Non-Normal Checklist
NNM	Non-Normal Maneuver
NPS	Navigation Performance Scales
N1	Low Pressure Rotor Speed
N2	High Pressure Rotor Speed
O	
OAT	Outside Air Temperature
OM	Outer Marker
OPT	Onboard Performance Tool
P	
PAPI	Precision Approach Path Indicator
PAR	Precision Approach Radar
PF	Pilot Flying
PFD	Primary Flight Display
PI	Performance Inflight

PIP	Product Improvement Package
PLI	Pitch Limit Indicator
PMC	Power Management Control
PM	Pilot Monitoring
PWS	Predictive Windshear System
Q	
QRH	Quick Reference Handbook
R	
RA	Radio Altitude Resolution Advisory
RAAS	Runway Awareness and Advisory System
RAIM	Receiver Autonomous Integrity Monitoring
RAT	Ram Air Turbine
RCAS	Roll Command Alerting System
RDMI	Radio Distance Magnetic Indicator
RMI	Radio Magnetic Indicator
RNAV	Area Navigation
RNP	Required Navigation Performance
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
SFP	Short Field Performance
SPD	Speed
STAR	Standard Terminal Arrival Route
T	
T	True
TA	Traffic Advisory or Tailored Arrival
TAC	Thrust Asymmetry Compensation
TACAN	Tactical Air Navigation
TAS	True Airspeed
TAT	Total Air Temperature
TCAS	Traffic Alert and Collision Avoidance System
TE	Trailing Edge
TFC	Traffic
TO	Takeoff
TDZE	Touchdown Zone Elevation
T/D	Top of Descent
TO/GA	Takeoff /Go-Around
TPR	Turbofan Power Ratio
TR	Traffic Resolution
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
VNAV	Vertical Navigation
VOR	VHF Omnidirectional Range
VR	Rotation Speed
VREF	Reference Speed
V/S	Vertical Speed
VSD	Vertical Situation Display
VSI	Vertical Speed Indicator
VTK	Vertical Track
V1	Takeoff Decision Speed
V2	Takeoff Safety Speed
W	
WGS-84	World Geodetic System of 1984
WPT	Waypoint
X	
XTK	Cross Track

2 General Information

2.1 Flight Deck Philosophy

This chapter outlines the Boeing flight deck design philosophy and 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.

The Boeing flight deck has changed significantly over the years with increased systems integration, automation and complexity. The flight training and flight manuals align with the Boeing flight deck design philosophy. An understanding of the design philosophies of the modern Boeing flight deck should reinforce the flight training and help flight crews deal with circumstances that may not be specifically covered in the operational flight manuals.

2.2 Key Elements of Flight Deck Design

- All displays and controls required for flight are designed to be viewable and reachable by both pilots or duplicated at each crew station and perform satisfactorily under all lighting conditions.
- Quiet or dark flight deck during normal operations. There are minimal indications of normal status.
- Alerts are categorized into time-critical warnings, warnings, cautions and advisories, and are prioritized by the urgency of required pilot response.
- Time critical warnings are non-normal operational or system condition requiring immediate crew awareness and corrective action to maintain safe flight
- Warnings alert the crew to a non-normal operational or system condition requiring immediate crew awareness and corrective action
- Cautions alert the crew to a non-normal operational or system condition requiring immediate crew awareness. Corrective action is required
- Advisories alert the crew to a non-normal operational or system condition requiring routine crew awareness. Corrective action can be required.
- Colors are consistent with industry standards and requirements. In general the colors used on the Boeing flight deck are:
- Red is the highest priority safety-related information. Warning level alerts are displayed in red with an aural, and require immediate awareness and corrective action. Red is also used for keep-out zones and do-not-exceed limits.
- Amber is the second priority safety-related information. Caution level alerts are displayed in amber with an aural, and require immediate crew awareness and subsequent response. Amber is also used for failure flags, non-normal sources, and regions of limited operation.
- Amber Advisories are displayed in amber text with no aural, and requires crew awareness and may require a response,

- Green is used to indicate active, engaged, selected and tuned. Green is also used to indicate fly-to areas.
- White is used for real-time information, scales and values that are ready to be used
- Magenta is used for target values and the FMC-generated flight path
- Cyan is used for inactive data, labels and background.
- Blue is used for informational purposes.
- System synoptics are simple schematics representative of airplane system operation and are supplemental information only.
- Linked and back-driven flight controls will reflect how the other pilot or the autoflight system is commanding the airplane. This control motion is an effective means of attracting attention to control input to aid situational awareness and enable a smooth transition, or handoff, between pilots and automation.
- Linked pilot controls, including fly-by-wire systems, provide conventional control wheel input and indications. Both pilot controls are mechanically linked and provide tactile and visual cues to how the pilot flying is controlling input to the airplane.
- The autoflight system will back-drive the control wheel and thrust levers. When the autopilot system is engaged the control wheel is back-driven to indicate what the autopilot system is commanding to the flight controls. The autothrottle system will back-drive the thrust levers according to what the autothrottle system is commanding. Pilot input can override the autopilot and autothrottle commands.

2.3 Pilot Responsibilities

Boeing flight decks are designed to support the priorities of aviate, navigate, communicate and manage airplane systems.

The Captain is ultimately responsible for the safe operation of the airplane. Both flight crew members are responsible for the safe conduct of the flight. Automation assists the flight crew in the efficient operation of the airplane. If the airplane is not performing as needed, or expected, the flight crew must assume positive control of the airplane.

The flight deck design assumes the pilot will:

- Respond correctly and safely to alert conditions.
- Prioritize warnings over cautions and prioritize cautions over advisories.
- Maintain situational awareness at all times. Both pilots should check the flight instruments and flight mode annunciations and verify that the airplane is responding appropriately. Both pilots need to anticipate what needs to be done next and how the airplane should respond.
- Use the appropriate level of automation for the situation. Hand off a task to automation in the state needed. Engage automation when the workload increases and take over manual control of the airplane when needed.
- Apply critical thinking and judgment. If indications are not as expected seek verifying information and take appropriate action.

2.4 Operational Philosophy

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 actions in accordance with Normal and Supplementary Procedures. Non-normal procedural actions and actions outside the crewmembers' responsibilities are assigned in accordance with QRH Checklist Instructions.

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 or segment. Supplementary Procedures are found in the FCOM Volume 1.

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

2.5 Display Panel Management

Unless specifically directed in a procedure, Boeing does not recommend what displays the crew should be monitoring during ground or in-flight operations. The flight crew is encouraged to select a display during any phase of flight that they feel is the most efficient way to get desired information.

2.5.1 Synoptic Display

Synoptic displays are provided as a means of assisting the flight crew in rapidly understanding the status of the airplane systems. However, crews should not rely solely on the displays for determining airplane status. Synoptic displays should only be used as necessary to get the desired information and then turned off. The clarity and simplicity of displayed information enable the flight crew to obtain necessary information from a brief scan.

Note: Reference to synoptic displays or maintenance information is not a requirement during the accomplishment of crew procedures.

If the flight crew elects to use synoptic displays in conjunction with accomplishment of procedures, they must assure no distraction from the intended task results. This is particularly true when accomplishing non-normal procedures. Under certain conditions, system faults can result in missing synoptic information. Therefore, decisions regarding non-normal situations should be based on EICAS messages and other flight deck effects and indications. In every case where a non-normal procedure results in a need for memory items, they should be completed before selecting a synoptic display. Accomplishment of necessary procedures should take priority over use of synoptic displays.

2.6 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.

2.6.1 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 40° of bank (25° 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.

777-200 – 777-300ER

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

787-8 – 787-10

Speeds depicted in the following table are applicable for all weights and are intended for use only as a back-up in the event FMC data is not available. The FMC computed flap maneuver speeds are calculated by using airplane weight and current altitude, and are indicated by the bugs on the airspeed display. The computed speeds allow better optimization of maneuver capability and margin to placard speeds than fixed speed increments.

B787-8 – B787-10

Flap Position	All Weights
Flaps UP	VREF 30 + 80
Flaps 1	VREF 30 + 60
Flaps 5	VREF 30 + 40
Flaps 15, 20 (787-8)	VREF 30 + 20
Flaps 10, 15, 17, 18, 20 (787-9 – 787-10)	VREF 30 + 20
Flaps 25	VREF 25
Flaps 30	VREF 30

2.7 Minimum Maneuver Speed

The top of the lower amber band on the airspeed display indicates the minimum maneuver speed. The functionality of the lower amber band is slightly different for flaps-down versus flaps-up operation; however, in both cases it alerts the crew that when operating at an airspeed within the amber band less than full maneuver capability exists.

777-200 – 777-300ER

Note: The target speed is always equal to or faster than the minimum maneuver speed (top of the amber band). During non-normal conditions, the target speed may be below the minimum maneuver speed.

787-8 – 787-10

Note: The target speed is always equal to or faster than the minimum maneuver speed (top of the amber band).

2.7.1 Flaps Down Amber Band

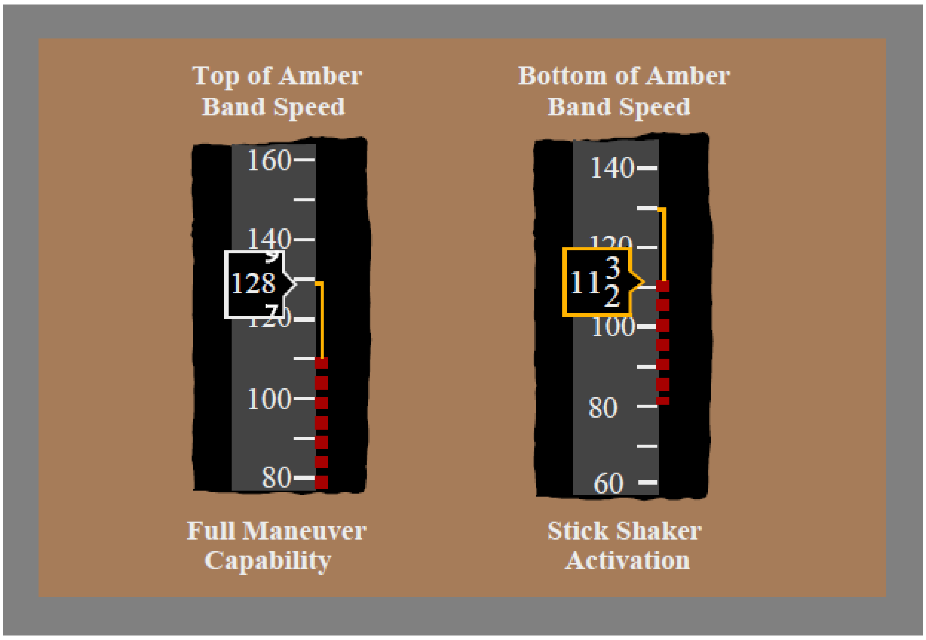
For all flaps-down operations (any time the flaps are not full-up) the minimum maneuver speed is the slowest speed that provides full maneuver capability, 1.3g or 40° of bank (25° of bank and 15° overshoot) to stick shaker. The top of the amber band does not vary with g load.

As airspeed is decreased below the top of the amber band, maneuver capability decreases. In 1g flight, the speed in the middle of the amber band provides adequate maneuver capability or 30° of bank (15° of bank and 15° overshoot). The speed at the bottom of the amber band (top of the red and black tape) corresponds to stick shaker activation for the current g load. If the g load is increased during maneuvering, the stick shaker activation speed increases also.

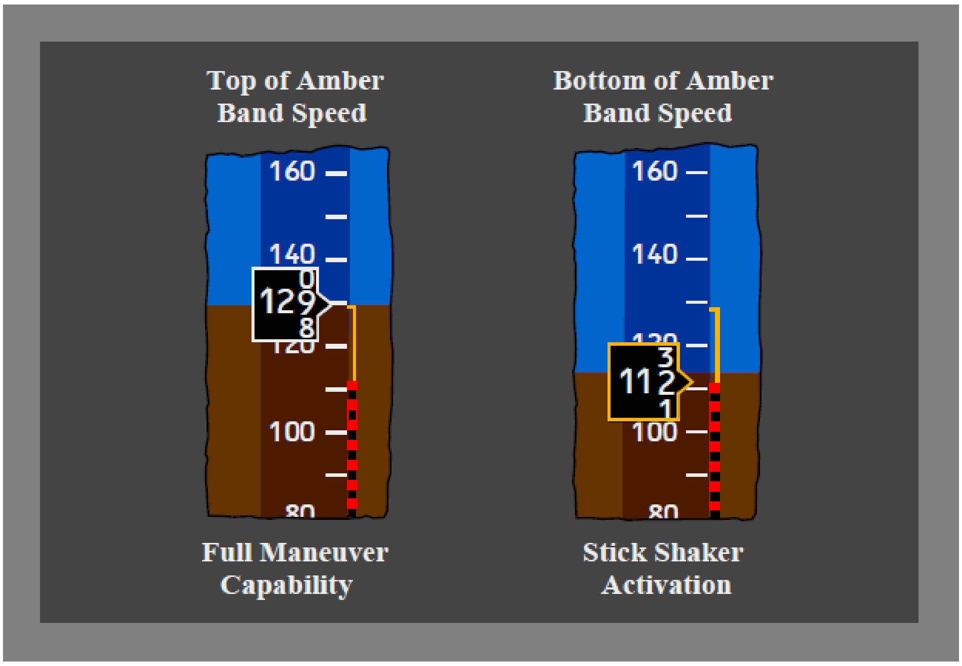
Note: Stick shaker is set to activate before the actual stall. There is sufficient margin to recover from stick shaker without stalling.

The following diagram is a representative sample showing airspeed relative to the amber band.

777-200 – 777-300ER



787-8 – 787-10



Minimum maneuver speeds (displayed as the top of the lower amber band) should not be confused with flap maneuver speeds. Flap maneuver speeds are based on airplane weight, while the minimum maneuver speed is calculated using airplane angle of attack and current airspeed. These speeds provide independent means to ensure that the current airspeed provides at least full maneuver capability for terminal-area maneuvering.

777-200 – 777-300ER

Note: During normal conditions, the flap maneuver speed for the current flap detent should always be equal to or faster than the minimum maneuver speed. During some non-normal conditions, the flap maneuver speed for the current flap position may be less than the minimum maneuver speed.

787-8 – 787-10

Note: The flap maneuver speed for the current flap detent should always be equal to or faster than the minimum maneuver speed.

2.7.2 Flaps Up Amber Band

For altitudes up to approximately 10,000 feet, the flaps-up amber band functions just like the flaps-down amber band described above, with the top of the amber band representing full maneuver capability. Due to increasing Mach effects between 10,000 and 20,000 feet, the maneuver capability at the top of the amber band decreases as altitude increases, but still provides at least adequate maneuver capability. Above approximately 20,000 feet, the top of the amber band shows the speed that provides 1.3g maneuver capability to low speed buffet (or an alternative approved maneuver capability as preset by maintenance).

2.8 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. These charts are generalized to show relative trends of maneuver capability during flap retraction and extension and are not meant to be representative of any one takeoff or landing condition.

When reviewing the maneuver margin illustrations, note that:

- there is a direct correlation between bank angle and load factor (gs) in level, constant speed flight. For example, 1.1g corresponds to 25° of bank, 1.3g ~ 40°, 2.0g ~ 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 retraction or extension 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 margins are based on basic stick shaker schedules and do not include adjustments for the use of anti-ice.

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.

2.8.1 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:

777-200 – 777-300ER

- 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

787-8 – 787-10

- Gross weight: generally maneuver margin decreases as gross weight increases.
- Altitude: generally 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

777-200 – 777-300ER

- Anti-ice: the use of engine or wing anti-ice reduces flaps-up and flaps-down maneuver margin. This effect remains until the airplane lands.

777-300ER

Note: The flaps-up TAI effect becomes zero or negligible at higher Mach numbers (heavy GW and higher altitudes).

787-8 – 787-10

- Anti-ice: the use of engine or wing anti-ice has no affect on flaps-up maneuver margin
- Anti-ice: the use of engine or wing anti-ice may reduce flaps-down maneuver margin. This effect varies depending on flap position and remains until TAT is above a threshold value for a specified time (to ensure all ice is gone) or until the airplane lands.

Note: The term "reduced maneuver margin", when used in reference to anti-ice systems, means that the stall warning logic adjusts stick shaker to a lower angle of attack. This results in a higher stick shaker speed and a higher minimum maneuver speed. Flap retraction and extension speeds are not affected by the use of anti-ice systems, therefore maneuver margin is reduced.

2.8.2 Maneuver Margins to Stick Shaker- Flap Retraction

777-200 – 777-300ER

Takeoff Flaps	At "Display"	Flap Retraction Speed	Select Flaps
20 or 15	"20" or "15" "5" "1"	Vref 30 + 20 Vref 30 + 40 Vref 30 + 60	5 1 UP
5	"5" "1"	Vref 30 + 40 Vref 30 + 60	1 UP

787-8

Takeoff Flaps	At "Display"	Select Flaps
20 or 15	"20" or "15" "5" "1"	5 1 UP
5	"5" "1"	1 UP

787-9, 787-10

Takeoff Flaps	At "Display"	Select Flaps
20, 18, 17, 15 or 10	"20", "18", "17", "15" "10" "5" "1"	5 1 UP
5	"5" "1"	1 UP

2.8.3 Maneuver Margins to Stick Shaker- Flap Extension

777-200 – 777-300ER

Current Flap Position	At Speedtape "Display"	Flap Extension Speed	Select Flaps	Command Speed for Selected Flaps
UP	"UP"	Vref 30 + 80	1	"1"
1	"1"	Vref 30 + 60	5	"5"
5	"5"	Vref 30 + 40	20	"20"
20	"20"	Vref 30 + 20	25 or 30	(Vref 25 or Vref 30) plus wind additives

787-8 – 787-10

Current Flap Position	At Speedtape "Display"	Select Flaps	Command Speed for Selected Flaps
UP	"UP"	1	"1"
1	"1"	5	"5"
5	"5"	20	"20"
20	"20"	25 or 30	(Vref 25 or Vref 30) plus wind additives

2.9 Command Speed

Command speed may be set by the pilot through the MCP or FMC and is displayed by a speed bug on the airspeed indication.

2.9.1 Takeoff

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

2.9.2 Climb, Cruise and Descent

Command speed is set to the appropriate speed by the FMC during VNAV operation or manually using the MCP.

2.9.3 Approach

Command speed is set to the maneuver speed for the selected flap position manually using the MCP.

2.9.4 Landing

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.

If a manual landing is planned with the autothrottle connected in gusty or high wind conditions, consider positioning the command speed to VREF + 10 knots. This helps protect against a sudden loss of airspeed during the flare.

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 approach speed should not exceed VREF + 15 knots. The following table shows examples of wind additives with a runway heading of 360°.

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

Note: Do not apply wind additives for steady tailwinds or tailwind gusts. Set command speed at VREF + 5 knots (autothrottle connected or disconnected).

2.9.5 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 30 + 20 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 “Use flaps 20 and VREF 30 + 20 knots for landing”, the flight crew would select flaps 20 as the landing flaps and look up the VREF 30 speed in the FMC or QRH and add 20 knots to that speed.

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

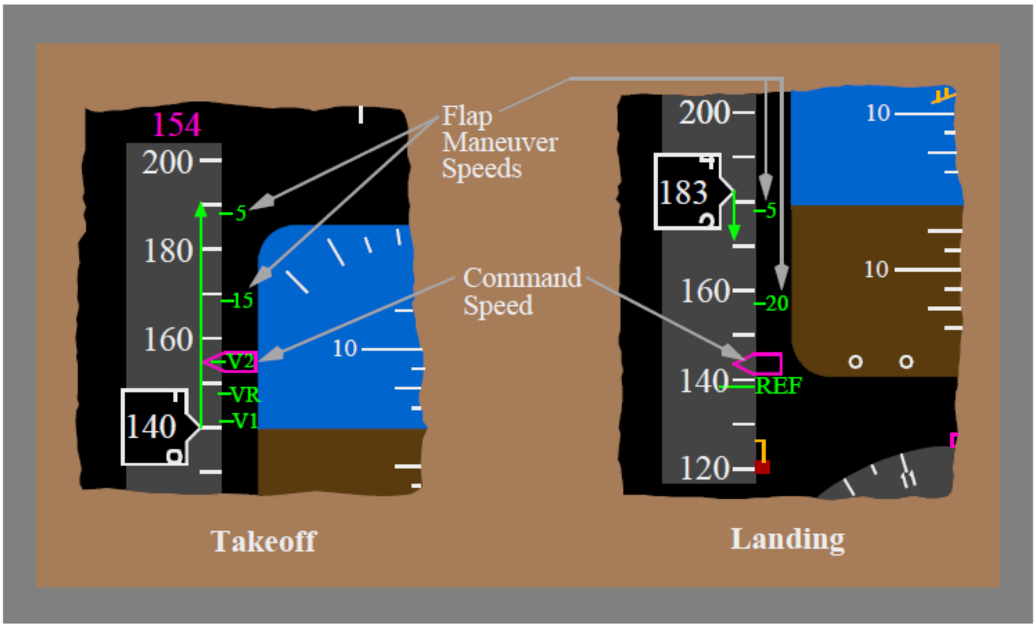
If the autothrottle is disconnected, or is planned to be disconnected prior to landing, appropriate wind additives must be added to the VREF to arrive at command speed, the speed used to fly the approach. For example, if the checklist states “use VREF 30 + 20 knots”, command speed should be positioned to VREF (VREF 30 + 20 knots) plus wind additive (5 knots minimum, 15 knots maximum).

2.10 Reference Speeds

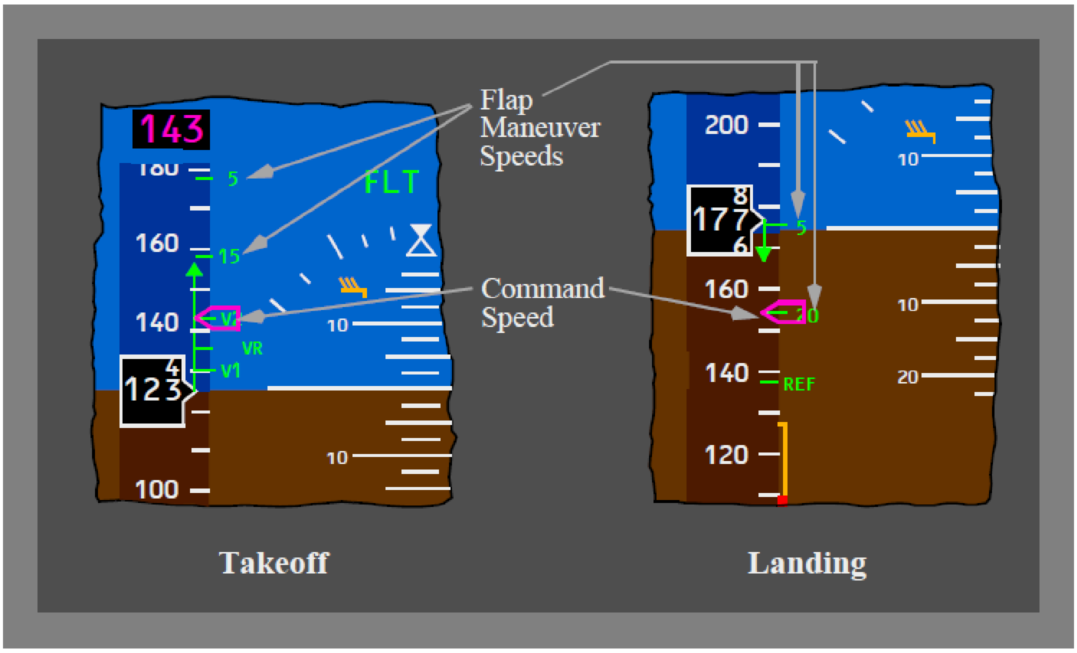
The following figure shows the positioning of the reference speeds on the airspeed indicator for takeoff and approach.

2.10.1 Reference Speed Setting

777-200 – 777-300ER



787-8 – 787-10



2.10.2 Takeoff

After zero fuel weight, V1, V2, and VR are entered into the FMC, airspeed bugs are automatically displayed at V1, VR, V2 and the minimum flap retraction speed for the next normal flap retraction position. Command speed is set at V2 using the MCP. V2 is the minimum takeoff safety speed and provides at least 30° bank capability (15° + 15° overshoot) for all takeoff flaps.

2.10.3 Approach – Landing

VREF is displayed upon entry of landing flaps/speed in the FMC. The maneuver speed for the current flap position and the next flap position are automatically displayed on the airspeed display.

777-200 – 777-300ER

VREF normally decreases as airplane gross weight decreases. However, in the 777-200ER, and 777-200LR, VREF reaches a limit, or floor at low gross weights. This floor is based on directional controllability limitations. Further reductions in weight will not change VREF which remains constant.

787-8 – 787-10

VREF normally decreases as airplane gross weight decreases. However, VREF reaches a limit, or floor at low gross weights. This floor is based on directional controllability limitations. Further reductions in weight will not change VREF which remains constant.

2.11 Thrust Management

2.11.1 Setting Thrust

777-200 – 777-300ER

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 N1 or EPR (as installed) 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 N1 or EPR (as installed) indication and maintaining situational awareness.

787-8 – 787-10

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 N1 or TPR (as installed) 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 N1 or TPR (as installed) indication and maintaining situational awareness.

2.11.2 Maximum Thrust

The term “maximum thrust” is used in various places in the FCTM and the FCOM. Maximum thrust is attained:

- for airplanes with engine EECs operating in the normal mode, by advancing the thrust levers full forward
- for airplanes with engine EECs operating in the alternate mode, 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.

Note: This definition of maximum thrust applies to all situations except when a fixed derate takeoff is accomplished. The fixed derate is considered a limitation for takeoff. Further explanation of thrust limitations during a fixed derate takeoff are found in the Reduced Thrust Takeoff section.

2.12 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 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 except altitude callouts during approach while below 500 feet AFE. No callout is necessary from the PM if the GPWS voice callout has been acknowledged by the PF. The recommended callout of “LAND” 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.

Recommended Callouts - ILS or GLS Approach

CONDITION / LOCATION	CALLOUT (Pilot Monitoring, unless noted)
First positive inward motion of localizer pointer (manual flight)	"LOCALIZER ALIVE"
Final approach fix inbound	"OUTER MARKER/FIX, ___FEET"
Suitable visual reference established	P1: "VISUAL"
At DA(H) - Suitable visual reference not established or visual references lost below DA(H)	P1: "GO AROUND"

Recommended Callouts - Non-ILS or Non-GLS Approach

CONDITION / LOCATION	CALLOUT (Pilot Monitoring, unless noted)
Final approach fix inbound	"VOR/NDB/FIX, PROFILE CHECKED"
Suitable visual reference established, i.e., PM calls visual cues	P1: "VISUAL"
At DA(H) or MDA(H)- Suitable visual reference not established or visual references lost below DA(H)	P1: "GO AROUND"

2.13 Electronic Flight Bag

This section provides guidance on the use of the optional Electronic Flight Bag (EFB). The EFB may contain some or all of the following options.

Note: As with paper charts, crews must avoid fixation on the display or distraction from primary crew duties while using any EFB application.

2.13.1 Airport Moving Map

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

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

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

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

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

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

2.13.2 Terminal Charts

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

2.13.3 Video Surveillance

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

2.14 Flight Path Vector

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

- as a reference for establishing and maintaining level flight when the F/D is not in use or not available. When maneuvering the airplane, adjust pitch to place the FPV on the horizon. This results in zero vertical velocity
- as a crosscheck of the vertical flight path angle when established in a climb, descent, or on a visual final approach segment

Note: When the AFDS FPA mode is selected, the FPV automatically appears to aid in establishing and monitoring the selected FPA.

777-200 – 777-300ER

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

787-8 – 787-10

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

- in climbs or descents, radar tilt can be adjusted to an appropriate elevation based on the displayed FPA. Radar tilt, like the FPV, is referenced to the horizon. Example: Adjusting the radar tilt to the same angle relative to the horizon as the FPV during climb results in the radar beam centered on the existing flight path

787-8 – 787-10

- as a qualitative indication of airplane lateral drift direction if the map is not available. The FPV moves left or right of the pitch scale to indicate the relative position of the ground track to the present heading. The amount of drift cannot be determined from this display unless the airplane is equipped with a horizon line heading scale. Example: FPV displaced to the left indicates wind component from the right and corresponding drift to the left

777-200 – 777-300ER

- as a qualitative indication of airplane lateral drift direction if the map is not available. The FPV moves left or right of the pitch scale to indicate the relative position of the ground track to the present heading. The amount of drift cannot be determined from this display. Example: FPV displaced to the left indicates wind component from the right and corresponding drift to the left

787-8 – 787-10

- for airplanes with a horizon line heading scale, the downwind track can be flown by setting the tail of the FPV on the downwind heading mark. Similarly on final approach, the FPV tail could be set to the final approach course of the runway
- as a cross-reference, when flying visual traffic patterns. On the downwind leg, the flight crew should position the FPV on the horizon line, in order to maintain level flight
- on final approach it provides a trajectory that quickly indicates a downburst. In addition, the position of the FPV in relation to the airplane symbol provides an indication of the wind direction.

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

2.15 Vertical Situation Display

787-8 – 787-10

The Vertical Situation Display (VSD) helps prevent controlled flight into terrain, and approach and landing accidents. It is a supplementary display, intended to improve situational awareness. Together with the lateral MAP, it creates a clear graphical picture of the airplane's horizontal and vertical position. In addition, it complements other safety features such as the GPWS. The VSD can be used during all phases of flight, but the main benefit is achieved during initial climb, descent, and approach. The VSD is not intended for use as a primary reference, or as a precise terrain following tool.

The VSD can be used during all phases of flight, but the main benefit is achieved during initial climb, descent, and approach. When the autopilot is engaged, the PF should consider selecting the VSD. During manual flight, it may be useful for the PM to also select the VSD.

During departure, the VSD allows crews to recognize possible terrain conflicts more readily, before a GPWS alert is generated. This may be particularly useful if the airplane is held at low altitude for a prolonged time.

During climb and descent, the VSD allows crews to check the vertical flight profile and monitor the vertical flight path vector. This leads to earlier identification of altitude constraints that may not be met.

VSD use is encouraged as much as possible during all approaches because it assists in establishing the correct glide path. If an approach procedure contains one or more step down fixes, the crew can determine that the FMC path and the airplane current flight path angle will comply with the correct path and clear all step down fixes at or above the published altitude. Dedicated decision gates at 1,000 ft. and 500 ft. help the crew achieve a stabilized approach.

During an instrument approach using V/S, the crew can use the dashed vertical speed line to establish and monitor the vertical path. This leads to earlier recognition of an unstable approach or an inappropriate rate of descent.

For visual approaches without a published vertical path (GP angle), a 3° reference vector is displayed. Crews can adjust the flight path angle to overlay the 3° reference line to maintain a stable approach.

To improve speed stability control, crews can use the range-to-target speed symbol (green dot) to show where excess speed will be dissipated along the vertical flight path vector. If excess speed is not an issue, the symbol does not appear on the display.

2.16 Cold Temperature Altitude Corrections

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. 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.

Boeing airplanes have uncompensated Baro-VNAV systems and are prohibited from using LNAV/VNAV minima on approach charts when operating outside of published temperature restriction limits. However, if cold temperature altitude corrections are applied as described in the Cold Temperature Operations Supplementary Procedures chapter of the FCOM, descent to the corrected LNAV (MDA) minima is allowed. There is no procedure for hot temperature corrections.

2.17 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.

2.17.1 Ice Crystal Icing

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

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

Note: An Ice Crystal Icing NNC is available in the QRH.

2.17.2 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.

2.18 Recommended Rudder Trim Technique

777-200 – 777-300ER

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 with TAC inoperative, this technique is the preferred method and provides near minimum drag.

777-200 – 777-300ER

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.

777-200 – 777-300ER

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

787-8 – 787-10

Flight control laws automatically compensate for thrust asymmetry or an out of rig condition by automatically inputting rudder trim as needed. Manual rudder trim is not required in the normal mode of operation unless directed by a NNC. When not operating in the normal mode, use the rudder trim technique in the secondary or direct mode described in the section below. This 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 minimum drag conditions.

787-8 – 787-10

Note: Large rudder pedal or rudder trim displacement may indicate the need for maintenance and should be noted in the airplane log.

2.18.1 Drag Factors Due to Trim Technique

777-200 – 777-300ER

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.

2.18.2 Primary Rudder Trim Technique

777-200 – 777-300ER

It is recommended that the autopilot remain engaged while accomplishing the primary rudder trim technique (using rudder trim only). After completing this technique, if the autopilot is disengaged, the 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 or HDG HOLD and stabilized for at least 30 seconds
- trim the rudder in the direction corresponding to the down (low) side of the control wheel until the control wheel indicates level. The indices on top of the control wheel should be used to ensure a level wheel condition. The airplane is properly trimmed when the control wheel is level, (zero index). As speed, gross weight, or altitude change, trim requirements may also change. In a proper trim condition, there may be a slight forward slip (slight bank angle indicated on the bank pointer) and a slight deflection of the slip/skid indicator, which is acceptable.

2.18.3 Rudder Trim Technique in the Secondary or Direct Mode

787-8 – 787-10

The following steps define rudder trim technique when operating in the secondary or direct mode:

- set symmetrical thrust
- balance fuel if required
- 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.

2.18.4 Alternate Rudder Trim Technique

777-200 – 777-300ER

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

The following steps define the alternate rudder trim technique:

- set symmetrical thrust
- balance fuel if required
- verify rudder trim is zero

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

After completing the alternate rudder trim technique, if the autopilot is disengaged the airplane may have a rolling tendency. Hold the wings level using the 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. When aileron trim inputs are complete the autopilot may be re-engaged as desired.

2.19 Flight Management Computer(s)/CDUs

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

2.19.1 FMC Route Verification Techniques

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

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

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

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

When pilots are evaluating the charted procedure against the navigation database, the areas of primary concern are: waypoint sequence, speed and altitude constraints, and no unexpected discontinuities. Minor differences between the magnetic heading or track on a navigation chart and the heading or track in the FMC may exist. Primarily, this is because the FMC has a lookup table for magnetic variation, but chart designers apply a local magnetic variation. Minor differences may also result from equipment manufacturer's application of magnetic variation. These minor differences are operationally acceptable.

2.19.2 FMC Performance Predictions

FMC performance predictions are based on the airplane being in a normal configuration and at normal thrust settings. These predictions include:

- climb and descent path predictions including top of climb and top of descent
- ECON, LRC, holding, and engine out speeds
- altitude capability
- step climb points
- fuel remaining at waypoints and destination or alternate
- estimated time of arrival at waypoints and destination or alternate
- holding time available.

2.19.3 Non-normal Configurations or Reduced Thrust

If operating in a non-normal configuration, such as gear down, flaps extended, spoilers extended, gear doors open, etc., or if operating at reduced thrust due to a non-normal condition, the above performance predictions are inaccurate.

FMC fuel predictions are based on a clean configuration at normal thrust settings. Fuel consumption may be significantly higher than predicted in other configurations. Fuel consumption can be significantly different than predicted when operating at a reduced thrust setting. Estimates of fuel remaining at waypoints, the destination or an alternate can be computed by the crew based on current fuel flow indications and should be updated frequently.

An accurate ETA is available if the current speed or Mach is entered into the VNAV cruise page.

Note: VNAV PTH operation for approaches is usable for non-normal configurations.

Holding time available is accurate in the clean and flaps one configuration provided the FMC holding speed is maintained.

2.20 RNAV Operations

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

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

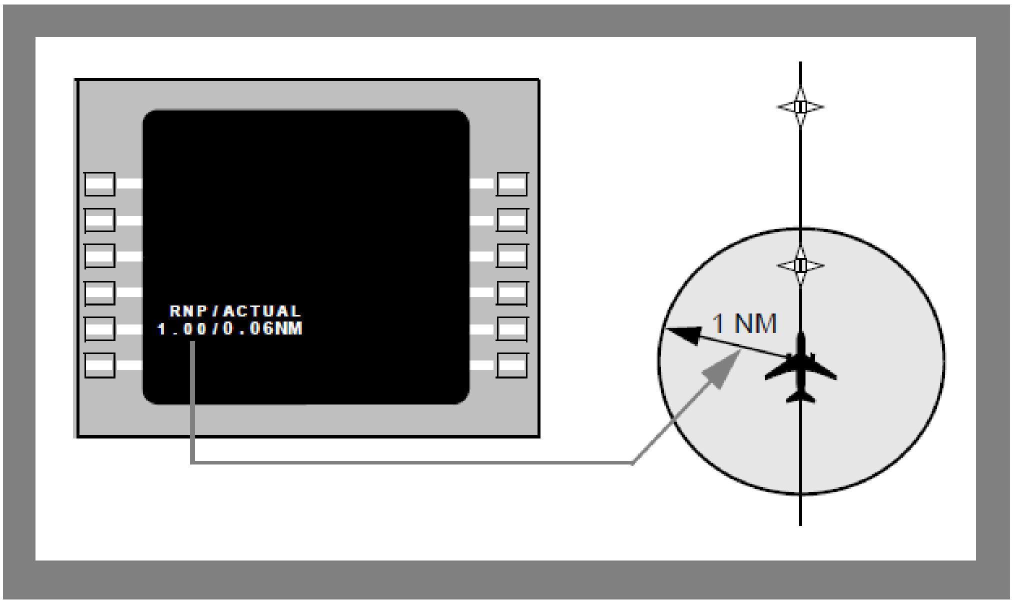
All Boeing FMCs are capable of performing RNAV operations. Regarding navigation accuracy, these FMCs differ only by demonstrated RNP capabilities and the ability to use GPS updating.

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

In general, oceanic operations require dual navigation systems (dual FMC or single FMC in combination with alternate navigation capability).

2.20.1 RNP and ANP Definitions

RNP (Required Navigation Performance) is a specified navigation performance for route, terminal, or approach procedures. It is a measure of the navigation performance accuracy necessary for operations within a defined airspace. It is shown in nautical miles. All RNP based procedures have an associated RNP level that is published on the procedure chart.



Oceanic RNPs are generally 4.0 or higher. Domestic en-route RNAV operations depend on the availability of radio updating (DME-DME) sources to support domestic RNPs. The following domestic RNP operations are fully supported by any Boeing FMC with DME-DME or GPS updating active:

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

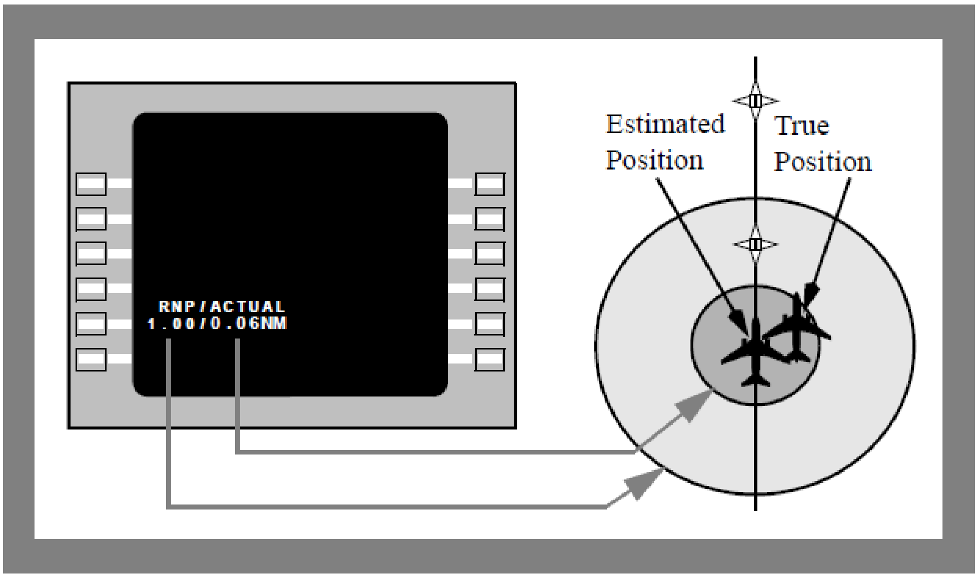
Terminal RNAV operations (SIDs, STARs and Transitions) are fully compatible with all FMCs with DME-DME or GPS updating active and are defined as:

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

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

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

ANP (Actual Navigation Performance) is the FMC calculated certainty of the airplane's position in nautical miles. It is situation information for the flight crew representing a system estimate of the radius of the area in which the actual position of the airplane lies. The system uses the best available sensor(s) to minimize positioning error. The flight crew or autoflight system must track the RNAV path using LNAV.



2.20.2 Basic RNP Concept

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

RNAV (RNP) AR (Authorization Required) procedures are RNP approaches that require special aircraft and aircrew authorization. For specific instructions refer to Instrument Approach - RNAV (RNP) AR.

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

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

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

Although today's airspace design has already established certain lateral limits (RNP), no Vertical Required Navigation Performance limits are published. Vertical Required

Navigation Performance is available on some FMCs and may be used for certain descent profiles such as Continuous Descent Approaches (CDA), Optimized Profile Descents (OPD) or Tailored Arrivals (TA).

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

2.20.3 Airplanes with Navigation Performance Scales (NPS)

For airplanes with Navigation Performance Scales (NPS) the flight crew can monitor the dynamic relationship between ANP, RNP, and current flight path deviations. The lateral and vertical deviation scales are based on the familiar concepts of a centerline indication, scale limits, and a deviation pointer and provide the flight crew with a clear indication of current position in relation to desired position and the total allowable error. Full scale lateral and vertical deviation for NPS is equal to the FMC RNP value. If the deviation approaches the limit, a correction back to the path is needed. Reference the FCOM for specific NPS system indications and description.

During RNP operations other than approach, anytime the deviation exceeds the limit or an amber deviation alert occurs, the crew may have to select a different autopilot roll or pitch mode or manually fly airplane back on course. If unable to comply, the flight crew must revert to other means of navigation such as conventional ground-based or radar navigation.

During RNP approach operation, anytime the deviation exceeds the limit or an amber deviation alert occurs the crew may change to a non-RNP procedure. If unable, the crew should execute a missed approach unless suitable visual reference is already established. In the event of a missed approach, the crew may consider requesting an alternate clearance.

2.20.4 Airplanes without Navigation Performance Scales (NPS)

777-200 – 777-300ER

For airplanes without NPS, the crew must refer to the FMC PROGRESS page for XTK and VTK information during the approach.

If a deviation occurs, and the correction back to course is not immediate, then the PM should refer to the FMC PROGRESS page and notify the PF if the maximum allowable deviations are reached. Normally XTK should not exceed 1.0 x RNP during RNP operations.

Note: An excessive cross-track error does not result in a crew alert.

During RNP operations other than approach, anytime the deviation exceeds the limit, the crew may have to select a different autopilot roll or pitch mode or manually fly the airplane back on course. If unable to comply, the flight crew must revert to other means of navigation such as conventional ground-based or radar navigation.

During RNP approach operation, anytime the deviation exceeds the limit the crew may change to a non-RNP procedure. If unable the crew should execute a missed approach unless suitable visual reference is already established. In the event of a missed approach, the crew may consider requesting an alternate clearance.

2.20.5 ANP Alerts

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

If the alert occurs during RNP approach operation, the crew may change to a non-RNP procedure. If unable, the crew should execute a missed approach unless suitable visual reference is already established. In the event of a missed approach, the crew may consider requesting an alternate non-RNP clearance.

2.20.6 Autoflight Use During RNP

Normally, a route segment or procedural leg is defined by its required width. For RNP operations, route width is normally equal to at least 2.0 x RNP from either side of the LNAV course. Required width is determined by minimum terrain or traffic clearance requirements. The probability of exceeding this maximum deviation while in LNAV with the autopilot engaged is very small. For each airplane type, minimum demonstrated RNPs are given in the AFM. These minimum values vary depending on LNAV, flight director and autopilot use, and whether GPS is the active source of position updating.

RNP operations require appropriate path tracking consistent with the RNP level. LNAV together with the flight director and the autopilot may be required for certain low RNP operations. Use of the autopilot and LNAV normally provides the required path tracking accuracy. During RNAV approaches using VNAV, VNAV PTH is required for any leg segment with a coded glide path angle. These procedures show only LNAV/VNAV approach minima and do not allow use of LNAV only. Use of the flight director alone may not provide sufficient guidance to maintain the path accurately.

787-8 – 787-10

Note: If the autopilot is not available, flight crews should use the flight director and the additional cues displayed on the navigation display (position trend vector, airplane symbol, and digital cross track deviation) with at least one map set at a range of 10 NM or less.

777-200 – 777-300ER

Note: If the autopilot is not available, flight crews should use the flight director and the additional cues displayed on the navigation display (position trend vector, airplane symbol, and digital cross track deviation) with at least one map set at the 10 NM range.

2.20.7 Radius-to-Fix (RF) Legs

RF legs are waypoints connected by a constant radius course similar to a DME arc. These are shown on terminal procedures as a curved track between two or more waypoints. Some considerations regarding use of RF legs:

- there may be a maximum speed shown on some straight legs or some RF legs of smaller radius. This limitation is critical for the crew to observe since the ability of the AFDS to track the RF leg is determined by ground speed and maximum available bank angle. In high tailwinds, the resulting ground speed may cause the maximum bank angle to be reached. In this situation, excessive course deviation may occur if the maximum RF speed is exceeded

- do not begin a procedure by proceeding direct to an RF leg. This may cause excessive deviation when the airplane maneuvers to join the RF leg. Normally there is a track-to-fix leg prior to an RF leg to ensure proper RF leg tracking
- intercept course to or direct to route modifications delete an RF leg if done to the second waypoint on an RF leg

777-200 – 777-300ER

- if a go-around is executed while on an RF leg, it is important to immediately re-select LNAV (or verify that LNAV has re-engaged for airplanes equipped with the TO/GA to LNAV feature) to avoid excessive course deviation. GA roll mode is a track hold mode and is not compatible with low RNP operations if left engaged. The pilot flying must continue to track the LNAV course using the map display as a reference until LNAV is re-engaged.

787-8 – 787-10

- if a go-around is executed while on an RF leg, it is important to verify that LNAV has re-engaged to avoid excessive course deviation. GA roll mode is a track hold mode and is not compatible with low RNP operations if left engaged. The pilot flying must continue to track the LNAV course using the map display as a reference until LNAV is re-engaged.

If a temporary loss of the FMC occurs, RF legs will appear as part of the inactive route when the FMC returns to normal operation. Once the route is activated and the EXEC key is pressed, a normal LNAV capture of an RF leg is possible if the situation permits.

2.21 GPS Use in Non-WGS-84 Reference Datum Airspace

In non-WGS-84 airspace, the local datum (position basis) used to survey the navigation database position information may result in significant position errors from a survey done using the WGS-84 datum. To the pilot, this means that the position of runways, airports, waypoints, navaids, etc., may not be as accurate as depicted on the map display and may not agree with the GPS position.

Using the FMC while receiving GPS position updating during SIDS, STARS and enroute navigation meets the required navigation accuracy in non-WGS-84 airspace. This navigation position accuracy may not be adequate for approaches, therefore the AFM requires the crew to inhibit GPS position updating while flying approaches in non-WGS-84 airspace “unless other appropriate procedures are used.”

2.22 Weather Radar and Terrain Display Policy

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

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

2.23 AFDS Guidelines

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

The Normal Procedures Introduction in Volume 1 of the FCOM states that normal procedures are written for the trained flight crew and assume full use of all automated features. This statement is not intended to prevent pilots from flying the airplane manually. Manual flight is encouraged to maintain pilot proficiency, but only when conditions and workload for both the pilot flying and pilot monitoring are such that safe operations are maintained. Many operators have developed an automation use policy that gives pilots the opportunity to maintain proficiency in manual flight.

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 nor designed to correct a significant out of trim condition or to recover the airplane from an abnormal flight condition and/or unusual attitude.

2.24 Autothrottle Use

Autothrottle use is recommended during all phases of flight. When in manual flight, autothrottle use is also recommended.

2.25 Manual Flight

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

2.26 Automatic Flight

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

Note: When the autopilot is in use, the PF makes AFDS mode selections. The PM may select new altitudes, but must ensure the PF is aware of any changes. Both pilots must monitor AFDS mode annunciations and the current FMC 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. For example, if the pilot failed to select the exit holding feature when cleared for the approach, the airplane will turn outbound in the holding pattern instead of initiating the approach. At this point, the pilot may select HDG SEL and continue the approach while using other automated features. A second example, if the airplane levels off unexpectedly during climb or descent with VNAV engaged, FLCH may be selected to continue the climb or descent until the FMC can be programmed.

2.26.1 Recommended Pitch and Roll Modes

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

FLCH has logic to allow shallow climbs and descents for small altitude changes. There is no need to use V/S mode for passenger comfort.

If unplanned speed or altitude restrictions are imposed during the arrival, the continued use of VNAV may induce an excessive workload. If this occurs, use FLCH or V/S as appropriate.

2.27 MCP Altitude Setting Techniques Using VNAV

When using VNAV for published instrument departures, arrivals, and approaches, the following recommendations should avoid unnecessary level-offs while ensuring minimum altitudes are met.

If waypoints with altitude constraints are not closely spaced, the normal MCP altitude setting technique is recommended.

If waypoints with altitude constraints are closely spaced to the extent that crew workload is adversely affected and unwanted level-offs are a concern, an alternate MCP altitude setting technique can be used with operator approval.

Note: When the alternate MCP altitude setting technique is used, the selection of a pitch mode other than VNAV PTH or VNAV SPD will result in risk of violating altitude constraints.

2.27.1 Normal MCP Altitude Setting Technique using VNAV

British Airways Virtual does not employ the Normal MCP Altitude Setting Technique using VNAV.

2.27.2 Alternate MCP Altitude Setting Technique using VNAV

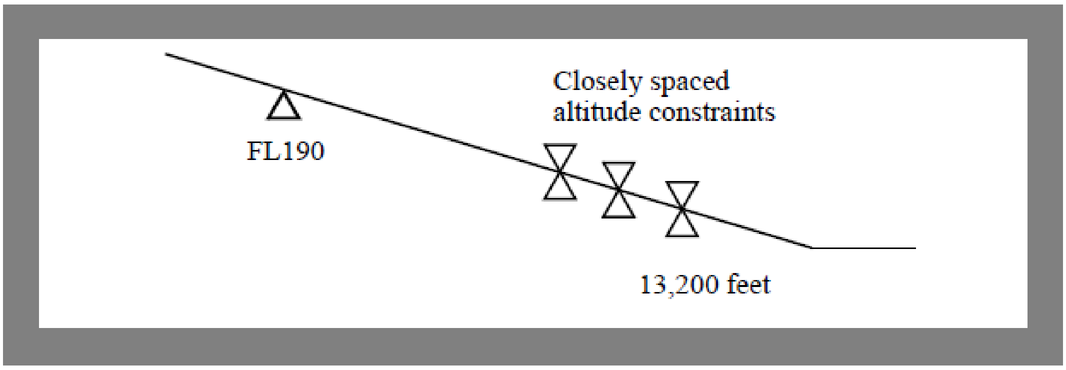
British Airways Virtual approves the Alternate MCP Altitude Setting Technique using VNAV. The following MCP altitude setting technique may be used during published instrument departures, arrivals, and approaches where altitude constraints are closely spaced to the extent that crew workload is adversely affected and unwanted level-offs are a concern:

- for departures, set the highest of the closely-spaced constraints
- for arrivals, initially set the lowest of the closely spaced altitude constraints or the FAF altitude, whichever is higher

Note: When approved by the operator, this technique may also be used for Tailored Arrivals (TA) regardless of how closely the altitude constraints are spaced.

In the following example, the airplane has been cleared from cruise level to “Descend Via” a STAR with published altitude constraints at or above FL 190, followed by three additional descent constraints, the lowest being at 13,200 feet. In this case, when the crew confirms the airplane will be at or above FL 190 for the corresponding waypoint, set the MCP to 13,200 feet, even though there are two altitude constraints before 13,200 feet.

Note: When using the alternate technique, the FMC generated path should be checked against each altitude constraint to ensure that the path complies with all constraints.



2.28 AFDS Mode Control Panel Faults

In-flight events have occurred where various AFDS pitch or roll modes, such as LNAV, VNAV or HDG SEL became un-selectable or ceased to function normally. Typically, these types of faults do not generate a failure annunciation. 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 or HDG HOLD	Set desired heading, disengage AFDS and manually roll wings level on the desired heading, and re-engage the AFDS. The AFDS will hold the established heading.
LNAV	Use HDG SEL or TRK SEL to maintain the airplane track on the magenta FMC course.
VNAV SPD or VNAV PTH (climb or descent)	Use FLCH, V/S or FPA. V/S or FPA should be selected for descent on final approach.
VNAV PTH (cruise)	Use altitude hold. If altitude hold is not directly selectable, use FLCH to automatically transition to altitude hold.
LOC	Use LNAV. Monitor and fly the approach referencing localizer raw data.
G/S	777-200 - 777-300ER Use V/S, FPA or VNAV PTH to descend on an ILS approach. Monitor and fly the approach referencing glide slope raw data. 787-8 - 787-10 Use V/S, FPA or VNAV PTH to descend on an ILS or GLS approach. Monitor and fly the approach referencing glide slope raw data.

2.29 Head Up Display

787-8 – 787-10

The Head Up Display (HUD) is a display system that allows a pilot to maintain head-up, eyes-out during all phases of flight while still monitoring performance and flight path guidance information. HUD use is encouraged at all times as it enhances the crew capability to monitor the airplane's behavior and performance while maintaining visual lookout. There are no restrictions on the use of the HUD.

Using the HUD during approach can enhance the accuracy of path control during the approach and the touchdown. Although touch down sink rates, lateral errors and along track errors can be decreased through use of the head-up Flight Path Vector (FPV), landings are done by visual reference.

The FPV displayed on the HUD indicates airplane flight path. When control inputs are made to airplane attitude or thrust, the rate that the airplane responds to these inputs varies with conditions. The FPV shows the airplane response to the control inputs as they take effect.

Airplanes equipped with dual HUDs allow the PM full awareness of the airplane performance and flight guidance information in the same format as the PF. This provides a quicker understanding of the actions taken by the PF which allows more time for the remainder of the required crosschecks. This head-up, eyes-out monitoring ability for both pilots is one of the main differences between airplanes equipped with dual HUDs and those airplanes equipped with a single HUD.

New HUD users may notice a tendency to focus attention on one layer of information (e.g., the HUD symbology) at the expense of the other (e.g., the outside environment). The following techniques will help crews to gain the best use from the HUD:

- adjust the brightness so the pilot can see the symbology on the HUD and can see through it
- the PF looks through the HUD symbology to use normal outside cues
- the PM uses a continual scan technique
- pilots will be less susceptible the more they use the HUD and practice the attention shifting techniques.

The HUD may be used at any altitude. The horizon line on the HUD is only aligned with the actual horizon at 0 ft. AGL. As altitude increases, a separation between the actual horizon and the horizon line on the HUD is visible. This separation is due to the curvature of the earth. At cruising altitudes, there can be a significant separation between the horizon line on the HUD and the actual horizon.

Techniques for using the HUD in various phases of flight are described in the applicable chapters of this manual.

2.30 Moderate to Heavy Rain, Hail or Sleet

The airplane is designed to operate satisfactorily when maximum rates of precipitation are encountered. However, flight into moderate to heavy rain, hail, or sleet could adversely affect 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.

2.31 Turbulent Air Penetration

Severe turbulence should be avoided if at all possible. However, if severe turbulence is encountered, use the turbulent air penetration procedure listed in the Supplementary Procedures chapter 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.

2.32 Electronic Flight Control System

The electronic flight control system generates control surface commands for airplane control in all three axes. The system tailors the control surface commands to provide exceptional handling qualities and a smoother ride for the passengers.

777-200 – 777-300ER

The primary difference from a conventional airplane is in the pitch axis. A control column input commands a pitch maneuver instead of commanding a surface to move, so anything else that tries to change the pitch attitude or flight path will be countered by the flight control system. Therefore, the system minimizes the airplane pitch response to thrust changes, configuration changes, turbulence and turns.

787-8 – 787-10

The primary differences from a conventional airplane are in the pitch, roll, and yaw axes. A control column, control wheel, or rudder pedal input commands a pitch, roll, or yaw maneuver instead of commanding a surface to move, so anything else that tries to change the airplane attitude or flight path will be countered by the flight control system. Therefore, the system minimizes the airplane pitch response to thrust changes, configuration changes, turbulence and turns for the pitch axis, and minimizes the airplane roll and yaw response to an imbalance or asymmetry or turbulence in the roll and yaw axes.

Thrust changes no longer need to be countered with a column input. This minimizes pilot work load during accelerations and decelerations. However, for a climb, as thrust is applied, the pitch attitude must be increased to begin the climb. For a descent, as thrust is reduced to idle, the pitch attitude must be decreased to begin the descent.

Speedbrake or flap changes no longer need to be countered with a column input. The flight control system automatically counters the change in lift. A small pitch change may be noticed as the flight control system changes the pitch attitude to keep the flight path relatively constant

For turns up to 30° of bank, the pilot does not need to add column back pressure to maintain level flight. For turns of more than 30° of bank, additional column back pressure is required.

777-200 – 777-300ER

For a roll or yaw asymmetry such as an out of rig or failed control surface that is not in the commanded position, the pilot must make a control input and trim as needed. The system does not automatically counter the asymmetry.

787-8 – 787-10

For a roll or yaw asymmetry such as an out of rig or failed control surface that is not in the commanded position, the pilot does not need to make any control input. The system automatically counters the asymmetry and trims the rudder to fair the lateral surfaces.

The pilot still needs to trim for speed changes. Column forces increase when out of trim to provide the conventional speed error cue.

2.33 Handling Characteristics

2.33.1 777-200 – 777-300ER

Condition	Conventional	777
Airplane pitch response due to: • thrust changes • turbulence • configuration changes • turns (up to 30° bank)	Pilot counters with column and trim	Flight control system counters with elevator and stabilizer.
Airspeed changes	Pilot counters with column and trim (speed stability)	
Thrust asymmetry on the ground	Pilot counters with pedal	TAC partially counters with rudder and moves pedals for awareness. Pilot pedal input required.
Thrust asymmetry in the air	Pilot counters with wheel and/or pedal. Manual rudder trim for long term	TAC counters with rudder and moves pedals for awareness.
Thrust asymmetry with an engine in reverse thrust	Pilot counters with pedal	
Crosswind on takeoff	Pilot counters with pedal and wheel	
Roll or yaw asymmetry in the air. (e.g., out of rig)	Pilot counters the roll with wheel. Manual rudder trim for long term	

2.33.2 787-8 – 787-10

Condition	Conventional	787
Airplane pitch response due to: • thrust changes • turbulence • configuration changes • turns (up to 30° bank)	Pilot counters with column and trim	Flight control system counters with elevator and stabilizer.
Airspeed changes	Pilot counters with column and trim (speed stability)	
Thrust asymmetry on the ground	Pilot counters with pedal	Flight control system partially counters with rudder and moves pedals for awareness. Pilot pedal input required
Thrust asymmetry in the air	Pilot counters with wheel and/or pedal. Manual rudder trim for long term	Flight control system counters with rudder and moves pedals for awareness
Thrust asymmetry with an engine in reverse thrust	Pilot counters with pedal	Flight control system partially counters with rudder. No pedal movement. Minor pilot pedal input required
Crosswind on takeoff	Pilot counters with pedal and wheel	Flight control system partially counters with rudder. No pedal movement. Minor pilot pedal input required. Pilot wheel input required
Roll or yaw asymmetry in the air. (e.g., out of rig)	Pilot counters the roll with wheel. Manual rudder trim for long term	Flight control system counters with lateral surfaces and rudder, then trims rudder. Moves pedals for awareness of larger asymmetries

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3 Ground Operations

3.1 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.

3.2 Runway/Taxiway Width Guidelines

3.2.1 Runway Width

Minimum recommended runway width for take-off and landing is 45 m (150 ft). B777 operations on runways down to 41 m (130 ft) are approved if annotated as such in the appropriate OM C Aerodrome Briefings. B787 operations on runways narrower than 45 m (150 ft) is not approved.

3.2.2 Taxiway Width

Minimum taxiway width in normal operation: 20 m.

Taxi with extreme caution when taxiway width is less than 23 m. Use of taxiways less than 20 m wide is only permitted with fleet approval and guidance to avoid departing the paved surface. This taxiway width guidance is specific to British Airways operation and has been developed following correspondence with Boeing.

3.2.3 Minimum Width for 180 Degree Turn

FCOM Dimensions details the minimum pavement width for 180deg turns. Additionally, the B777 QRH details the BA required runway width for 180deg turns under Operational Information, 180° Turn Procedure.

3.3 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.

3.4 Push Back or Towing

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 is 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 during pushback or towing accidents. Procedures that do not have personnel in the vicinity of the nose wheels help to reduce the possibility of these types of accidents.

777-200 – 777-300ER

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

787-8 – 787-10

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

The captain should ensure that all appropriate checklists are completed prior to airplane movement. All passengers should be in their seats, all doors closed and all equipment away from the airplane. After 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. Ground personnel may disconnect when the pushback is complete and the brakes set to park. It is not necessary to have ground personnel connected for the duration of the engine start process.

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

3.5 Taxi

3.5.1 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:

3.5.2 Prior to Taxi

- review NOTAMS and current ATIS for any taxiway or runway closures, construction activity, or other airport risks that could affect the taxi route

777-200 – 777-300ER

- both pilots verify that the correct airplane position is in the FMC and the EFB airport moving map, (as installed), shows correct placement

787-8 – 787-10

- both pilots verify that the correct airplane position is in the FMC and the ND airport map display shows correct placement

777-200 – 777-300ER, 787-8 – 787-10

- 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
- an airport diagram should be readily available to each crewmember during taxi.

3.5.3 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.

3.5.4 Prior to Landing

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

3.5.5 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.

3.6 Airport Map Display

787-8 – 787-10

The ND airport map display is intended to enhance crew positional awareness while planning taxi routes and while taxiing. See further discussion in Chapter 1 Airport Moving Map.

Note: Crews must avoid fixation on the display or distraction from primary crew duties while using the airport map display.

Crews must use direct visual observation out flight deck windows as the primary taxi navigation reference. Use the ND airport map mode to provide enhanced positional awareness by:

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

In flight, the ND airport plan mode may be used to aid in runway exit planning and anticipating the taxi route to the gate or parking spot.

Note: GPS position must be available to use the ND airport map mode.

3.7 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.

3.7.1 Use of the Ground Maneuver Camera System (GMCS)

777-300, 777-300ER

The GMCS, if available, can be useful in observing areas beneath the airplane. The GMCS is designed to aid the flight crew in determining the location of the nose and main gear wheels prior to or during turns while taxiing and its use should be limited to this function.

Direct visual observation out the flight deck windows remains the primary means of determining when to initiate turns and verifying airplane position relative to the intended taxi path. The Ground Maneuver Taxi display may be used sparingly to determine the proximity of the nose wheels and main gear to the taxi surface edge and when the main gear have cleared the inside corner of a turn.

Note: Use caution not to fixate on or be distracted by the video display at the expense of airplane control. Ensure at least one pilot is always looking outside the airplane.

Due to the position of the tail-mounted cameras, the following normal conditions may be observed:

- the formation of contrails just behind the engines
- venting of oil from the engines
- large displacement rapid flaperon movement.

No crew procedures or actions, except use as a reference during taxi operations, are predicated on the use of the GMCS. EICAS alert messages remain the primary means to direct the crew to the appropriate non-normal procedures. GMCS use during takeoff, approach and landing is prohibited.

3.8 Thrust Use

Thrust use during ground operation demands sound judgment and technique. Even at relatively low thrust the air blast effects from the large, high bypass engines can be destructive and cause injury. Airplane response to thrust lever movement is slow, particularly at high gross weights. Engine noise level in the flight deck is low and not indicative of thrust output. Idle thrust is adequate for taxiing under most conditions. A slightly higher thrust setting may be 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.

3.9 Backing with Reverse Thrust

Backing with reverse thrust is prohibited.

3.10 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 ground speed display on the flight instruments may be used to determine actual taxi speed. The appropriate taxi speed depends on turn radius and surface condition.

787-8 – 787-10

During initial brake pedal application or initial release after long brake applications, brake response may not feel instantaneous. A short brake response transition time is normal and is required to ensure smooth brake performance. This initial brake response transition time does not impact brake modulation, effectiveness or performance.

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

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.

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 momentary use of idle reverse thrust may be needed on slippery surfaces for airplane control. The use of reverse thrust above reverse idle is not recommended due to the possibility of foreign object damage and engine surge. Consider having the airplane towed rather than relying on the extended use of reverse thrust for airplane control.

Note: If reverse thrust is selected after V speeds have been entered, the V speeds are removed from the airspeed display, and full TO thrust becomes the thrust limit for takeoff.

3.10.1 Carbon Brake Life

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

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

3.11 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.

3.12 Tiller/Rudder Pedal Steering

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

787-8 – 787-10

Note: The left and right tillers are not interconnected. To ensure airplane not compromised during taxi, only one pilot should make tiller control inputs at a time. Do not transfer tiller control when the airplane is in a turn.

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

3.12.1 Main Gear Aft Axle Steering

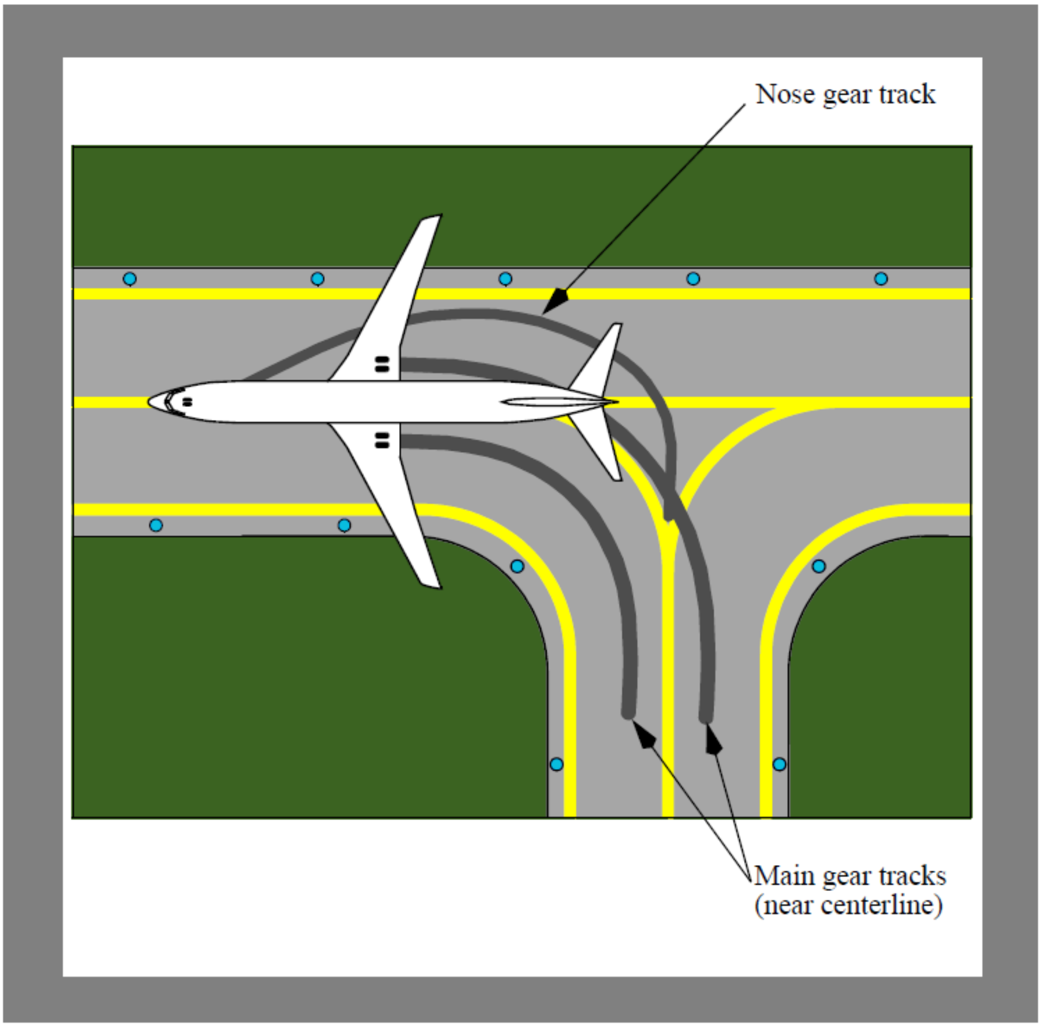
777-200 – 777-300ER

Main gear aft axle steering provides shorter turn radius, reduces thrust requirements for tight turns, and minimizes tire scrubbing. Main gear aft axle steering operation is especially important at heavy weights where stress may be applied to wheels and tires. Excessive tire scrubbing and tire slippage can result from taxiing under these conditions with main gear aft axle steering inoperative.

3.13 Turning Radius and Gear Tracking

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

As the following diagram illustrates, while the 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).



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

777-200 – 777-300ER

Model	Pilot Seat Position (forward of nose gear) feet (meters)	Pilot Seat Position (forward of main gear) feet (meters)
777 - 200	12 (3.7)	97 (29.6)
777 - 200LR	12 (3.7)	97 (29.6)
777 - 300	12 (3.7)	114 (34.8)
777 - 300ER	12 (3.7)	114 (34.8)

787-8 – 787-10

Model	Pilot Seat Position (forward of nose gear) feet (meters)	Pilot Seat Position (forward of main gear) feet (meters)
787 - 8	8.75 (2.7)	83.75 (25.5)
787 - 9	8.75 (2.7)	93.75 (28.6)
787 - 10	8.75 (2.7)	103.75 (31.6)

3.14.1 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.

3.14.2 Turns of 90 degrees or more

777-200 – 777-300ER

Initiate the turn as the intersecting taxiway centerline (or intended exit point) approaches the aft edge of the number 2 window. Initially use approximately full nose wheel steering tiller displacement. Adjust the tiller input as the airplane turns to keep the nose wheels outside of the taxiway centerline, near the outside radius of the turn. Nearing turn completion, when the main gear are clear of the inside radius, gradually release the tiller input as the airplane lines up with the intersecting taxiway centerline or intended taxi path.

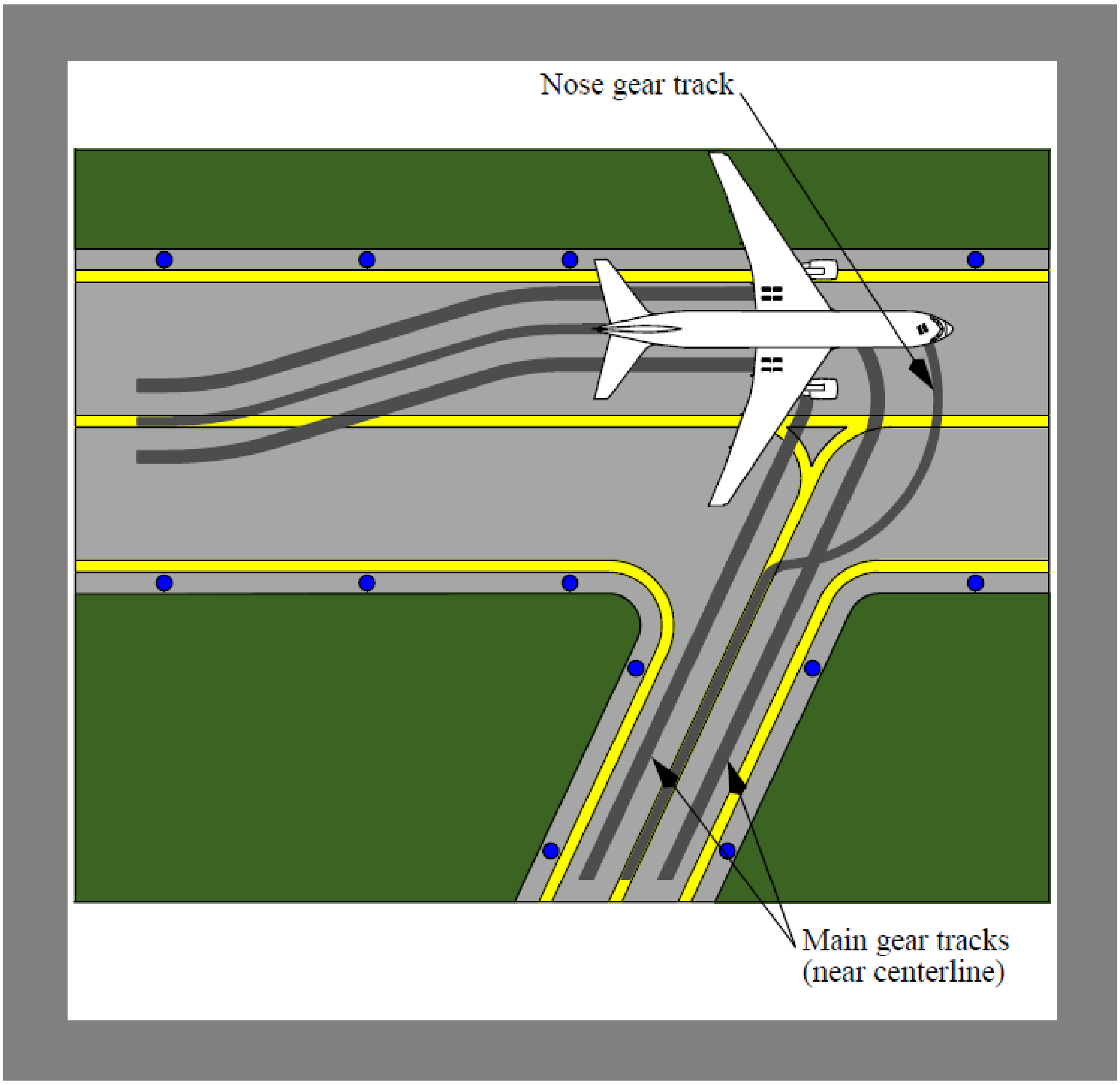
787-8 – 787-10

Initiate the turn as the intersecting taxiway centerline (or intended exit point) approaches approximately the center of the side window. Initially use approximately full nose wheel steering tiller displacement. Adjust the tiller input as the airplane turns to keep the nose wheels outside of the taxiway centerline, near the outside radius of the turn. Nearing turn completion, when the main gear are clear of the inside radius, gradually release the tiller input as the airplane lines up with the intersecting taxiway centerline or intended taxi path.

3.15 Sharp Turns to a Narrow Taxiway

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

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



3.16 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, because it leaves the pavement in the turn before the main gear.

777-200 – 777-300ER

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

CAUTION: The '15 Degree Offset' technique is a BA technique designed to position the main gear reliably as close as possible to the edge of the paved surface. It is applicable to the B777-200/200ER only. 777 QRH OI.180 describes this technique, and also describes use of the GMCS for 777-300ER 180 degree turns (Extract available on BAV Forums).

787-8 – 787-10

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

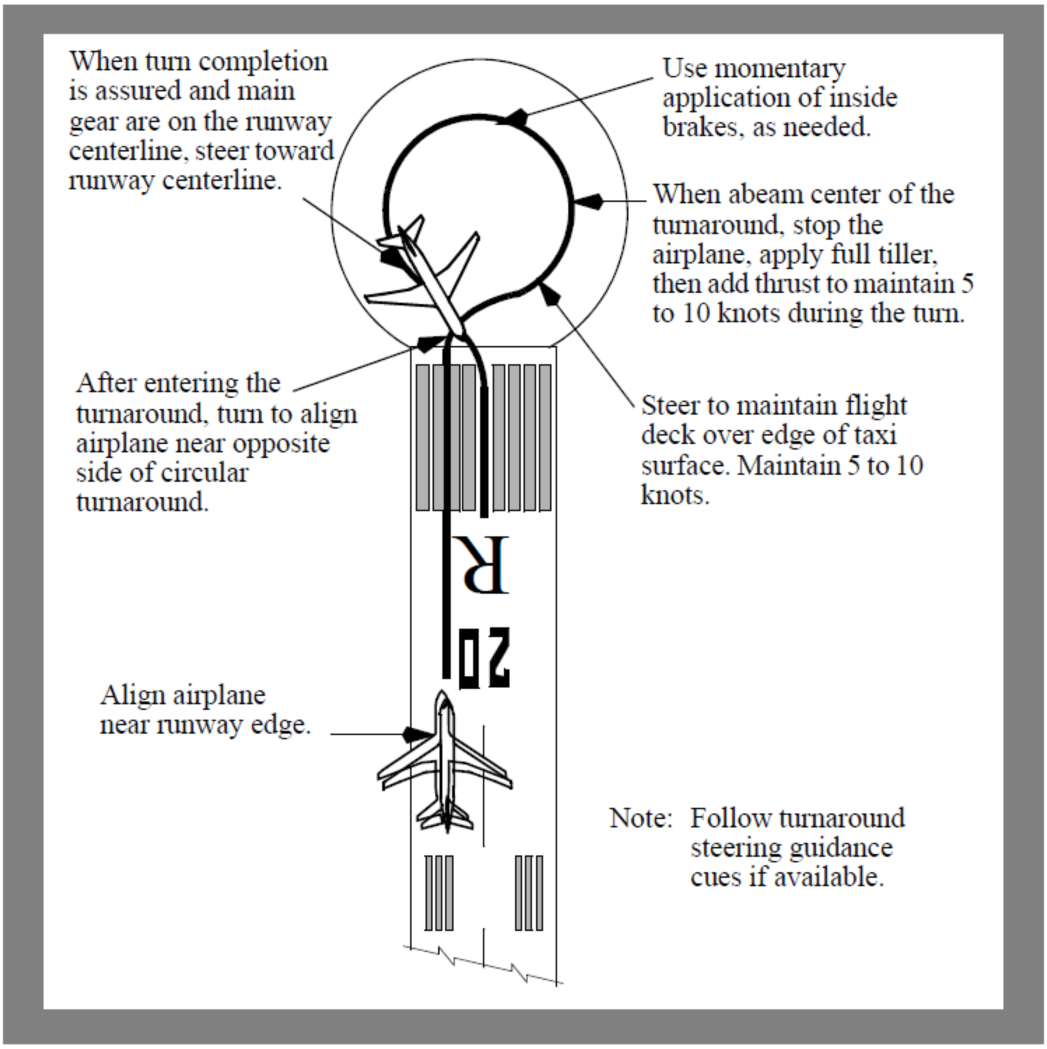
Note: Painted runway markings are slippery when wet and may cause skidding of the nose gear during the turn.

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 tiller to the maximum steering angle, release the brakes, then add thrust on the outboard engine. Only use the engine on the outboard side of the turn and maintain 5 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 tiller input as required to align the airplane with the new direction of taxi.

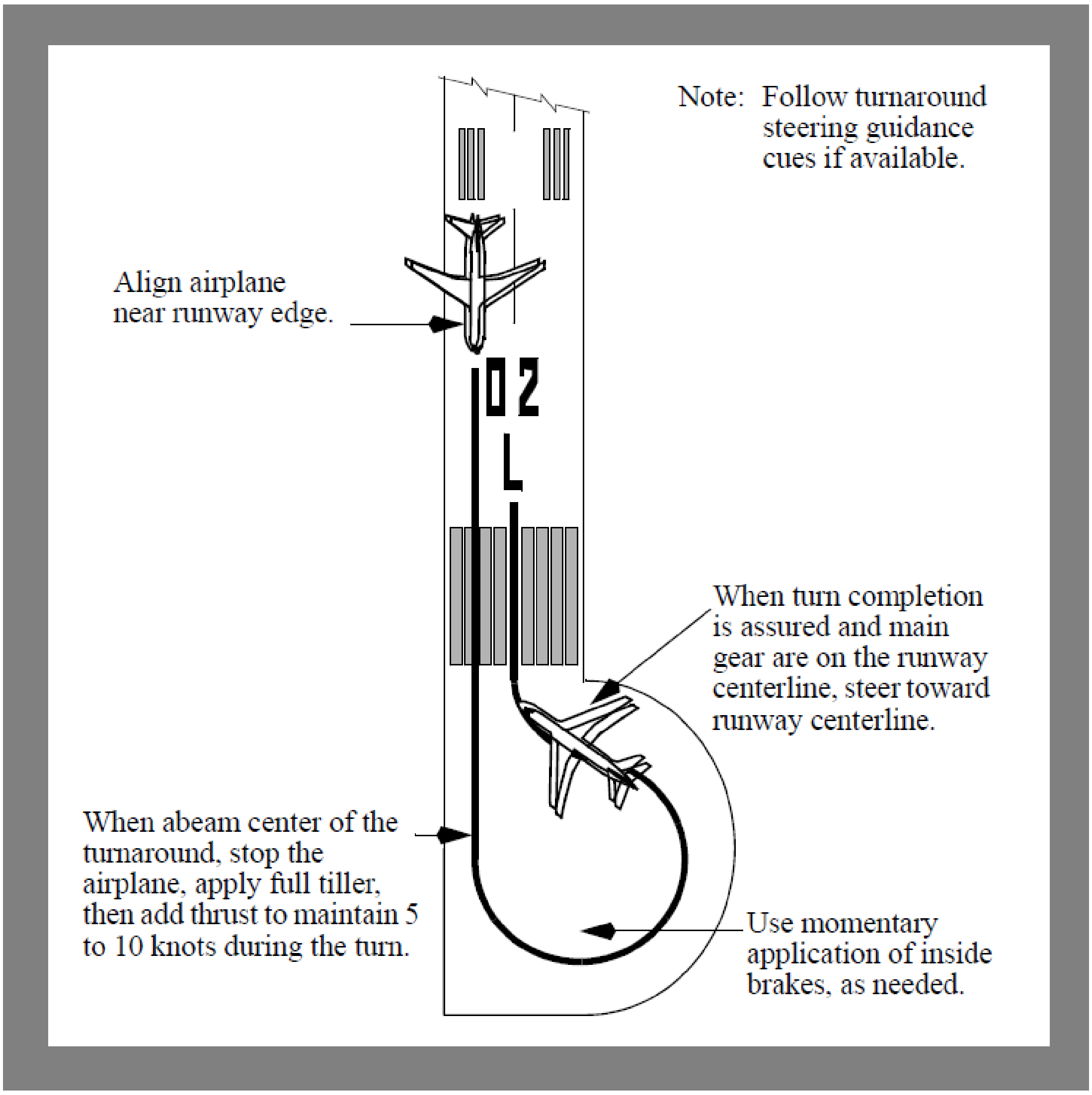
This technique results in a low speed turn and less runway being used. It does not impose undue stress on the landing gear and tires provided the wheel brakes are not locked during the turn. If the nose gear skids, a good technique is to apply the inside wheel brake briefly and keep the airplane turning 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.

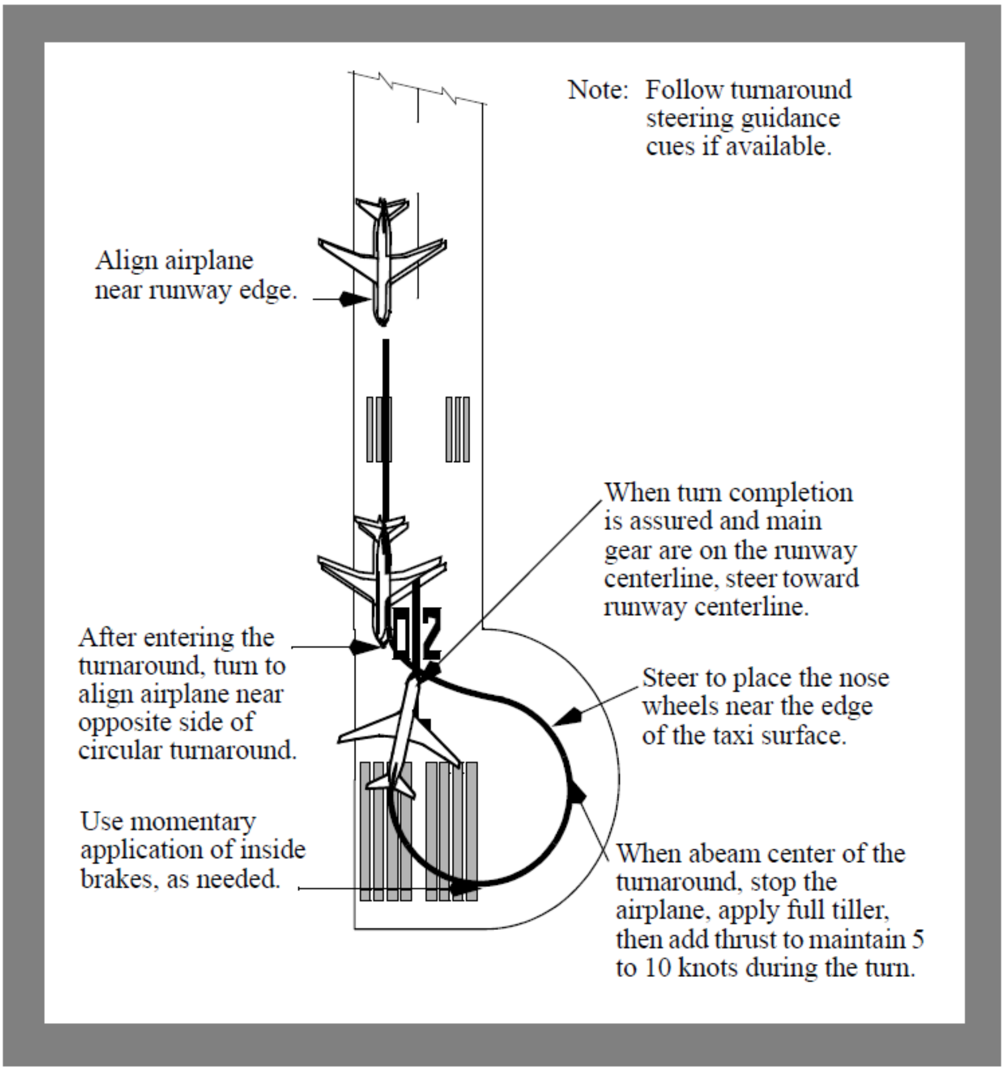
3.16.1 Techniques when using a Circular Turnaround



3.16.2 Techniques when using a Hammerhead Turnaround



3.16.3 Techniques when using a Hammerhead Turnaround



3.17 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 of 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.

3.17.1 Low Visibility

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

3.17.2 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 contaminants is a maintenance function addressed in the AMM.

3.18 Taxi – Aft CG

787-8 – 787-10

Taxi operations with aft CG (at 30% MAC or greater) are more susceptible to encountering nose wheel skidding or scrubbing and can increase the turn radius due to reduced nose gear steering effectiveness. At aft CG, for turn angles greater than those typically required for high speed runway turnoffs on a dry surface, use a maximum of approximately 6-8 knots. Whenever space is available make turns using less than full tiller deflection. Avoid abrupt tiller steering inputs. If the nose wheel is on painted or wet surfaces, the possibility of nose wheel skidding is increased. When needed, differential braking can be used to reduce the turn radius.

3.19 Engine Out Taxi

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. British Airways EOT procedures are published in the ECL, and also FCOM SP.EOT.

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4 Takeoff and Initial Climb

4.1 Preface

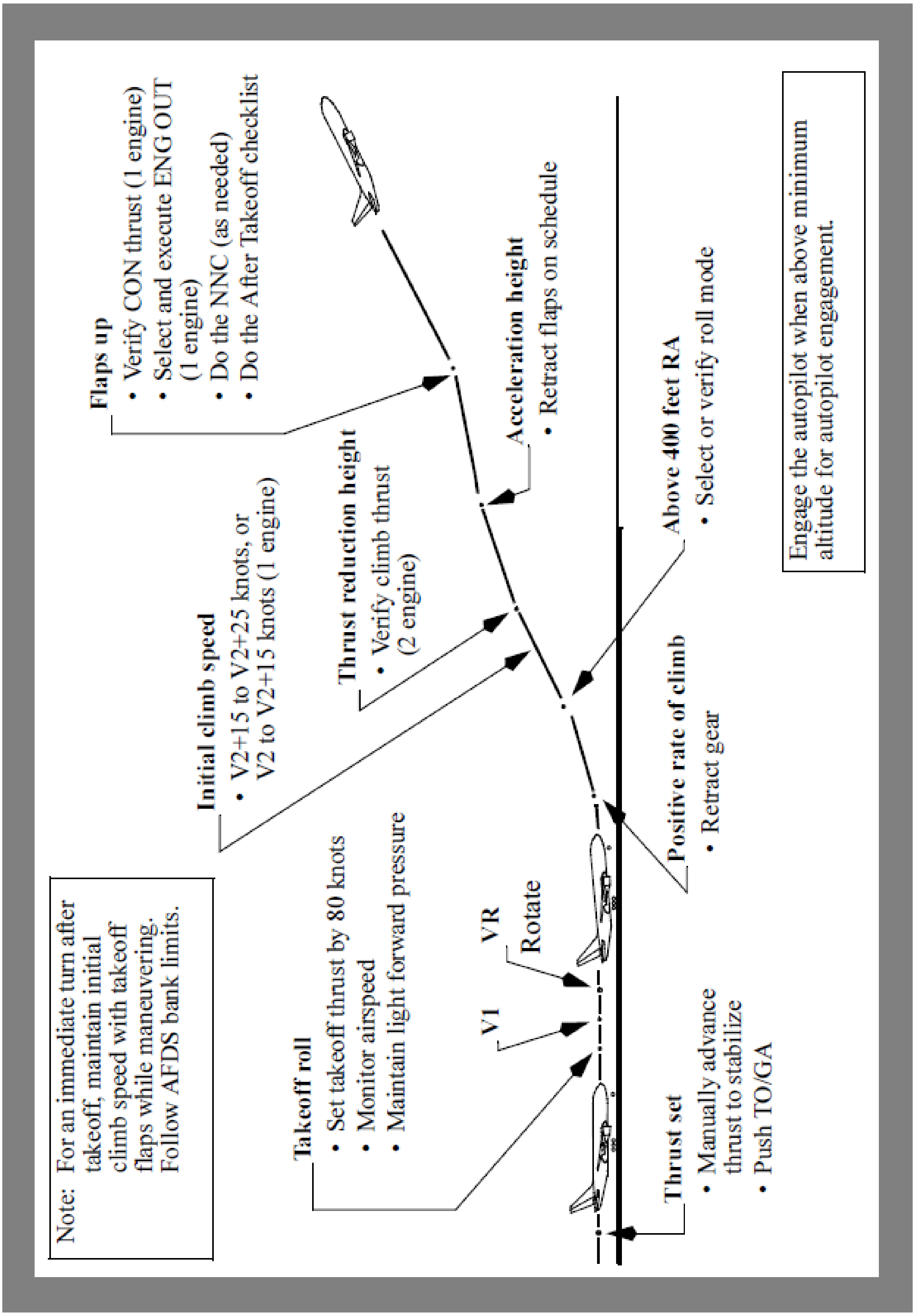
This chapter outlines the recommended operating practices and techniques for takeoff and initial climb. Engine failure during takeoff/initial climb is also addressed. The discussion portion of each illustration highlights important information.

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.

4.2 Takeoff

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

4.3 Takeoff Profile



4.4 Takeoff – General

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

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

777-200 – 777-300ER

Note: The lower center MFD is normally blank for takeoff to reduce the display of unnecessary information.

787-8 – 787-10

Note: The secondary engine instrument display on the EICAS is normally blank for takeoff to reduce the display of unnecessary information.

The PF normally displays the takeoff reference page on the CDU. Display of the takeoff reference page allows the crew to have immediate access to V-speeds during takeoff in the event that V-speeds are inadvertently removed from the airspeed display. After changes to the takeoff briefing have been updated during the Before Takeoff Procedure, the PF may elect to display the CLB page for takeoff. However, to reduce heads down activity, climb constraint modification immediately after takeoff should normally be accomplished on the mode control panel. Modify the CLB page when workload permits. The PM normally displays the LEGS page during takeoff and departure to allow timely route modification if necessary.

4.5 Takeoff Flap Setting

CARD and OPT will provide optimized takeoff flap settings in accordance with British Airways performance standards. The minimum tail clearance remains constant for all takeoff flap settings. The rotation speed schedules were developed to maintain a constant tail clearance.

4.6 Takeoff Speeds

777-200 – 777-300ER

Proper takeoff speeds (V1, VR, and V2) are based on takeoff weight, flaps setting, thrust rating and assumed temperature, ambient temperature, QNH, wind, runway surface condition, and performance options. Uplinked or OPT computed takeoff speeds (if available) should be used. The FCOM and FMC computed takeoff speeds (if enabled) are only valid for dispatch performance based on balanced field length, no improved climb, the most forward CG limit, and dry runway. Wet runway takeoff speeds may also be available for airplanes with wet runway takeoff performance in the AFM.

787-8 – 787-10

Proper takeoff speeds (V1, VR, and V2) are based on takeoff weight, flaps setting, thrust rating and assumed temperature, ambient temperature, QNH, wind, runway surface condition, and performance options. Uplinked or OPT computed takeoff speeds (if available) should be used. The FCOM computed takeoff speeds are only valid for dispatch performance based on balanced field length, no improved climb, the most forward CG limit, and dry or wet runway.

777-200 – 777-300ER

The FCOM and FMC computed takeoff speeds do not consider runway length available, minimum engine-out climb gradient capability, or obstacle clearance requirement. The FCOM and FMC computed takeoff speeds can only be used when compliance of these requirements has been verified separately with a takeoff analysis (runway/airport analysis), another approved source, or by dispatch. The FCOM and FMC computed takeoff speeds are not valid for dispatch performance based on optimized V1 (unbalanced field length), Improved Climb, alternate forward CG limit, or contaminated or slippery runway.

787-8 – 787-10

The FCOM takeoff speeds do not consider runway length available, minimum engine-out climb gradient capability, or obstacle clearance requirement. The FCOM takeoff speeds can only be used when compliance of these requirements has been verified separately with an approved source or by dispatch. The FCOM computed takeoff speeds are not valid for dispatch performance based on optimized V1 (unbalanced field length), Improved Climb, alternate forward CG limit, or contaminated or slippery runway.

4.7 Thrust Management

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

High thrust settings from jet engine blast over unpaved surfaces or thin asphalt pavement intended only to support occasional airplane 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.

4.8 Initiating Takeoff Roll

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

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

Rolling takeoffs are accomplished in two ways:

777-200 – 777-300ER

- if cleared for takeoff before or while entering the runway, maintain normal taxi speed. When the airplane is aligned with the runway centerline ensure the nose wheel steering tiller is released and apply takeoff thrust by advancing the thrust levers to approximately 55% N1. 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.

787-8 – 787-10

- if cleared for takeoff before or while entering the runway, maintain normal taxi speed. When the airplane is aligned with the runway centerline ensure the nose wheel steering tiller is released and apply takeoff thrust by advancing the thrust levers to approximately 20 TPR (RR) or 40% N1 (GE). 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 tiller is released, release brakes, then apply takeoff thrust as described above.

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

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

777-200 – 777-300ER

Note: If the nose wheel steering tiller is not released before application of takeoff thrust, a configuration warning may occur due to the aft axle steering being out of the locked position.

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.

777-200 – 777-300ER

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

787-8 – 787-10

Note: During tailwind conditions, slight TPR (as installed) fluctuations may occur on some engines before 5 knots forward airspeed.

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

777-200 – 777-300ER

Ensure the target N1 or EPR is set by 80 knots. Minor increases in thrust may be made immediately after 80 knots to reach the target N1 or EPR. After takeoff thrust is set, a small deviation in N1or 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 variations in thrust settings, runway conditions, etc., it is not practical to specify a precise tolerance for N1or EPR deviation between the engines.

787-8 – 787-10

Ensure the target N1 or TPR is set by 80 knots. Minor increases in thrust may be made immediately after 80 knots to reach the target N1 or TPR. After takeoff thrust is set, a small deviation in N1or TPR 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 variations in thrust settings, runway conditions, etc., it is not practical to specify a precise tolerance for N1or TPR deviation between the engines.

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

The PF should keep one hand on the thrust levers until V1 in order to respond quickly to a rejected takeoff condition. After V1, the PF'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. Another source of speed information is the ground speed indication. Early recognition of a malfunction is important in making a sound go/stop decision. Refer to the Airspeed Unreliable section in Chapter 8 for an expanded discussion of this subject.

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

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

The HOLD mode protects against thrust lever movement if a system fault occurs. Lack of the HOLD annunciation means the protective feature may not be active. If 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.

4.9 Rotation and Liftoff – All Engines

777-200 – 777-300ER

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 airport analysis or FMC are developed to provide adequate tail clearance.

787-8 – 787-10

Takeoff speeds are established based on minimum control speed, stall speed, and tail clearance margins. 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, airport analysis or FMC 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. However, takeoffs at low thrust setting (low excess energy) will result in a lower initial pitch attitude target to achieve the desired climb speed.

777-200 – 777-300ER

The use of stabilizer trim during rotation is not recommended. 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.

787-8 – 787-10

The use of stabilizer trim during rotation is not recommended. After liftoff, use the attitude indications on the PFD or HUD 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: The flight director pitch command is not used for rotation.

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

Note: Do not adjust takeoff speeds or control forces to compensate for increased body length.

777-200 – 777-300ER

Using the technique above, resultant rotation rates vary from 2° to 2.5° per second with rates being lowest on longer airplanes. Liftoff attitude is achieved in approximately 4 seconds.

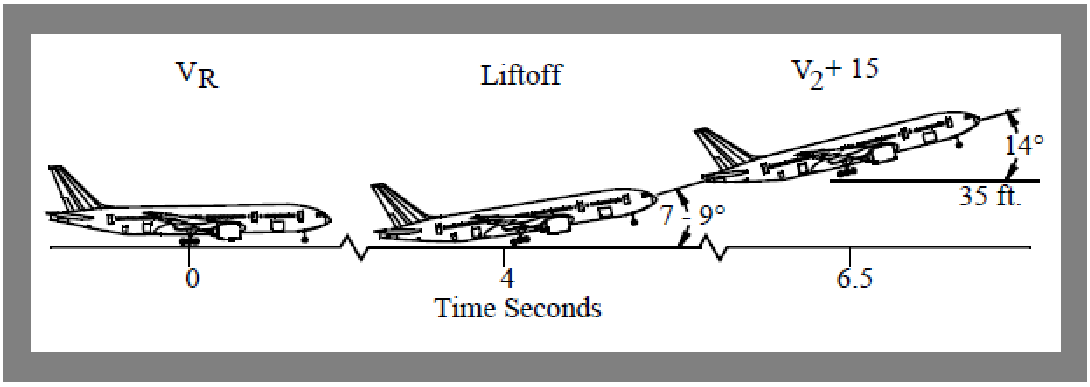
787-8 – 787-10

Using the technique above, resultant rotation rates vary from 2° to 2.5° per second. Liftoff attitude is achieved in approximately 3 to 4 seconds depending on airplane weight and thrust setting.

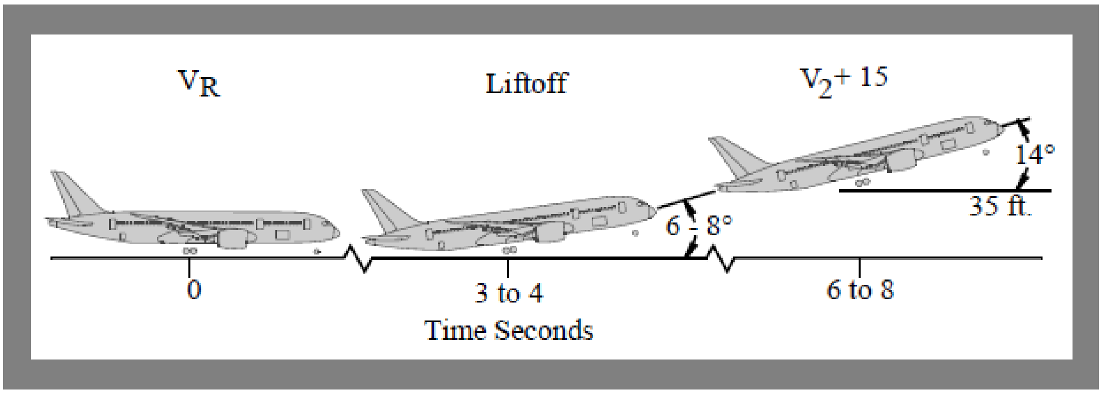
4.9.1 Typical Rotation, All Engines

The following figure shows typical rotation with all engines operating.

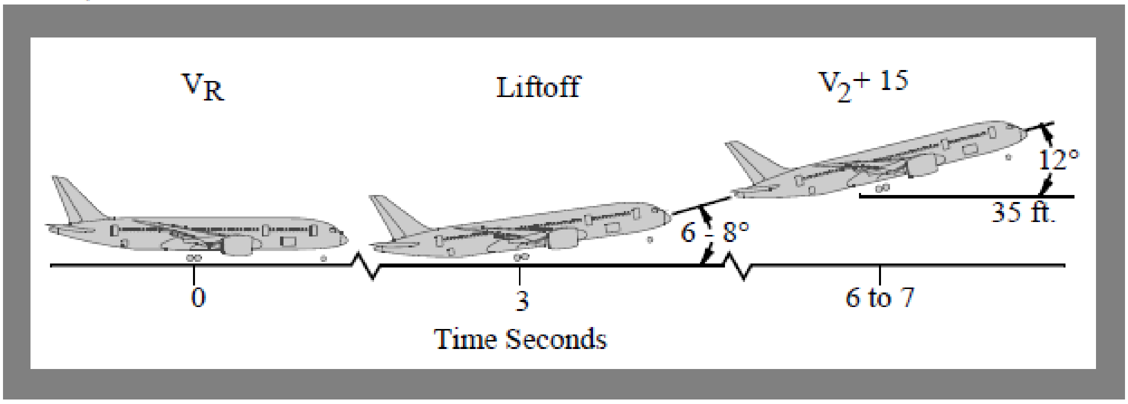
777-200 – 777-300ER



787-8



787-9, 787-10



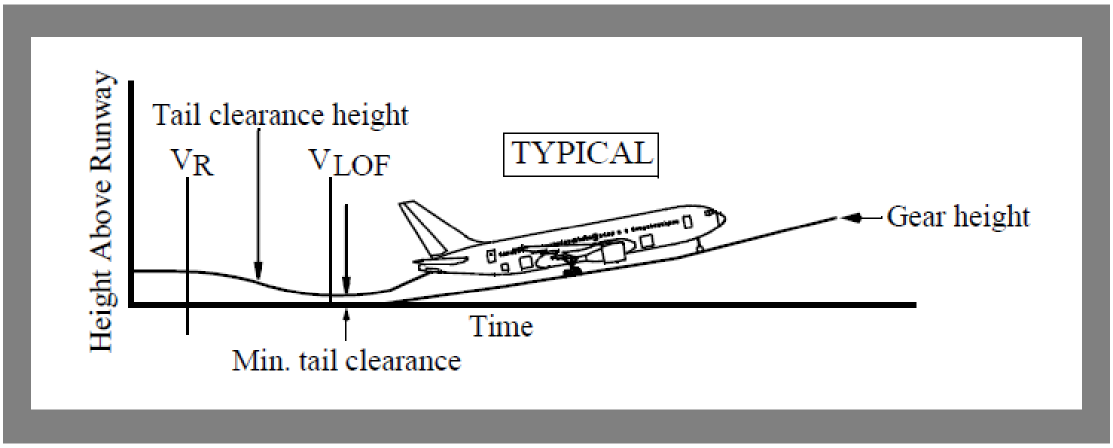
Retract the landing gear after a positive rate of climb is indicated on the altimeter.

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

Note: When operating at low gross weights, takeoff with less than full rated thrust will aid in aircraft directional control in the event of an engine failure. The rotation should be accomplished at the normal rate, but the pitch attitudes during the transition to initial climb may be higher than normal.

4.9.2 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 Tail Strike NNC.



777-200 – 777-300ER

Model	Flaps	Liftoff Attitude (degrees)	Minimum Tail Clearance inches (cm)	Tail Strike Pitch Attitude (degrees)
777-200	5, 15, 20	8.5	37 (94)	12.1
777-200LR	5, 15, 20	8.5	37 (94)	12.1
777-F	5, 15, 20	8.5	37 (94)	12.1
777-300	5, 15, 20	7.0	36 (91)	8.9
777-300ER	5, 15, 20	8.5	30 (76)	10.0

Note: 777-300ER values valid when the Semi-Levered Gear (SLG) is operative. When the SLG is inoperative, use 777-300 values.

787-8 – 787-10

Model	Flaps	Liftoff Attitude (degrees)	Minimum Tail Clearance inches (cm)	Tail Strike Pitch Attitude (degrees)
787-8	5, 15, 20	7.0	42 (107)	11.2
787-9	5, 10, 15, 17, 18, 20	6-7.5	29 (74)	9.7
787-10	5, 10, 15, 17, 18, 20	5.5-7.5	32 (81)	9.7

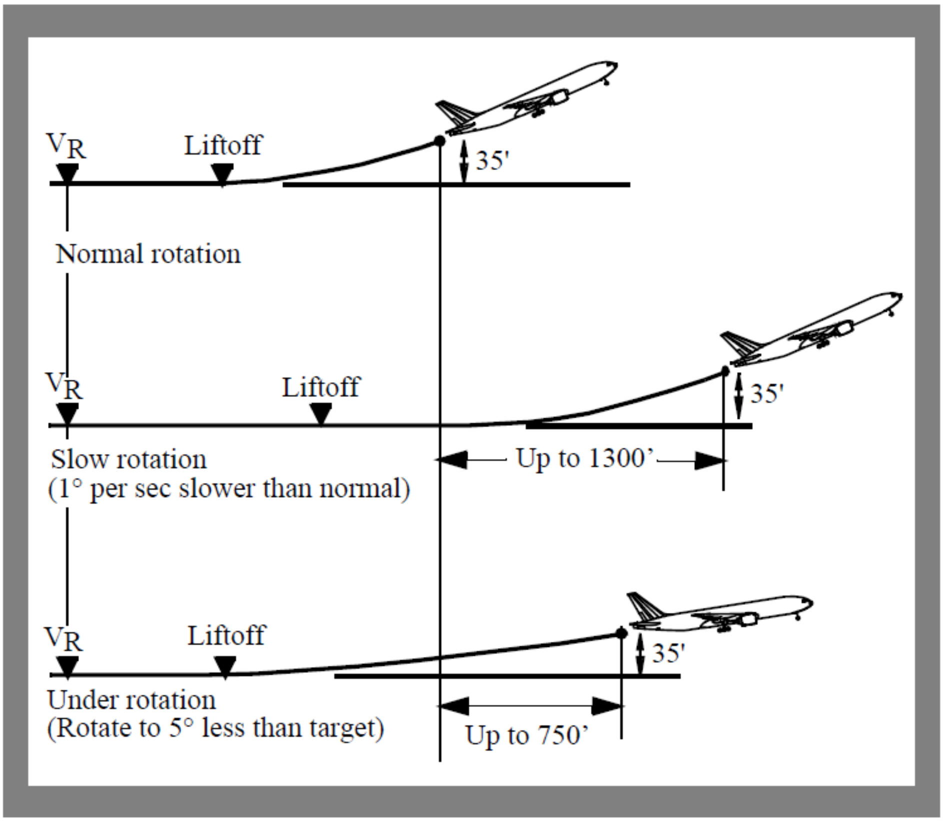
4.10 Effect of Rotation Speed and Pitch Rate on Liftoff

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.

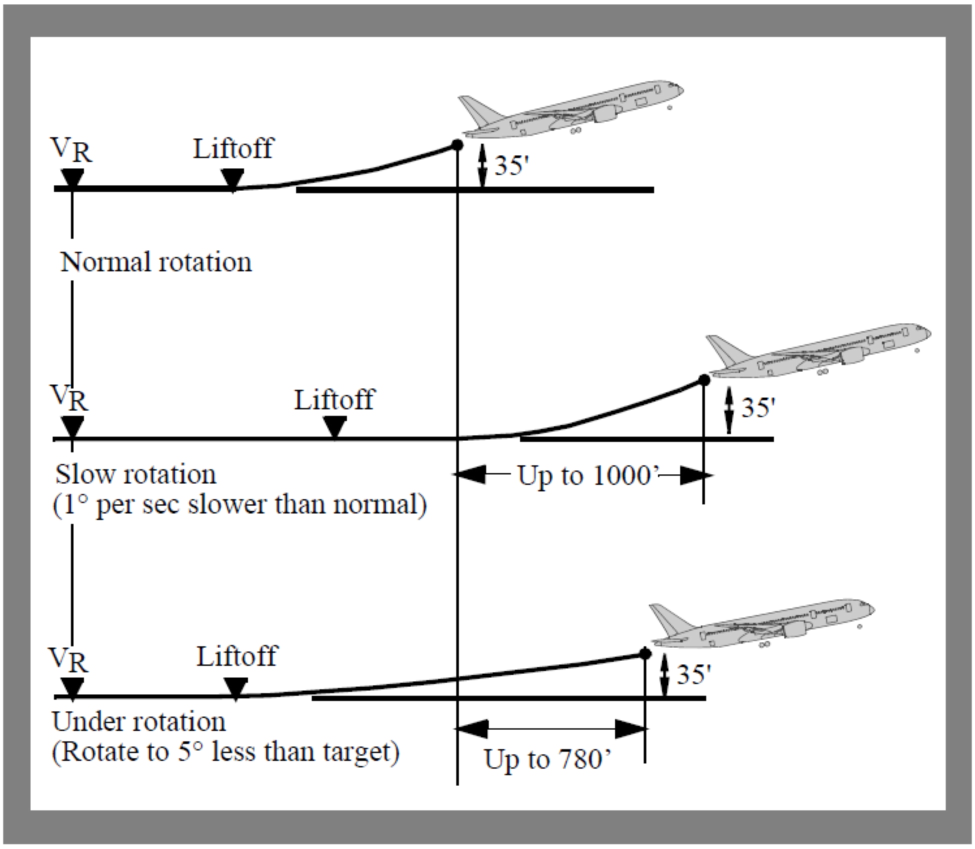
An improper rotation can have an effect on the command speed after liftoff. If the rotation is delayed beyond V2 + 15 knots, the speed commanded by the flight director is rotation speed up to a maximum of V2 + 25 knots. An earlier liftoff does not affect the commanded initial climb speed, however, either 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.

777-200 – 777-300ER



787-8 – 787-10



4.11 Center-Of-Gravity Effects

777-200 – 777-300ER

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

787-8 – 787-10

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

787-8 – 787-10

CAUTION: Do not exceed 55% N1 during static engine run-up. Do not release the brakes with N1 greater than 55%. A tip-up can occur and directional control can be reduced.

787-8 – 787-10

Refer to the Aft CG Takeoff Supplementary Procedure in the FCOM for additional details.

4.12 Crosswind Takeoff

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.

Note: Engine stress and possible engine surge can occur with a strong crosswind or tailwind component if takeoff thrust is set before brake release. Therefore, the rolling takeoff procedure is strongly advised when crosswinds exceed 20 knots or tailwinds exceed 5 knots.

4.13 Takeoff Crosswind Guidelines

Crosswind guidelines are not considered limitations. OM A states the British Airways Virtual's crosswind policy.

787-8 – 787-10

CAUTION: Do not exceed 55% N1 during static engine run-up in an aft CG configuration. Do not release the brakes with N1 greater than 55% in an aft CG configuration. A tip-up can occur and directional control can be reduced.

Takeoff crosswind guideline considerations:

- takeoff crosswind guidelines increase with higher gross weights and more forward CGs, and assume an engine out RTO and proper pilot technique
- on slippery runways, crosswind guidelines are a function of runway surface condition and airplane loading
- 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.

787-8 – 787-10

- Crosswind guidelines for takeoff assume rolling takeoff procedures (no brakes)

4.13.1 Runway Condition Assessment – TALPA

The following table is an abbreviated version of the Matrix for runway condition assessment in terms of the Takeoff and Landing Performance Assessment (TALPA) categories contained in AC 25-31. The runway condition descriptions and codes are aligned with control/braking action reports.

Runway Condition Assessment		
Runway Condition Description	**Runway Condition Code**	**Control / Braking Action**
• Dry	6	---
• Frost • Wet (includes damp and 1/8" (3mm) depth or less of water) **1/8" (3mm) depth or less of:** • Slush • Dry Snow • Wet Snow	5	Good
-15°C and colder OAT: • Compacted Snow	4	Good to Medium
• Slippery when wet (wet runway) • Dry or Wet Snow (any depth) over Compacted Snow **Greater than 1/8" (3mm) depth:** • Dry Snow • Wet Snow **Warmer than -15°C OAT:** • Compacted snow	3	Medium

Runway Condition Assessment		
Runway Condition Description	**Runway Condition Code**	**Control / Braking Action**
Greater than 1/8" (3mm) depth: • Water • Slush	2	Medium to Poor
• Ice	1	Poor
• Wet Ice • Water on top of Compacted Snow • Dry Snow or Wet Snow over Ice	0	Nil

4.13.2 Takeoff Crosswind Guidelines – TALPA

The crosswind guideline is determined by entering the table below with Runway Condition Code or Control/Braking Action.

777-200 – 777-300ER

TO Weight 1,000 lb/kg	Runway Condition Code	Control/ Braking Action	Center of Gravity (% MAC) 30% or less	35%	39%	TO Aft Limit
			Crosswind Component (knots)			
550 lb (250 kg) and above	6	---	40	40	40	29
	5	Good	40	40	34	25
	4	Good to Medium	35	29	24	18
	3	Medium	25	20	19	15
	2	Medium to Poor	15	15	15	10
	1	Poor	10	10	10	10
	0	Nil	---	---	---	---
470 lb (215 kg)	6	---	40	40	33	24
	5	Good	40	34	29	21
	4	Good to Medium	30	25	21	16
	3	Medium	23	19	18	13
	2	Medium to Poor	15	15	15	10
	1	Poor	10	10	10	10
	0	Nil	---	---	---	---

TO Weight 1,000 lb/kg	Runway Condition Code	Control/ Braking Action	Center of Gravity (% MAC) 30% or less	35%	39%	TO Aft Limit
			Crosswind Component (knots)			
390 lb (180 kg) and below*	6	---	40	33	28	22
	5	Good	35	29	24	20
	4	Good to Medium	27	22	19	16
	3	Medium	20	18	17	12
	2	Medium to Poor	15	15	15	10
	1	Poor	10	10	10	10
	0	Nil	---	---	---	---

Interpolation is permitted for intermediate gross weights and CG positions.

*** At gross weights of 390,000 lbs (180,000 kgs) and below, when the takeoff aft CG limit is less than 39% MAC and the airplane CG is more than 35% MAC, interpolate using crosswinds from the columns labeled "35% MAC" and "Takeoff Aft Limit".**

787-8

TO Weight 1,000 lb/kg	Runway Condition Code		Center of Gravity (% MAC)			
			20% or less	25%	30%	TO Aft Limit
		Control / Braking Action	Crosswind Component (knots)			
430 lb (195 kg) and above	6	---	40**	40**	40**	31
	5	Good	40**	40**	37	24
	4	Good to Medium	35	32	25	17
	3	Medium	25	22	20	13
	2	Medium to Poor	15	15	15	10
	1	Poor	10	10	10	10
	0	Nil	---	---	---	---
350 lb (159 kg)	6	---	40**	40**	37	24
	5	Good	40**	38	31	20
	4	Good to Medium	33	27	22	15
	3	Medium	24	20	18	12
	2	Medium to Poor	15	15	15	10
	1	Poor	10	10	10	10
	0	Nil	---	---	---	---

TO Weight 1,000 lb/kg	Runway Condition Code		Center of Gravity (% MAC)			
			20% or less	25%	30%	TO Aft Limit
		Control / Braking Action	Crosswind Component (knots)			
270 lb (122 kg) and below*	6	---	40**	37	30	25
	5	Good	37	31	26	22
	4	Good to Medium	28	25	21	18
	3	Medium	22	18	16	15
	2	Medium to Poor	15	15	15	12
	1	Poor	10	10	10	10
	0	Nil	---	---	---	---

Interpolation is permitted for intermediate gross weights and CG positions.

***At gross weights of 237,000 lbs (107,501 kgs) and below, when the takeoff aft CG limit is less than 30% MAC and the airplane CG is more than 25% MAC, interpolate using crosswinds from the columns labeled "25% MAC" and "30% MAC".**

****Maximum takeoff steady-state crosswind component is limited to 40 knots for airplanes with GEnx-1B engines installed.**

787-8

Note: Reduce all takeoff crosswind guidelines by 5 knots if thrust is above 20 TPR (RR engines) / 40% N1 (GE engines) at brake release for takeoff roll.

787-9

TO Weight 1,000 lb/kg	Runway Condition Code	Control / Braking Action	Center of Gravity (% MAC) 20% or less	25%	30%	TO Aft Limit
			Crosswind Component (knots)			
430 lb (195 kg) and above	6	---	40**	40**	40**	28
	5	Good	40**	40**	35	23
	4	Good to Medium	35	31	25	17
	3	Medium	25	22	20	13
	2	Medium to Poor	15	15	15	10
	1	Poor	10	10	10	10
	0	Nil	---	---	---	---
350 lb (159 kg)	6	---	40**	40**	37	24
	5	Good	40**	37	30	20
	4	Good to Medium	32	27	22	15
	3	Medium	24	20	18	12
	2	Medium to Poor	15	15	15	10
	1	Poor	10	10	10	10
	0	Nil	---	---	---	---

TO Weight 1,000 lb/kg	Runway Condition Code	Control / Braking Action	Center of Gravity (% MAC) 20% or less	25%	30%	TO Aft Limit
			Crosswind Component (knots)			
270 lb (122 kg) and below*	6	---	40**	37	30	28
	5	Good	37	31	26	25
	4	Good to Medium	28	25	21	20
	3	Medium	22	18	16	16
	2	Medium to Poor	15	15	15	12
	1	Poor	10	10	10	10
	0	Nil	---	---	---	---

Interpolation is permitted for intermediate gross weights and CG positions.

***At gross weights of 250,000 lbs (113,398 kgs) and below, when the takeoff aft CG limit is less than 30% MAC and the airplane CG is more than 25% MAC, interpolate using crosswinds from the columns labeled "25% MAC" and "30% MAC".**

****Maximum takeoff steady-state crosswind component is limited to 40 knots for airplanes with GEnx-1B engines installed.**

787-9

Note: Reduce all takeoff crosswind guidelines by 5 knots if thrust is above 20 TPR (RR engines) / 40% N1 (GE engines) at brake release for takeoff roll.

787-10

TO Weight 1,000 lb/kg	Runway Condition Code		Center of Gravity (% MAC)			
			20% or less	25%	30%	TO Aft Limit
		Control/ Braking Action	Crosswind Component (knots)			
430 lb (195 kg) and above	6	---	40**	40**	40**	24
	5	Good	40**	40**	35	18
	4	Good to Medium	35	31	25	16
	3	Medium	25	22	20	13
	2	Medium to Poor	15	15	15	10
	1	Poor	10	10	10	10
	0	Nil	---	---	---	---
350 lb (159kg)	6	---	40**	40**	36	24
	5	Good	40**	36	30	16
	4	Good to Medium	32	27	22	13
	3	Medium	24	20	18	12
	2	Medium to Poor	15	15	15	10
	1	Poor	10	10	10	10
	0	Nil	---	---	---	---

TO Weight 1,000 lb/kg	Runway Condition Code		Center of Gravity (% MAC)			
			20% or less	25%	30%	TO Aft Limit
		Control / Braking Action	Crosswind Component (knots)			
270 lb (122 kg) and below*	6	---	40**	37	28	28
	5	Good	37	31	26	26
	4	Good to Medium	28	25	21	21
	3	Medium	22	18	16	16
	2	Medium to Poor	15	15	10	10
	1	Poor	10	10	10	10
	0	Nil	---	---	---	---

Interpolation is permitted for intermediate gross weights and CG positions

*** At gross weights of 265,000 lbs (120,202 kgs) and below, when the takeoff aft CG limit is less than 30% MAC and the airplane CG is more than 25% MAC, interpolate using crosswinds from the columns labeled "25% MAC" and "30% MAC".**

****Maximum takeoff steady-state crosswind component is limited to 40 knots for airplanes with GEnx-1B engines installed.**

Rolling takeoff procedure is strongly advised for all crosswinds exceeding 20 knots

787-10

Note: Reduce all takeoff crosswind guidelines by 5 knots if thrust is above 20 TPR (RR engines) / 40% N1 (GE engines) at brake release for takeoff roll.

4.14 Directional Control

777-200 – 777-300ER

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.

787-8 – 787-10

Initial runway alignment and smooth symmetrical thrust application result in acceptable crosswind control capability during takeoff. Below 80 knots maintaining forward pressure on the control column increases nose wheel steering effectiveness. Counter any deviation from the centerline during thrust application with immediate, smooth, and positive control inputs. Smooth rudder and control wheel inputs result in a normal takeoff with no overcontrolling. In crosswind conditions with low airspeed, the crosswind acting on the engine nacelles causes a downwind turning tendency. When airspeed is below 80 knots, up to full application of upwind rudder can be needed to maintain runway alignment. 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.

4.15 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.

4.16 Gusty Wind and Strong Crosswind Conditions

Do not rotate early or use a higher than normal rotation rate in an attempt to clear the ground and reduce the gust effect because this reduces tail clearance margins. Limit control wheel input to that required to keep the wings level. Use of excessive control wheel increases spoiler deployment which has the effect of reducing tail clearance. All of these factors provide maximum energy to accelerate through gusts while maintaining tail clearance margins at liftoff. The 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.

4.17 Reduced and Derated Takeoff Thrust

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

Takeoff thrust reduction can be achieved using reduced takeoff thrust (Assumed Temperature Method or ATM), derated takeoff thrust (fixed derate - 787 only), or a combination of these two methods (- 787 only). Regardless of the method, takeoff speeds based on the selected rating (full rated or fixed derate) and the selected assumed temperature should be used. These takeoff speeds may be obtained from the takeoff analysis (runway/airport analysis) or another approved source. Takeoff with less than full rated takeoff thrust using any of these methods complies with all regulatory takeoff performance requirements.

Note: Takeoff with full rated takeoff thrust is recommended if windshear conditions are suspected, unless the use of a fixed derate is required to meet a dispatch performance requirement.

777-200 – 777-300ER

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

4.18 Reduced Takeoff Thrust (ATM)

Reduced takeoff thrust (ATM) is a takeoff thrust level less than the full rated takeoff thrust. Reduced takeoff thrust is achieved by selecting an assumed temperature higher than the actual ambient temperature.

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

Note: Reduced takeoff thrust (ATM) may be used for takeoff on a wet runway if approved takeoff performance data for a wet runway is used. However, reduced takeoff thrust (ATM) is not permitted for takeoff on a runway contaminated with standing water, slush, snow, or ice.

4.19 Derated Takeoff Thrust (Fixed Derate)

Derated takeoff thrust (fixed derate) is a certified takeoff thrust rating lower than full rated takeoff thrust. In order to use derated takeoff thrust, takeoff performance data for the specific fixed derate level is required. Derated takeoff thrust is obtained by selection of TO I or TO 2 in the FMC.

When using derated takeoff thrust, the takeoff thrust setting is considered a takeoff operating limit since minimum control speeds (VMCG and VMCA), stabilizer trim setting, and Minimum Takeoff Weight are based on the derated takeoff thrust. Thrust levers should not be advanced unless conditions are encountered during the takeoff where additional thrust is needed on both engines, such as a windshear condition.

Note: If an engine failure occurs during takeoff, any thrust increase could result in loss of directional control. See the section titled “Engine Failure during a Derated Thrust (Fixed Derate) Takeoff” later in this chapter.

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

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

777-200 - 777-300ER

Derated takeoff thrust (fixed derate) may permit a lower takeoff weight when takeoff weight is limited by the Minimum Takeoff Weight requirement.

4.20 Combination ATM and Fixed Derate

787-8, 787-9

Note: All limitations and restrictions for reduced takeoff thrust (ATM) and derated takeoff thrust (fixed derate) must be observed.

Reduced takeoff thrust (ATM) and derated takeoff thrust (fixed derate) may be combined by first selecting a fixed derate and then an assumed temperature higher than the actual ambient temperature. Thrust levers should not be advanced unless conditions are encountered during the takeoff where additional thrust is needed on both engines, such as a windshear condition.

Note: If an engine failure occurs during takeoff, any thrust increase beyond the fixed derate limit could result in loss of directional control. See the section titled “Engine Failure during a Combined ATM and Fixed Derate Takeoff” later in this chapter.

4.21 Thrust Control

777-200 – 777-300ER, 787-8, 787-9

When conducting a reduced thrust (ATM) takeoff, if more thrust is needed (up to maximum thrust) when thrust is in HOLD mode, 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.

787-8, 787-9

When conducting a derated thrust (fixed derate) takeoff or a takeoff with a combination ATM and fixed derate, takeoff speeds consider VMCG and VMCA only at the fixed derate level of thrust. Thrust levers should not be advanced beyond the fixed derate limit unless conditions are encountered during the takeoff where additional thrust is needed on both engines, such as a windshear condition.

Note: If an engine failure occurs during takeoff, any thrust increase beyond the fixed derate limit could result in loss of directional control.

777-200 – 777-300ER, 787-8, 787-9

When combining a high level of derate with a high assumed temperature, or if a climb thrust rating higher than the automatically selected climb thrust rating is selected, it is possible that the climb thrust may be higher than the takeoff thrust. In such case, thrust levers will advance forward upon reaching thrust reduction altitude.

If more thrust is needed (up to maximum thrust) when the airplane is on the ground and HOLD mode is displayed, the thrust levers must be manually advanced.

After the airplane is in the air, pushing a TO/GA switch advances the thrust levers to maximum available thrust and THR REF is annunciated.

4.22 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.

4.23 Low Visibility Takeoff

Low visibility takeoff operations, below landing minima, may require a takeoff alternate. When selecting a takeoff alternate, consideration should be given to unexpected events such as an engine failure or other non-normal situation that could affect landing minima at the takeoff alternate. Operators, who have authorization for engine inoperative Category II/III operations, may be authorized lower alternate minima.

With proper crew training and appropriate runway lighting, takeoffs with visibility as low as 500ft/150m RVR may be authorized (FAA). With takeoff guidance systems and centerline lighting that meets FAA or International Civil Aviation Organization (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.

4.23.1 Low Visibility Takeoff Using HUD

787-8 – 787-10

During takeoff, normal procedures including callouts are used. Once the airplane is aligned with the runway, verify display of the ground roll guidance cue on the HUD. Also, adjust the combiner brightness to allow both runway markings and symbology to be viewed clearly. The PF performs the takeoff roll by using visual cues and HUD symbology. The HUD guidance provides steering commands to maintain the centerline, however the runway markings and runway lighting are the primary indication of centerline tracking.

Initiate a smooth continuous rotation to place the airplane pitch reference symbol over the target pitch line. Once the airplane pitch is stabilized, transition to the flight path vector and guidance cue. When large dynamic control inputs are required such as during takeoff rotation or go-around, turbulence and crosswinds often magnify the movement of the flight path vector. Aggressive maneuvering can result in an overshoot of the flight path vector and guidance cue. Whenever large dynamic control inputs are made, the pilot should continue the normal flight instrument scan and not focus attention exclusively on the HUD symbology.

Airplanes equipped with dual HUDs allow either pilot to perform the takeoff while providing head-up, eyes-out monitoring capability for the other pilot. The integration of the HUD into the flight deck design, where EICAS is the primary means of displaying system indications and alerts, allows the PM to include monitoring the HUD during the normal takeoff roll.

4.24 Adverse Runway Conditions

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 contaminants 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.

4.25 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 (extract available on BAV Forums) 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 before 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 before the end of the runway.

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

4.26 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 must be made before V1 speed.

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.

If the takeoff is rejected before the HOLD annunciation, the autothrottle should be disconnected as the thrust levers are moved to idle. If the autothrottle is not disconnected, the thrust levers advance to the selected takeoff thrust position when released. After HOLD is annunciated, the thrust levers, when retarded, remain in idle. For procedural consistency, disconnect the autothrottles for all rejected takeoffs.

777-200 – 777-300ER

If an engine failure occurs above TAC activation speed, TAC provides rudder input, as needed, to help maintain directional control. TAC rudder input is available during forward thrust operations only, until speed is reduced below TAC activation speed. With TAC inoperative, the PF must make rudder inputs.

787-8 – 787-10

If an engine failure occurs above 65 knots, the flight control system provides rudder input, as needed, to help maintain directional control. Automatic rudder input is available during forward or reverse thrust operations, until speed is reduced below 65 knots.

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.

4.27 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 14 CFR Part 25 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 before 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 that the majority of past RTO accidents were not the result of an RTO initiated because of an engine failure. Full takeoff thrust from all engines was available. With normal takeoff thrust, the 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.

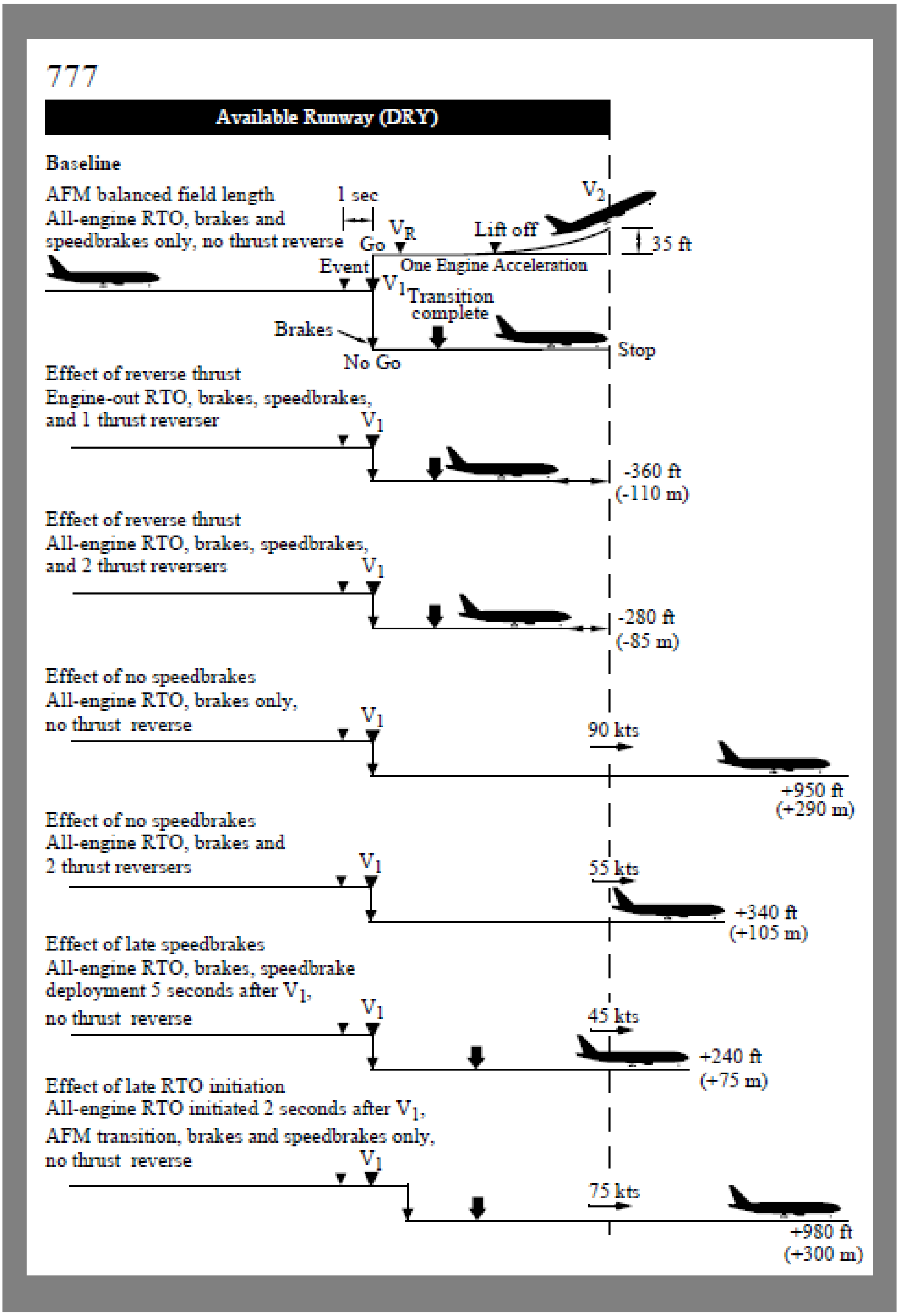
4.28 RTO Execution Operational Margins

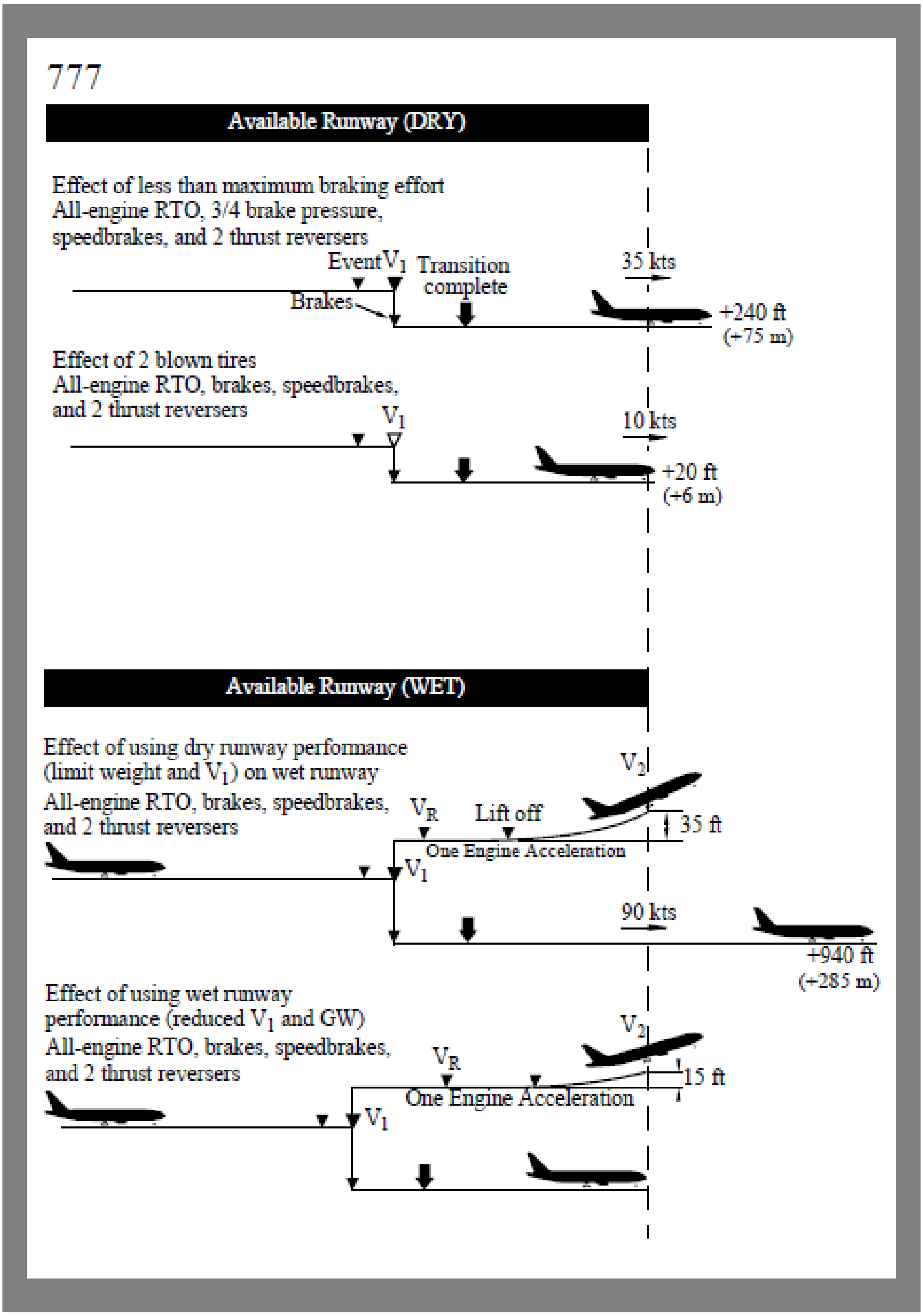
A successful rejected takeoff at or near V1 is dependent upon the captain making timely decisions and using the proper procedures.

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.

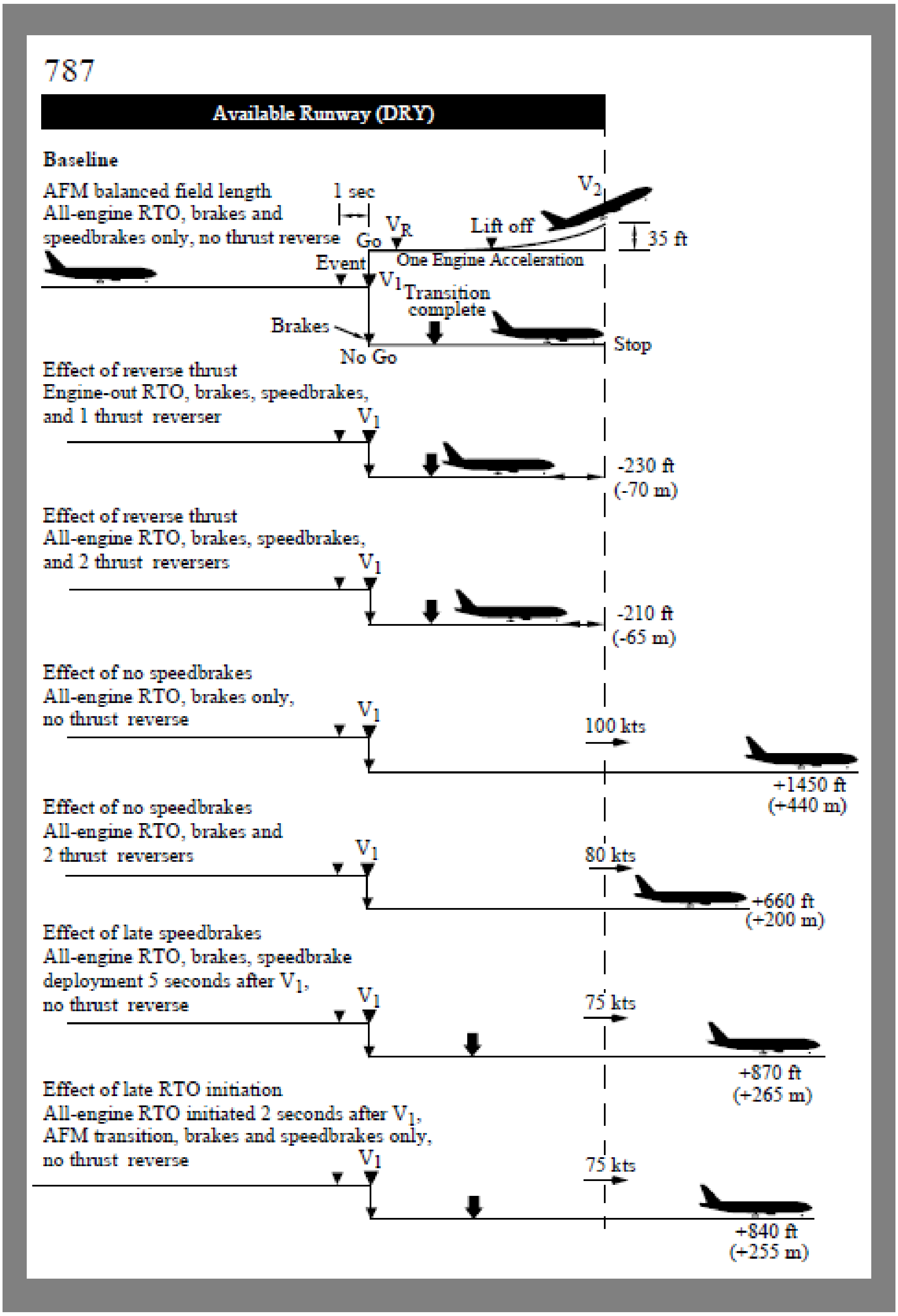
Each condition is compared to the baseline condition. The estimated speed at the end of the runway and the estimated overrun distance are indicated at the right edge of each figure. The distance estimates assume an overrun area that can produce the same braking forces as the runway surface. If less than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

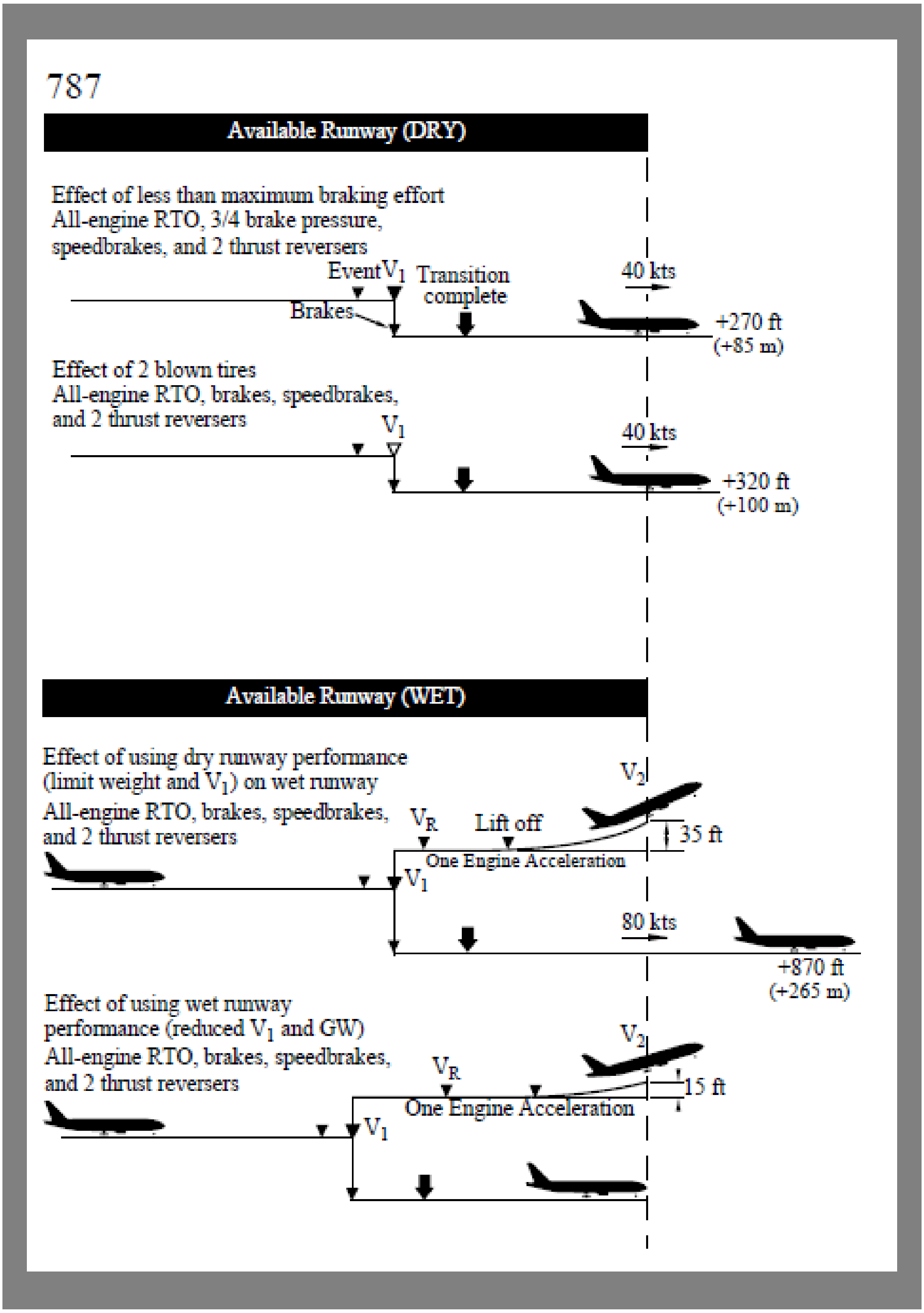
777-200 – 777-300ER




777
Available Runway (DRY)
Effect of less than maximum braking effort
All-engine RTO, 3/4 brake pressure, speedbrakes, and 2 thrust reversers
Event
V1
Transition complete
Brakes
35 kts
+240 ft
(+75 m)
Effect of 2 blown tires
All-engine RTO, brakes, speedbrakes, and 2 thrust reversers
V1
10 kts
+20 ft
(+6 m)
Available Runway (WET)
Effect of using dry runway performance (limit weight and V1) on wet runway
All-engine RTO, brakes, speedbrakes, and 2 thrust reversers
VR
Lift off
V2
35 ft
One Engine Acceleration
V1
90 kts
+940 ft
(+285 m)
Effect of using wet runway performance (reduced V1 and GW)
All-engine RTO, brakes, speedbrakes, and 2 thrust reversers
VR
V2
15 ft
One Engine Acceleration
V1

787-8 – 787-10


787
Available Runway (DRY)
Baseline
AFM balanced field length
All-engine RTO, brakes and
speedbrakes only, no thrust reverse
1 sec
Go
V1
VR
Lift off
V2
35 ft
Event
One Engine Acceleration
Transition
complete
Brakes
No Go
Stop
Effect of reverse thrust
Engine-out RTO, brakes, speedbrakes,
and 1 thrust reverser
-230 ft
(-70 m)
Effect of reverse thrust
All-engine RTO, brakes, speedbrakes,
and 2 thrust reversers
-210 ft
(-65 m)
Effect of no speedbrakes
All-engine RTO, brakes only,
no thrust reverse
100 kts
+1450 ft
(+440 m)
Effect of no speedbrakes
All-engine RTO, brakes and
2 thrust reversers
80 kts
+660 ft
(+200 m)
Effect of late speedbrakes
All-engine RTO, brakes, speedbrake
deployment 5 seconds after V1,
no thrust reverse
75 kts
+870 ft
(+265 m)
Effect of late RTO initiation
All-engine RTO initiated 2 seconds after V1,
AFM transition, brakes and speedbrakes only,
no thrust reverse
75 kts
+840 ft
(+255 m)


787
Available Runway (DRY)
Effect of less than maximum braking effort
All-engine RTO, 3/4 brake pressure, speedbrakes, and 2 thrust reversers
Event
V1
Transition complete
40 kts
Brakes
+270 ft
(+85 m)
Effect of 2 blown tires
All-engine RTO, brakes, speedbrakes, and 2 thrust reversers
V1
40 kts
+320 ft
(+100 m)
Available Runway (WET)
Effect of using dry runway performance (limit weight and V1) on wet runway
All-engine RTO, brakes, speedbrakes, and 2 thrust reversers
V2
VR
Lift off
35 ft
One Engine Acceleration
V1
80 kts
+870 ft
(+265 m)
Effect of using wet runway performance (reduced V1 and GW)
All-engine RTO, brakes, speedbrakes, and 2 thrust reversers
V2
VR
15 ft
One Engine Acceleration
V1

4.29 Initial Climb – All Engines

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

After liftoff, the flight director commands pitch to maintain an airspeed of V2 + 15 to 25 knots until another pitch mode is engaged.

V2 + 15 knots is the optimum climb speed with takeoff flaps. It results in the maximum altitude gain in the shortest distance from takeoff. Acceleration to higher speeds reduces the altitude gain. If airspeed exceeds V2 + 15 knots during the initial climb, stop the acceleration but do not attempt to reduce airspeed to V2 + 15 knots. 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 braking occurs during gear retraction. After gear and flaps are retracted, the PM should verify that the gear and flap indications are normal.

4.30 Minimum Fuel Operation

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.

4.31 Immediate Turn after Takeoff – All Engines

Obstacle clearance, noise abatement, or departure procedures may require an immediate turn after takeoff. Initiate the turn at the appropriate altitude (normally at least 400 feet AGL) and maintain V2 + 15 to V2 + 25 knots with takeoff flaps.

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.

4.32 Roll Modes

After takeoff and climb is stabilized, select LNAV (if not armed before takeoff) after passing 400 feet AGL. If LNAV is armed for takeoff, it engages above 50 feet AGL and within 2.5 NM of the active leg. If the departure procedure or route does not begin at the end of the runway, it may be necessary to use the HDG SEL mode at 400 feet AGL to intercept the desired track for LNAV capture. When the departure procedure is not a part of the active flight plan, use HDG SEL, TRK SEL or HDG HOLD mode. When an immediate turn after takeoff is necessary, the desired heading may be preset before takeoff.

777-200 – 777-300ER

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

787-8 – 787-10

Navaids and appropriate radials or tracks required for use during the departure may be displayed on the ND using the FIX page feature. ADF is also displayed on the mini map when the station is tuned on the CDU. The VOR station is displayed when selected on the ND menu.

4.33 Pitch Modes

VNAV, armed on the ground with the appropriate acceleration altitude entered, is the recommended pitch mode for takeoff. When armed for takeoff, VNAV engages at 400 feet AGL and provides AFDS management for acceleration, flap retraction and climb out. The VNAV profile and acceleration schedule is compatible with most planned departures.

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

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

Note: If climb thrust is required prior to acceleration height, manually set climb thrust using the CLB/CON switch on the MCP.

4.34 Autopilot Engagement

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

4.35 Flap Retraction Schedule

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.

1,000 feet AFE is normally used as the acceleration height to initiate thrust reduction and flap retraction.

Note: For airplanes equipped with EFB, the ACCEL HT value displayed on the PERFORMANCE - TAKEOFF page may be used as the acceleration height to initiate thrust reduction and flap retraction.

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 40° of bank (25° of bank and 15° overshoot) is provided when the airplane has accelerated to the recommended maneuver speed for the selected flap position.

With airspeed increasing, flap retractions should be initiated when airspeed reaches the maneuver speed for the existing flap position. The maneuver speed for the existing flap position is indicated by the numbered flap maneuver speed bugs on the airspeed display.

4.35.1 Takeoff Flap Retraction Speed Schedule

777-200 – 787-8

T/O Flaps	At "Display"	Select Flaps
20 or 15	"20" or "15"	5
	"5"	1
	"1"	UP
5	"5"	1
	"1"	UP

787-9, 787-10

Takeoff Flaps	At "Display"	Select Flaps
20, 18, 17, 15 or 10	"20", "18", "17", "15" or "10"	5
	"5"	1
	"1"	UP
5	"5"	1
	"1"	UP

For flaps up maneuvering, maintain at least:

- “UP”

4.36 Noise Abatement Takeoff

Thrust reduction and acceleration heights can be entered on the takeoff reference page. Following flap retraction, maintain flaps up maneuver speed until the noise abatement profile is satisfied and the airplane is clear of obstacles or above any minimum crossing altitude. This is normally achieved through the FMC speed restriction entered on the CLB page. It may also be accomplished using speed intervention or FLCH.

Note: Specific local airport procedures should be followed.

4.37 Takeoff – Engine Failure

4.38 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.

4.39 Engine Failure Recognition

777-200 – 777-300ER

During an engine failure at or after V1, the TAC automatically inputs rudder to compensate for most of the yaw resulting from asymmetrical thrust. The PF is still required to add a small amount of rudder which aids in engine failure recognition. If the TAC is inoperative, the onset of the yaw may be rapid.

787-8 – 787-10

During an engine failure at or after V1, the flight control system automatically inputs rudder to compensate for most of the yaw resulting from asymmetrical thrust. The PF is still required to add a small amount of rudder which aids in engine failure recognition.

777-200 – 777-300ER

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.

4.40 Rotation and Liftoff - One Engine Inoperative

777-200 – 777-300ER

If an engine fails between V1 and liftoff, the TAC automatically inputs rudder to compensate for most of the yaw resulting from asymmetrical thrust. The PF is still required to add a small amount of rudder to maintain directional control. If the TAC is inoperative, maintain directional control by smoothly applying rudder proportionate with thrust decay.

787-8 – 787-10

If an engine fails between V1 and liftoff, the flight control system automatically inputs rudder to compensate for most of the yaw resulting from asymmetrical thrust. The PF is still required to add a small amount of rudder to maintain directional control.

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 resulting in a 12° to 13° target 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, resulting in a rotation rate of approx 1.5° to 2.5° per second. After liftoff adjust pitch attitude to maintain the desired speed.

777-200 – 777-300ER

If an engine fails after liftoff, the TAC automatically inputs rudder to fully compensate for the yaw resulting from asymmetrical thrust. If the TAC is inoperative, apply rudder and aileron to control heading and keep the wings level. The correct rudder input approximately centers the control wheel.

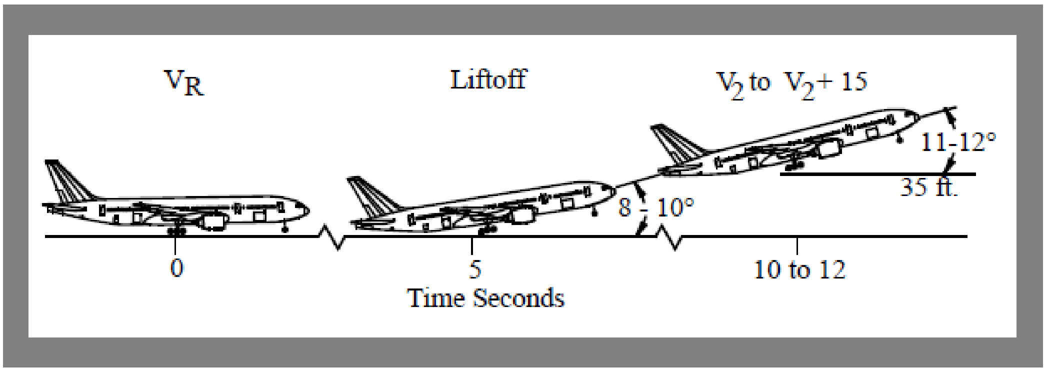
787-8 – 787-10

If an engine fails after liftoff, the flight control system automatically inputs rudder to fully compensate for the yaw resulting from asymmetrical thrust.

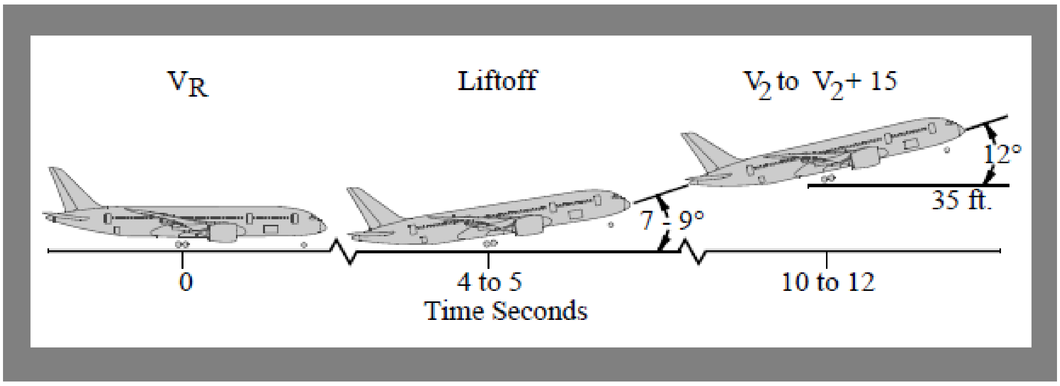
4.40.1 Typical Rotation - One Engine Inoperative

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

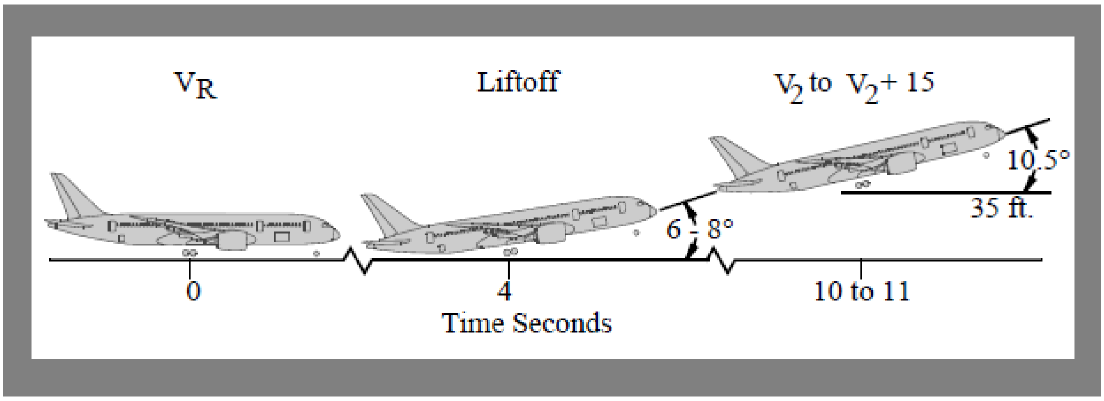
777-200 – 777-300ER



787-8



787-9, 787-10



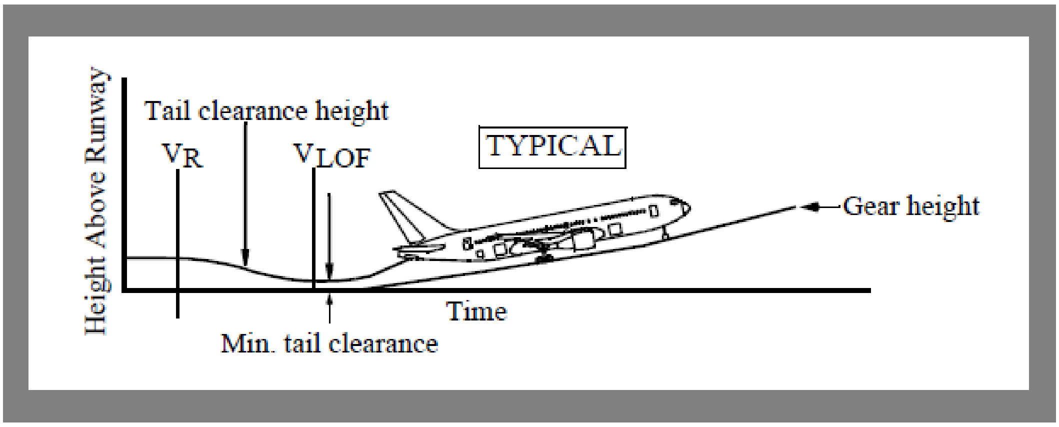
Retract the landing gear after a positive rate of climb is indicated on the altimeter.

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

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

The minimum tail clearance remains constant for all takeoff flap settings. The rotation speed schedules were developed to maintain a constant tail clearance.



777-200 – 777-300ER

Model	Flaps	Liftoff Attitude (degrees)	Minimum Tail Clearance inches (cm)	Tail Strike Pitch Attitude (degrees)
777-200	5, 15, 20	9.5	26 (66)	12.1
777-200LR	5, 15, 20	9.5	35 (89)	12.1
777-F	5, 15, 20	9.5	35 (89)	12.1
777-300	5, 15, 20	8.0	24 (61)	8.9
777-300ER	5, 15, 20	9.0	16 (41)	10.0

Note: 777-300ER values valid when the Semi-Levered Gear (SLG) is operative. When the SLG is inoperative, use 777-300 values.

787-8 – 787-10

Model	Flaps	Liftoff Attitude (degrees)	Minimum Tail Clearance inches (cm)	Tail Strike Pitch Attitude (degrees)
787-8	5, 15, 20	9.2	30 (76)	11.2
787-9	5, 10, 15, 17, 18, 20	6-8	19 (48)	9.7
787-10	5, 10, 15, 17, 18, 20	5.5-7.5	32 (81)	9.7

4.41 Initial Climb - One Engine Inoperative

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 + 15 knots.

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

Retract the landing gear after a positive rate of climb is indicated on the altimeter. The initial climb attitude should be adjusted to maintain a minimum of V2. If an engine fails at an airspeed between V2 and V2 + 15 knots, climb at the airspeed at which the failure occurred. If engine failure occurs above V2 + 15 knots, increase pitch to reduce airspeed to V2 + 15 knots and maintain V2 + 15 knots until reaching acceleration height. Select ENG OUT climb after flap retraction and all obstructions are cleared.

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

Indications of an engine fire, impending engine breakup or approaching or exceeding engine limits, should be dealt with as soon as possible. Accomplish the appropriate 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.

4.42 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 with takeoff flaps while maneuvering.

Note: The AFDS limits the bank angle to 15° until V2 + 10 knots to maintain at least adequate maneuver margin. The bank angle limit increases to 25° by V2 + 20 knots if LNAV is engaged, or when HDG SEL or TRK SEL is engaged with the bank limit in AUTO.

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

4.43 Autopilot Engagement - One Engine Inoperative

777-200 – 777-300ER

When at a safe altitude above 200 feet AGL with correct rudder pedal input as needed, the autopilot may be engaged. If the TAC is not operating, rudder trim must be manually applied.

787-8 – 787-10

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

4.44 Flap Retraction – One Engine Inoperative

British Airways 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 limit within 5 minutes (10 minutes optional) after initiating takeoff. Some combinations of high gross weight, takeoff flap selection and airport elevation may require initiating flap retraction as low as 400 feet after takeoff with an engine failure.

At typical training weights, adequate performance exists to climb to 1,000 feet before beginning flap retraction. Therefore, during training 1,000 feet is used as the acceleration height for engine failure after V1.

At engine out acceleration height, if VNAV is engaged, a near-level climb segment is commanded for acceleration. Retract flaps on the takeoff flap retraction speed schedule. With flaps up and airspeed at or above the flaps up maneuver speed, VNAV automatically sets the reference thrust limit to Max Continuous Thrust (CON).

At engine out acceleration height, if VNAV is not engaged, leave the pitch mode in TO/GA and 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 commands a near level flap retraction segment. Accelerate and retract flaps on the takeoff flap retraction speed schedule.

787-8 – 787-10

If a takeoff in extreme climb-limited conditions is attempted without VNAV armed for takeoff, and an engine failure occurs, the AFDS may command low frequency pitch oscillations during acceleration and flap retraction. During the pitch oscillations there may be momentary altitude losses, but the overall climb gradient will remain positive. If the oscillations are unacceptable, disconnect the autopilot and continue the acceleration manually, stabilizing pitch attitude to minimize vertical speed excursions.

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.

777-200 – 777-300ER

As the airplane accelerates and flaps are retracted, the rudder is automatically adjusted by the TAC to maintain the control wheel centered. If the TAC is inoperative, manually adjust the rudder pedal position to maintain the control wheel centered and trim to relieve rudder pedal pressure.

787-8 – 787-10

As the airplane accelerates and flaps are retracted, the rudder is automatically adjusted by the flight control system to maintain the control wheel centered.

4.45 Flaps Up - One Engine Inoperative

After flap retraction and at or above flaps up maneuver speed, if VNAV is not engaged, select FLCH, verify maximum continuous thrust (CON) is set, select and execute ENG OUT prompt, and continue the 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. With flaps up, the FMC commands a climb at flaps up maneuver speed and the autothrottles transition automatically to maximum continuous thrust if VNAV is engaged. If this does not occur, select FLCH and flaps up maneuver speed until clear of obstacles. Maximum continuous thrust is automatically set when FLCH is selected.

4.46 Noise Abatement - One Engine Inoperative

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

4.47 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 while still on the runway, or by pushing the TO/GA switch when airborne. 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.

4.48 Engine Failure During a Derated Thrust (Fixed Derate) Takeoff

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

4.49 Engine Failure During a Combined ATM and Fixed Derate Takeoff

Although the ATM takeoff thrust setting is not considered a takeoff operating limit, the selected fixed derate is still considered a takeoff operating limit. This is because takeoff speeds consider VMCG and VMCA only at the fixed derate level of thrust. If an engine failure occurs during takeoff, any thrust increase beyond the fixed derate limit could result in loss of directional control and should not be accomplished unless in the opinion of the captain, terrain clearance cannot be assured.

If an engine failure occurs during takeoff when using both the reduced thrust (ATM) and fixed derate methods, Boeing recommends that the thrust levers not be advanced. This is because the fixed derate limit is not displayed on engine or flight instruments. However, if operators have developed a procedure that makes the fixed derate limit immediately available to the crew, thrust may be advanced to the fixed derate limit only.

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5 Climb, Cruise, Descent and Holding

5.1 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.

6 Climb

6.1 Reduced Thrust Climb

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

777-200 – 777-300ER

The FMC provides two reduced thrust climb selections on the THRUST LIMIT page:

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

787-8 – 787-10

The FMC provides two reduced thrust climb selections on the THRUST LIMIT page

- CLB 1 depends upon the specific derate thrust limit options selected by the operator
- CLB 2 depends upon the specific derate thrust limit options selected by the operator.

Reduced thrust climb may also be automatically selected by the FMC depending upon the amount of thrust reduction made for takeoff by either the fixed derate or assumed temperature method.

Climb thrust reductions are gradually removed as the airplane climbs until full climb thrust is restored. If rate of climb should drop below approximately 500 feet per minute, the next higher climb rating should be selected.

Prior to takeoff, the pilot may override the automatically selected climb thrust limit after the takeoff selection has been completed by selecting another climb thrust limit on the THRUST LIMIT page. When the automatically selected climb thrust limit is overridden, the previously selected takeoff derate is not affected.

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

6.2 Climb Constraints

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

Normally, set all maximum or hard altitude constraints in the MCP altitude window. 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.

When using VNAV, if altitude constraints are closely spaced to the extent that crew workload is adversely affected and unwanted level-offs are a concern, the alternate MCP altitude setting technique can be used with operator approval. Refer to Chapter 1, MCP Altitude Setting Techniques Using VNAV for more information on this subject.

Note: When the alternate MCP altitude setting technique using VNAV is used, the selection of a pitch mode other than VNAV SPD for climbs results in a risk of violating altitude constraints.

For climbs in pitch modes other than VNAV SPD, set the MCP altitude to the next altitude constraint or the clearance altitude, whichever is lower. For altitude constraints that are "at or above" set the clearance altitude.

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

6.3 Low Altitude Level Off

Occasionally a low altitude climb restriction is required after takeoff. This altitude restriction should be set in the MCP altitude window. When the airplane approaches this altitude, the mode annunciation changes to ALT or VNAV ALT and the airplane levels off. The autothrottle SPD mode engages and controls to the target speed. If altitude capture occurs while still in the TO/GA pitch mode, confirm the SPD autothrottle mode engages and set the desired command speed at level off.

6.3.1 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 AFDS 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 reduced thrust for takeoff at low weights whenever possible
- reduce from takeoff to climb thrust earlier than normal
- disengage the AFDS 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.

6.4 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.

6.5 Climb Speed Determination

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

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

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

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

6.6 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 AUTO or 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.

6.7 Economy Climb

The normal economy climb speed schedule of the FMC minimizes trip cost. The FMC generates a fixed speed schedule as a function of cost index and weight.

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

6.7.1 Economy Climb Schedule - FMC Data Unavailable

- 250 knots/VREF 30 + 80 knots, whichever is higher- Below 10,000 feet

777-200 - 777-300ER

- 310 knots/0.84M - Above 10,000 feet

787-8

- 320 knots/0.85M - Above 10,000 feet

787-9, 787-10

- 330 knots/0.85M - Above 10,000 feet

6.8 Maximum Rate Climb

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

777-200 - 777-300ER

- flaps up maneuver speed + 60 knots until intercepting 0.82M

787-8

- VREF 30 + 140 knots until intercepting 0.82M

787-9, 787-10

- VREF 30 + 140 knots until intercepting 0.84M

6.9 Maximum Angle Climb

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

6.10 Engine Inoperative Climb

The recommended engine inoperative climb speed approximates the speed for maximum climb gradient and varies with gross weight and altitude. At high altitudes and weights, a fixed Mach is used as an upper limit on the engine out climb speed. Engine out climb speed is the FMC default used during climb when ENG OUT climb is selected.

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. In the clean configuration, select the engine out prompt on the CDU CLB page.

The engine out mode provides VNAV commands to climb at engine out climb speed to cruise altitude, or maximum engine out altitude, whichever is lower. If the airplane is currently above maximum engine out altitude, driftdown information is available. Upon reaching level off altitude, the command speed changes to EO SPD. Engine Out LRC or Company Speed (CO SPD) may be selected. Leave thrust set at maximum continuous thrust until airspeed increases to the commanded value.

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

7 Cruise

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

7.1 Maximum Altitude

Maximum altitude is the highest altitude at which the airplane can be operated. It is determined by three basic characteristics, (certified altitude, thrust limit altitude and buffet or maneuver margin) which are unique to each airplane model. The FMC predicted maximum altitude is the lowest of:

- maximum certified altitude - the altitude determined during certification considering structural limit (limits on the fuselage), rapid descent capability, or other factors determined by the certifying authority
- thrust limited altitude - the altitude at which sufficient thrust is available to provide a specific minimum rate of climb. (Reference the Long Range Cruise Maximum Operating Altitude table in the PI Chapter, Volume 1 of the FCOM). Depending on the thrust rating of the engines, the thrust limited altitude may be above or below the maneuver altitude capability

777-200LR, 777-F, 777-300ER

- buffet or maneuver limited altitude - the altitude at which a specific maneuver margin exists prior to buffet onset. This altitude provides a g margin prior to buffet chosen by airline policy. The minimum margin available is 0.3g (40° bank) prior to buffet. Some regulatory agencies may require a different minimum maneuver margin.

777-200, 777-300, 787-8 – 787-10

- buffet or maneuver limited altitude - the altitude at which a specific maneuver margin exists prior to buffet onset. This altitude provides a g margin prior to buffet chosen by airline policy. The minimum margin available is 0.2g (33° bank) prior to buffet. Some regulatory agencies may require a different minimum maneuver margin.

Although each of these limits are checked by the FMC, available thrust may limit the ability to accomplish anything other than relatively minor maneuvering. The amber band limits do not provide an indication of maneuver capability as limited by available thrust.

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

Note: To get the most accurate altitude limits from the FMC, ensure that the airplane weight, cruise CG, and temperature entries are correct.

For LNAV operation, the FMC provides a real-time bank angle limiting function. This function protects the commanded bank angle from exceeding the current available thrust limit. This bank angle limiting protection is only available when in LNAV.

For operations other than LNAV, when operating at or near maximum altitude fly at least 10 knots above the lower amber band and use bank angles of 10° or less. If speed drops below the lower amber band, immediately increase speed by doing one or more of the following:

- reduce angle of bank
- increase thrust up to maximum continuous
- descend.

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

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

7.2 Optimum Altitude

The optimum (OPT) altitude shown on the CRZ page is determined based on aircraft gross weight and cruise speed in still air. When operating in the ECON mode, OPT altitude results in minimum trip cost based on the entered cost index. However, when operation is based on manually entered speed or selected LRC speed, OPT altitude is based on minimum fuel burn. OPT altitude increases as weight decreases during the flight.

OPT altitude calculation does not consider the effects of temperature deviations from standard day or sensed or forecast winds at altitude. Since OPT altitude only provides optimum performance in still air, when factoring winds, it may not be the best altitude for the aircraft to minimize cost or fuel.

For shorter trips, OPT altitude computation is based on ECON speed and uses different logic and different input parameters than long trips.

7.3 Recommended Altitude

The recommended (RECMD) altitude shown on the CRZ page accounts for forecast winds and temperatures aloft along the flight plan route, over the next 250-500 nm immediately in front of the airplane, above and below the aircraft entered cruise altitude. When operating in the ECON mode, RECMD altitude is based on minimum trip cost associated with the entered cost index. However, when operation is based on manually entered speed or selected LRC speed, RECMD altitude is based on minimum fuel burn.

The RECMD altitude is based on the entered cruise altitude and step size. The RECMD altitude may be a Step Climb or Step Descent.

To provide usable and accurate RECMD altitude, the FMC requires accurate forecast winds at multiple altitudes above and below cruise altitude. Winds can be entered manually at waypoints and at discrete altitudes for cruise descent, or they may be uplinked. When significant variation exists between sensed and forecast temperatures or winds aloft (magnitude or direction), flying at RECMD altitudes may not be the most cost effective or fuel efficient.

Since the RECMD altitude evaluates the winds and temperatures above and below the aircraft entered cruise altitude, it may provide a different altitude than the Step Climb. The

Step Climb calculation only looks above the entered cruise altitude for the remainder of the flight

7.4 Cruise Speed Determination

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

ECON cruise is a variable speed schedule that is a function of gross weight, cruise altitude, cost index, and headwind 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.

Note: Thrust limits or maximum speed limits are generally encountered with cost index entries of 5000 or more.

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

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

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

7.5 Step Climb

Flight plans not constrained by short trip distance are typically based on conducting the cruise portion of the flight close to optimum altitude, provided the difference in the wind speed is small and the temperature lapse rate is standard. Since the optimum altitude increases as fuel is consumed during the flight, it is necessary to climb to a higher cruise altitude periodically to achieve the flight plan fuel burn. This technique, referred to as Step Climb Cruise, is typically accomplished by entering an appropriate step size in the FMC according to the available cruise levels. For most flights, one or more step climbs may be required before reaching T/D.

It may be advantageous to request an initial cruise altitude above the OPT altitude if altitude changes are difficult to obtain on specific routes. This minimizes the possibility of being held at a low altitude at high fuel consumption conditions for long periods of time. The requested initial cruise altitude should be below the MAX altitude. Consideration also needs to be given to turbulence, wind speed and temperature.

The thrust limit is impacted by temperature. An increase in the temperature during cruise results in a decrease in the available thrust. When at a cruise level close to MAX altitude an unanticipated temperature increase could result in insufficient thrust available to maintain desired cruise speed. Entry of accurate forecast temperature information at cruise altitudes is the best way to avoid this thrust deficient situation.

The flight crew may program Step Climb into the FMC flight plan in the following three ways:

- Calculated Step - the FMC calculates the best STEP TO altitude based on entered step size, and also calculates the most advantageous location at which to step. Based on current cruise altitude and step size, several altitudes above the current cruise altitude are evaluated to determine the altitude and location of the step that will minimize trip cost or trip fuel based on ECON mode or manual speed entry. The calculated step location is a function of the route length, current cruise speed mode and altitude, forecast wind, and forecast temperature, step size, gross weight, entered cruise CG. The calculated step does not require crew input.
- Planned STEP TO altitude - The flight crew enters a specific STEP TO altitude on the VNAV CRZ page in 1R. In this case the FMC uses only that altitude to determine the optimum location for the entered STEP TO altitude. The FMC evaluates the location of the step based on the route length, current cruise speed mode, altitude, forecast wind, and temperature, gross weight and entered cruise CG.
- Planned Step - The flight crew enters a particular STEP TO altitude at a specific cruise waypoint. The flight crew can enter multiple planned steps. Flight plan predictions assume that the airplane will remain level at the current cruise altitude until reaching the next specified planned step waypoint, and then immediately climb to the STEP TO altitude. In this case, both the altitude and the location for the step are determined by the crew. Once a planned step is entered the FMC will not compute Calculated Step points until after the last planned step point is passed.

Step altitudes can be planned at waypoints or they can be optimum step points calculated by the FMC. Optimum step points are a function of the route length, flight conditions, speed mode, present airplane altitude, STEP TO altitude (or adjacent STEP TO altitudes) and gross weight. The FMC computed step point provides for minimum trip cost for the flight, including allowances for climb fuel. Initiate a cruise climb to the new altitude as close as practicable to the step climb point.

Note: FMC default values for the step size may not be appropriate for RVSM or airspace that is referenced to the metric system. Manually enter the appropriate step size values as needed.

7.5.1 Fuel for Enroute Climb

777-200 – 777-300ER

The additional fuel required for a 4,000 foot enroute climb varies from 300 to 1,000 lbs (225 to 450 kgs) depending on the airplane gross weight, initial altitude, air temperature, and climb speed. The fuel increment is largest for high gross weights and low initial altitudes. Additional fuel burn is offset by fuel savings in the descent. It is usually beneficial to climb to a higher altitude if recommended by the FMC or the flight plan, provided the wind information used is reliable.

787-8 – 787-10

The additional fuel required for a 4,000 foot enroute climb varies from 100 to 400 lbs (45 to 180 kgs) depending on the airplane gross weight, initial altitude, air temperature, and climb speed. The fuel increment is largest for high gross weights and low initial altitudes. Additional fuel burn is offset by fuel savings in the descent. It is usually beneficial to climb to a higher altitude if recommended by the FMC or the flight plan, provided the wind information used is reliable.

7.6 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 0.01 Mach results in an increase of 0.5° to 0.7° C total air temperature.

7.7 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

777-200 - 777-300ER

- 2,000 feet above optimum altitude: 1% to 2% increase in trip fuel

787-8 - 787-10

- 2,000 feet above optimum altitude: 1% increase in trip fuel

777-200 - 777-300ER

- 4,000 feet below optimum altitude: 4% to 5% increase in trip fuel

787-8 - 787-10

- 4,000 feet below optimum altitude: 2% increase in trip fuel

777-200 - 777-300ER

- 8,000 feet below optimum altitude: 12% to 14% increase in trip fuel

787-8

- 8,000 feet below optimum altitude: 4% increase in trip fuel.

787-9, 787-10

- 8,000 feet below optimum altitude: 5% increase in trip fuel

777-200 - 777-300ER

- cruise speed 0.01M above scheduled: 1% to 2% increase in trip fuel.

787-9 - 787-10

- cruise speed 0.01M above scheduled: 2% increase in trip fuel.

777-200 – 777-300ER

For cruise within 2,000 feet of optimum, long range cruise speed can be approximated by using 0.84M. Long range cruise also provides the best buffet margin at all cruise altitudes.

787-8 – 787-10

For cruise within 2,000 feet of optimum, long range cruise speed can be approximated by using 0.85M. 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.

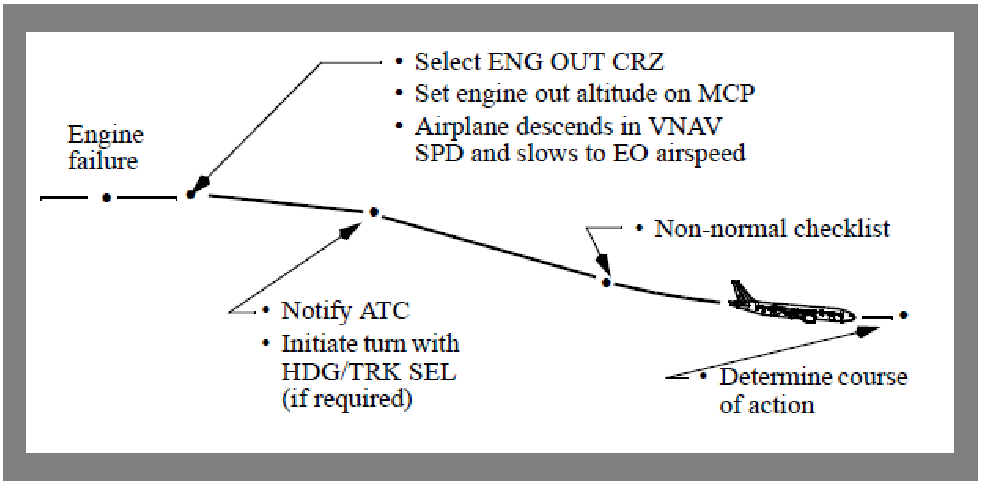
7.8 Engine Inoperative Cruise/Driftdown

Execution of a non-normal checklist or sudden engine failure may lead to the requirement to perform an engine inoperative driftdown and diversion to an alternate airport. Engine inoperative cruise information is available from the FMC. An analysis of diversion airport options is available using the FMC ALTN page.

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

Set the engine out cruise altitude in the MCP altitude window and execute the EO D/D page. Thrust reference changes to CON and the autothrottle maintains MCT. The airplane descends in VNAV using the VNAV SPD pitch mode. The VNAV SPD mode may command the airplane to nearly level flight to control an airspeed increase above the driftdown target speed. If the excess airspeed cannot be reduced with the airplane in nearly level flight, then the FMC transitions to the VNAV PTH mode. In the VNAV PTH mode, the FMC commands a flight path for a 300 fpm descent rate. The autothrottle SPD mode then controls the airspeed.

At altitude capture the ENG OUT CRZ page is displayed. Maintain MCT and driftdown altitude until the EO SPD speed is established.



Note: If the airplane is at or below maximum engine out altitude when an engine becomes inoperative, select and execute the EO CRZ page and maintain engine out cruise speed.

If required to cruise at maximum altitude, set MCT and establish a climb, decelerating slowly to EO CLB speed. At level off select EO LRC for best fuel economy.

An alternate target driftdown speed can be selected using the MOD CRZ or EO D/D page. LRC speed would result in a lower driftdown altitude but better fuel performance. A company speed (CO SPD) could be selected, this provides for a higher driftdown speed and a shorter flight time to the alternate.

An engine out cruise altitude can be entered on the MOD CRZ or EO D/D page. If an engine out cruise altitude is entered while the airplane is more than 150 feet above the computed maximum altitude, the FMC commands a driftdown schedule for descent to the entered engine out cruise altitude. If a cruise altitude is entered after the airplane has descended to within 150 feet of the computed maximum altitude or to a lower altitude, the FMC commands a cruise descent at approximately 1,250 fpm for descent to a lower engine out cruise altitude.

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

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

7.9 High Altitude High Speed Flight

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

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.

7.9.1 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 pitch attitude change, the change in rate of climb is proportional to the true airspeed. For example, an attitude change at 290 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 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.

7.10 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.

7.10.1 Flight and Performance

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 based on the operators approved engine inoperative cruise speed. 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).

7.11 Polar Operations

Refer to the FMC Polar Navigation section in the FCOM for specifics about operations in polar regions and a description of the boundaries of the polar regions.

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

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

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

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

787-8 – 787-10

Note: To use SATCOM on the ground, the IRUs must be aligned.

777-200 – 777-300ER

Note: To use SATCOM on the ground, the ADIRU must be aligned.

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

777-200 – 777-300ER

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

787-8 – 787-10

The primary roll mode for polar operations should be LNAV, which may be used with the heading reference switch in the NORM position. HDG SEL/HOLD and TRK SEL/HOLD are functional and will automatically switch to TRUE heading reference when operating in polar regions. Deviations from planned route may be accomplished in TRK SEL or HDG SEL.

If either the North Pole (NPOLE) or the South Pole (S90EXXXXX or S90WXXXXX) waypoint is used, a rapid heading and track reversal occurs passing the polar waypoint. If operating in HDG/TRK SEL or HDG/TRK HOLD while near either pole, it is necessary to frequently update the heading/track selector to reflect the rapidly changing and/or reversed heading/track or the AFDS will command an unwanted turn. For this reason, LNAV is the preferred roll mode.

Loss of both GPS units or loss of GPS updating results in an increased ANP and possible display of the NAV UNABLE RNP message, but normally does not prevent polar operation.

777-200 – 777-300ER

The ADIRU is a fault tolerant unit. Total failure of the ADIRU is an extremely unlikely event since a number of independent failures must occur before all navigation functions are lost. In the unlikely event the ADIRU does fail, the non-normal checklist provides the crew with inoperative items and necessary crew actions. With at least one GPS operational, the Navigation Display is operational and accurately displays the FMC route and airplane track and position information. LNAV is inoperative. A heading reference must be entered into the FMC to regain use of the compass rose. Because of the large and rapidly changing magnetic variations in the polar regions, it may be more practical to enter the true track as a heading reference while in the polar region. This provides a more intuitive navigation display and allow tracking of the planned route in HDG SEL. True track may be obtained from the computer flight plan or from the Navigation Display. Magnetic compass information should be used, if available, to update the heading reference when departing the polar region. With a total ADIRU failure, plan a raw data instrument approach.

787-8 - 787-10

Total failure of the IRS is an extremely unlikely event since a number of independent equipment failures must occur before all inertial based navigation functions are lost. In the unlikely event all the components of the IRS fail, EICAS messages and the associated non-normal checklists provide the crew with inoperative items and necessary crew actions. With at least one GPS operational, the Navigation Display MAP and PFD Mini-Map are operational and accurately display the FMC route and airplane track and position information. LNAV is inoperative. With a total IRS failure, plan a raw data instrument approach.

8 Descent

8.1 Descent Speed Determination

The default FMC descent speed schedule is an economy (ECON) descent from cruise altitude to the airport speed transition altitude. At the airport speed transition altitude, the airspeed is reduced to the airport speed restriction speed in the navigation database minus 10 knots. The speed schedule is adjusted to accommodate waypoint speed/altitude constraints displayed on the LEGS pages, and speed/altitude constraints displayed on the DES page. If desired, the ECON speed schedule can be modified by alternate Mach, Mach/IAS, or IAS values on the DES page target speed line. If the FMC information is not available, use target speeds from the Descent Rates table in this chapter.

8.2 Descent Path

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

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

8.3 Descent Constraints

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

Normally, set all mandatory altitude restrictions and “at or above” constraints in the MCP altitude window. 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.

When using VNAV, if altitude constraints are closely spaced to the extent that crew workload is adversely affected and unwanted level-offs are a concern, the alternate MCP altitude setting technique can be used with operator approval. Refer to MCP Altitude Setting Techniques Using VNAV in this FCTM for more information on this subject.

Note: When the alternate MCP altitude setting technique using VNAV is used, the selection of a pitch mode other than VNAV PTH or VNAV SPD for descent will result in a risk of violating altitude constraints.

For descents in pitch modes other than VNAV PTH or VNAV SPD, the MCP altitude must be set at the next altitude constraint, or as published in the FCOM for an instrument approach.

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

8.4 Speed Intervention

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

8.5 Offpath Descent

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

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

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

8.6 Descent Preparation Using HUD System

787-8 – 787-10

If the combiner was previously stowed, the combiner should be positioned and the pilot should verify that it is properly aligned with the overhead unit. For night landings, set combiner brightness high enough to ensure that the symbology is visible over bright touchdown zone lights.

8.7 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.

777-200 – 777-300ER

Proper descent planning is necessary to arrive at the desired altitude at the proper speed and configuration. The distance required for the descent is approximately 3 NM/1,000 feet altitude loss for no wind conditions using ECON speed. Rate of descent is dependent upon thrust, drag, airspeed schedule and gross weight.

787-8 – 787-10

Proper descent planning is necessary to arrive at the desired altitude at the proper speed and configuration. The distance required for the descent is approximately 3.5 NM/1,000 feet altitude loss for no wind conditions using ECON speed. Rate of descent is dependent upon thrust, drag, airspeed schedule and gross weight.

8.8 Descent Rates

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

777-200 – 777-300ER

Target Speed	Rate of Descent (Typical)	
	Clean	With Speedbrake
0.84M / 310 knots	2200 fpm	5300 fpm
250 knots	1400 fpm	3300 fpm
VREF 30 + 80 knots	1000 fpm	2300 fpm

787-8

Target Speed	Rate of Descent (Typical)	
	Clean	With Speedbrake
0.85M / 330 knots	2700 fpm	7500 fpm
250 knots	1400 fpm	3400 fpm
Flaps Up Maneuver Speed	1000 fpm	2000 fpm

787-9

Target Speed	Rate of Descent (Typical)	
	Clean	With Speedbrake
0.85M / 330 knots	2700 fpm	6500 fpm
250 knots	1500 fpm	3400 fpm
Flaps Up Maneuver Speed	1200 fpm	2400 fpm

787-10

Target Speed	Rate of Descent (Typical)	
	Clean	With Speedbrake
0.85M / 330 knots	2600 fpm	6000 fpm
250 knots	1500 fpm	3400 fpm
Flaps Up Maneuver Speed	1100 fpm	2300 fpm

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

The speedbrake may be used to correct the descent profile if arriving too high or too fast. The 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.

777-200 – 777-300ER

Losing airspeed can be difficult and may require a level flight segment. For planning purposes, it requires approximately 60 seconds and 6 NM to decelerate from 310 to 250 knots in level flight without speedbrakes. It requires an additional 50 seconds and 4 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%.

787-8 – 787-10

Losing airspeed can be difficult and may require a level flight segment. For planning purposes, it requires approximately 80 seconds and 9 NM to decelerate from 330 to 250 knots in level flight without speedbrakes. It requires an additional 40 seconds and 4 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 60%.

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

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

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

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

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

8.10 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 above 200 knots. This minimizes passenger discomfort and increases gear door life.

8.11 Speed Restrictions

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.

8.12 Engine Icing During Descent

The use of anti-ice and the increased thrust required increases the descent distance. Therefore, proper descent planning is necessary to arrive at the initial approach fix at the correct altitude, speed, and configuration. The anticipated anti-ice use altitude should be entered on the DESCENT FORECAST page to assist the FMC in computing a more accurate descent profile.

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

Note: The engine anti-icing system should be AUTO or 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.

8.13 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.

777-200 – 777-300ER

If the FMC holding speed is greater than the ICAO or FAA maximum holding speed, holding may be conducted at flaps 1, using flaps 1 maneuver speed. Flaps 1 uses approximately 7% more fuel than flaps up. Holding speeds in the FMC provide an optimum holding speed based upon fuel burn and speed capability, but are never lower than flaps up maneuver speed.

787-8 – 787-10

If the FMC holding speed is greater than the ICAO or FAA maximum holding speed, holding may be conducted at flaps 1, using flaps 1 maneuver speed. Flaps 1 uses approximately 5% more fuel than flaps up. Holding speeds in the FMC provide an optimum holding speed based upon fuel burn and speed capability, but are never lower than flaps up maneuver speed.

Maintain clean configuration if holding in turbulence. Clean configuration is also recommended for holding in icing conditions. However, to comply with speed restrictions, flaps 1 may be used in icing.

If the holding pattern has not been programmed in the FMC, the initial outbound leg should be flown for 1 minute when at or below 14,000 feet or 1 1/2 minutes when above 14,000 feet or as required by the regulatory authority. 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. However, the holding pattern depicted on the map display will not exceed the limits.

8.14 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
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 (May be restricted to an airspeed of 210 KIAS. This non-standard pattern will be identified by an icon.)
14,001 feet MSL and above	265 knots

#

8.15 Procedure Holding

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

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

8.16 Holding Airspeeds Not Available from the FMC

If holding speed is not available from the FMC, refer to the PI chapter in the OM. If time does not permit immediate reference to the OM, the following speed schedule may be used temporarily. This simplified holding speed schedule may not match the FMC or OM holding speeds because the FMC and OM 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 OM:

- flaps up maneuver speed approximates minimum fuel burn speed and may be used at low altitudes

777-200 – 777-300

- above FL250, use VREF 30 + 100 knots to provide at least a 0.3 g margin to initial buffet (full maneuver capability).

777-200LR, 777-F, 777-300ER

- above 10,000 feet, use VREF 30 + 120 knots to provide at least a 0.3 g margin to initial buffet (full maneuver capability).

787-8 - 787-10

- above FL200, use VREF 30 + 100 knots to provide at least a 0.3 g margin to initial buffet (full maneuver capability).

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9 Approach and Missed Approach

9.1 Preface

777-200 – 777-300ER

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.

787-8 – 787-10

This chapter outlines recommended operating practices and techniques for ILS, GLS (as installed), non-ILS/GLS, 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.

10 Approach

10.1 Instrument Approaches

All safe instrument approaches have certain basic factors in common. These include good descent planning, careful review of the approach procedure, accurate flying, and good crew coordination. Thorough planning is the key to a safe, unhurried, professional approach.

Ensure the waypoint sequence on the LEGS page, altitude and speed restrictions, and the map display reflect the air traffic clearance. Last minute air traffic changes or constraints may be managed by appropriate use of the MCP heading, altitude and airspeed selectors. Updating the waypoint sequence on the LEGS page should be accomplished only as time permits.

777-200 – 777-300ER

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 selector set to the proper position. Verify ILS, VOR and ADF are tuned and identified if required for the approach.

787-8 – 787-10

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. Display VOR on the map display as needed. Verify ILS, GLS, VOR and ADF are tuned and identified if required for the approach.

Note: The requirement to tune and identify navaids can be satisfied by confirming that the tuned navaid frequency is replaced by the correct alphabetical identifier on the PFD/ND or by aurally identifying the navaid.

777-200 – 777-300ER

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.

787-8 – 787-10

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 or GLS 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.

10.2 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

Note: B777-200 - B777-300ER, B787-8, B787-9, B787-10 are Category D.

10.3 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.

10.4 Approach Clearance

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

If using a VNAV path, all altitude and speed constraints must be entered by selecting a published arrival. When properly entered, the VNAV path profile complies with all altitude and airspeed constraints. Crossing altitudes may be higher than the minimum altitudes for that segment because the VNAV path is designed to optimize descent profiles.

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

10.5 Procedure Turn

On most approaches the procedure turn must be completed within specified limits, such as within 10 NM of the procedure turn fix or beacon. The FMC depicted procedure turn, or holding pattern in lieu of procedure turn, complies with airspace limits. The published procedure turn altitudes are normally minimum altitudes.

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

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 the map to assure the airplane remains within protected airspace.

10.6 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

777-200 - 777-300ER

- on ILS final approach and either the localizer or the glide slope indicator shows full deflection

787-8 - 787-10

- on ILS or GLS final approach and either the localizer or the glide slope indicator shows full deflection

787-8 - 787-10

- on IAN final approach and either the FAC pointer or the glide path pointer shows full deflection
- on an RNP based approach and an alert message indicates that ANP exceeds RNP
- for airplanes with NPS, during RNP approach operation, anytime the NPS deviation exceeds the limit or an amber deviation alert occurs unless the aircrew is able to change to a non-RNP procedure

777-200 - 777-300ER

- for airplanes without NPS, during RNP approach operation, anytime the XTK exceeds 1.0 X RNP unless the aircrew is able to change to a non-RNP procedure.
- on a radar approach and radio communication is lost.

10.7 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 certain approaches using a VNAV path; or a MDA(H) for approaches that do not use vertical guidance, or where a DA(H) is not authorized for use. Most agencies do not require specific visual references below alert height (AH).

Approach charts use the abbreviation DA(H) or MDA(H). DA(H) applies to Category I, II, and certain fail passive Category III operations. A decision altitude “DA” or minimum descent altitude “MDA” is referenced to MSL and the parenthetical height “(H)” is referenced to 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.

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

10.9 Flap Configurations for Approach and Landing

777-200 – 787-8

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

787-9, 787-10

During maneuvering for an approach, when the situation dictates an earlier than normal speed reduction, the use of flaps 10 through 20 with the gear up is acceptable.

10.9.1 Flap Setting for Landing

For normal landings, use flaps 25 or flaps 30. Flaps 30 will minimize landing speed, and landing distance. Flaps 25 provides better noise abatement and reduced flap wear/loads.

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

10.10 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 varies with airplane weight and provides full maneuver capability or at least 40° of bank (25° of bank and 15° overshoot) to stick shaker at all weights.

10.10.1 Flap Extension Schedule

Current Flap Position	At Speedtape "Display"	Select Flaps	Command Speed for Selected Flaps
UP	"UP"	1	"1"
1	"1"	5	"5"
5	"5"	20	"20"
20	"20"	25 or 30	(Vref 25 or Vref 30) plus wind additives

10.11 Maneuver Margin

Maneuver Margin - Landing and Go-Around 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 (25° bank with a 15° overshoot).

777-200 – 777-300ER

Full maneuver margin exists for all normal landing procedures whenever speed is at or above the maneuver speed for the current flap setting. At least adequate maneuver margin exists with flaps 20 at VREF 30 + 5 knots during a go-around at go-around thrust.

787-8 – 787-10

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 20 at VREF 30 + 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 the FCTM for an explanation of wind additives.

10.12 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.

10.12.1 Determination of a MAP

777-200 – 777-300ER

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, two methods for determining the MAP are acceptable in lieu of timing due to the accuracy of FMC positioning:

787-8 – 787-10

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

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

10.12.2 Timing During Approaches

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

Timing for instrument approaches is not necessary as long as there is no NAV UNABLE RNP alert displayed.

10.12.3 Instrument Landing System

777-200 – 777-300ER

10.12.4 Instrument Landing System or GBAS Landing System

787-8 – 787-10

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.

10.12.5 Instrument Approach using VNAV or V/S

777-200 – 777-300ER

10.12.6 Instrument Approach using VNAV, IAN or V/S

787-8 – 787-10

When specifically authorized by the appropriate regulatory authority, non-ILS approaches may be flown to the following minima:

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

If not specifically authorized to use the MDA(H) as a DA(H), use the MDA(H) specified for the instrument procedure being flown.

10.12.7 Non-ILS Approaches

787-8

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.

10.12.8 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.

10.12.9 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.

10.13 ILS Approach

777-200 – 777-300ER

10.14 ILS or GLS Approach

787-8 – 787-10

The ILS approach flight pattern assumes all preparations for the approach such as review of approach procedure, setting of minima, inbound course and radios are complete. It focuses on crew actions and avionics systems information. It also includes unique considerations during low weather minima operations. The flight pattern may be modified to suit local traffic and air traffic requirements.

787-8 - 787-10

The recommended operating practices and techniques in this section apply to both ILS and GLS approaches. Except for station tuning, pilot actions are identical. A sub-section titled GLS Approach containing information specific to the GLS is located at the end of this section.

10.14.1 Fail Operation

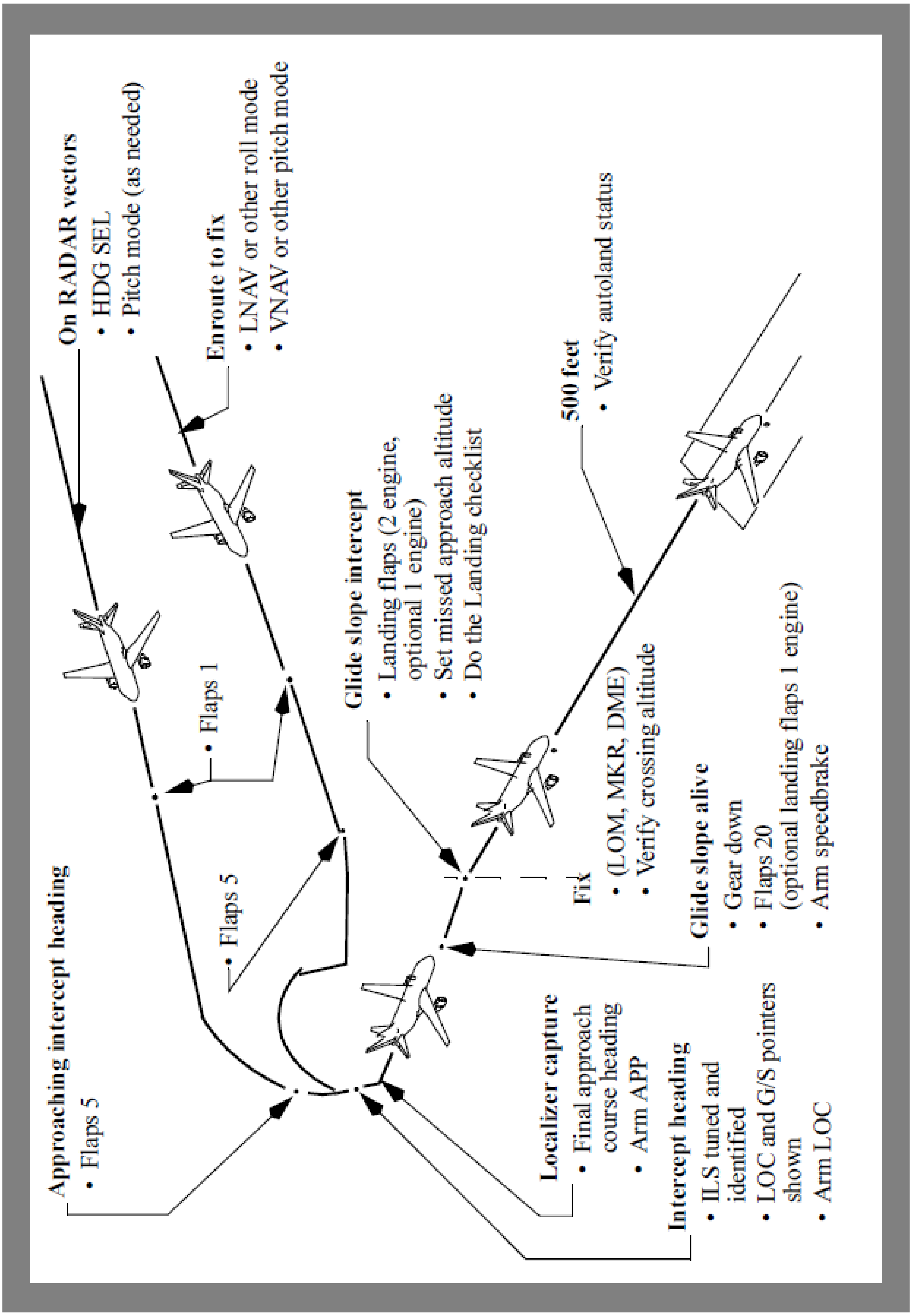
Fail operational refers to an AFDS capable of completing an ILS approach, autoland, and rollout following the failure of any single system component after passing alert height.

10.14.2 Fail Passive

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

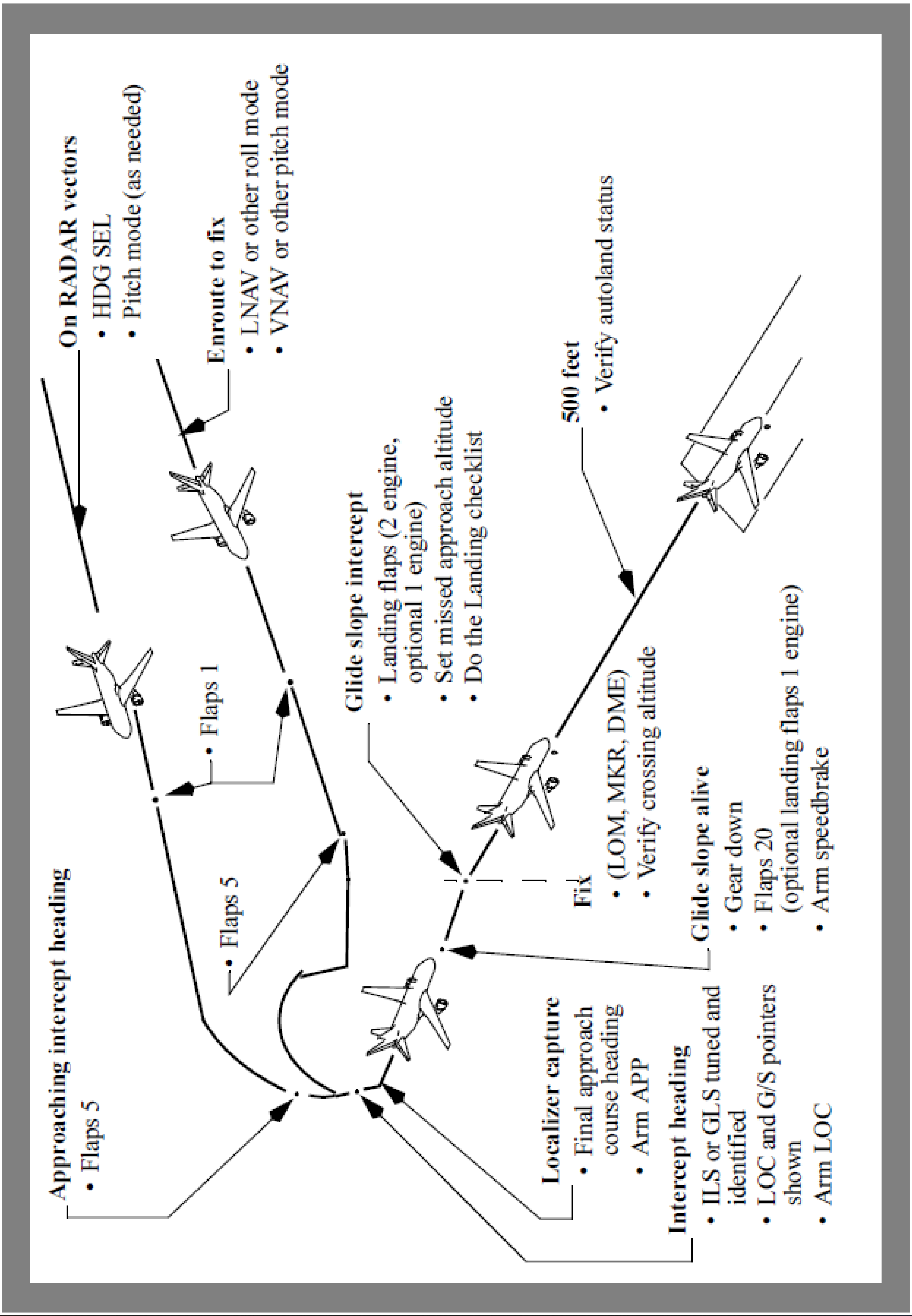
10.14.3 ILS Approach – Fail Operational

777-200 – 777-300ER



10.14.4 ILS or GLS Approach – Fail Operational

787-8 – 787-10



10.14.5 Decision Altitude or Height - DA(H)

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

For most Category II and Category III fail passive approaches, the Decision Height is the controlling minima and the altitude value specified is advisory. A Decision Height is usually based on a specified radio altitude above the terrain on the final approach or touchdown zone.

10.14.6 Alert Height - AH

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

10.14.7 Procedure Turn and Initial Approach

ILS Cross the procedure turn fix at flaps 5 maneuver airspeed. If a complete arrival procedure to the localizer and glide slope capture point has been selected via the CDU, the initial approach phase may be completed using LNAV and VNAV.

10.14.8 Approach

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

787-8 – 787-10

On all approaches, pilots are encouraged to use HUD whenever possible.

787-8 – 787-10

During strong crosswinds, the HUD flight path vector symbol may display a dashed outline. Selecting the declutter mode removes the speed and altitude tapes and increases the viewing area of the flight path vector. This may change the flight path vector symbol back to solid, displaying the current flight path of the airplane.

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

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

The approach procedure may be flown using HDG SEL, TRK SEL, or LNAV for lateral tracking and VNAV, FLCH, V/S, or FPA for altitude changes. VNAV is the preferred descent mode when the FMS flight plan is programmed for the intended arrival.

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.

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

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

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

APP mode should not be selected until:

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

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

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

10.14.9 Final Approach

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

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

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

At glide slope capture, observe the flight mode annunciations for correct modes. At this time, select landing flaps and VREF + 5 knots or VREF plus wind additive if landing manually, and do 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 recommended callouts during final approach and the pilot flying should acknowledge callouts.

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

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

There have been incidents where airplanes have captured false glide slope signals and maintained continuous on glide slope indications as a result of an ILS ground transmitter erroneously left in the test mode. False glide slope signals can be detected by crosschecking the final approach fix crossing altitude and VNAV path information before glide slope capture. A normal pitch attitude and descent rate should also be indicated on final approach after glide slope capture. Further, if a glide slope anomaly is suspected, an abnormal altitude range-distance relationship may exist. This can be identified by crosschecking distance to the runway with altitude or crosschecking the airplane position with waypoints indicated on the navigation display. The altitude should be approximately 300 feet HAT per NM of distance to the runway for a 3° glide slope.

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

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

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

Autopilots having fail operational capability are designed to safely continue an approach below AH after a single failure of an autopilot element. The autopilots protect against any probable system failure and safely land the airplane. The pilot should not interfere below AH unless it is clearly evident pilot action is required.

During an autoland with crosswind conditions, the runway alignment maneuver uses sideslip to reduce the crab angle of the airplane at touchdown. Alignment begins at 500 feet radio altitude or lower, depending on the strength of the crosswind. The amount of sideslip induced is limited to 5°. When a strong crosswind is present, the airplane does not fully align with the runway, but lands with a slight crab angle. In all cases, the upwind wing is low at touchdown. The autopilot and autobrakes should remain engaged until a safe stop is assured and adequate visibility exists to control the airplane using visual references.

10.14.10 Intercepting Glide Slope from Above

777-200 – 777-300ER

The following technique may be used for ILS approaches, however it is not recommended for approaches using VNAV.

787-8 – 787-10

The following technique may be used for ILS, GLS, or approaches using IAN; however it is not recommended for approaches using VNAV.

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.

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

777-200 - 777-300ER

- select the V/S mode and set -1000 to -1500 fpm to achieve G/S capture and be stabilized for the approach by 1,000 feet AFE. Use of the green altitude range arc may assist in establishing the correct rate of descent.

787-8 – 787-10

- select the V/S mode and set -1000 to -1500 fpm to achieve G/S capture and be stabilized for the approach by 1,000 feet AFE. Use of the VSD or 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. At G/S capture observe the flight mode annunciations for correct modes and monitor G/S deviation. After G/S capture, continue with normal procedures. Comply with the recommendations on the use of speedbrakes found in Chapter 4 of this manual.

Note: If the G/S is not captured or the approach not stabilized by 1,000 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 1,000 feet AFE, even in VMC conditions. See the section titled Stabilized Approach Recommendations earlier in this chapter for more information on stabilized approach criteria.

10.14.11 Decision Altitude or Height - 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 slope to the flare. Do not descend below the visual glide path.

10.14.12 Raw Data - (No Flight Director)

Raw data approaches are normally used during training to improve the instrument scanflow.

777-200 - 777-300ER

ILS deviation is displayed on the attitude display. ILS deviation may also be displayed on the ND by selecting APP mode on the EFIS Control Panel. The localizer course deviation scale on the attitude display remains normal scale during the approach and does not change to expanded scale at approximately 5/8 dot, as happens with F/D and/or autopilot engaged and localizer captured. Continue to crosscheck the map display against the attitude display raw data. Select VOR/ADF switches to display appropriate pointers on the ND.

787-8 - 787-10

ILS deviation is displayed on the attitude display. The localizer course deviation scale on the attitude display remains normal scale during the approach and does not change to expanded scale at approximately 5/8 dot, as happens with F/D and/or autopilot engaged and localizer captured. Continue to crosscheck the map display against the attitude display raw data. Select VOR or ADF (as installed) to display appropriate pointers on the ND.

777-200 - 777-300ER

The magnetic course/bearing information from the VOR/ADF pointers on the navigation display may be used to supplement the attitude display localizer deviation indication during initial course interception. Begin the turn to the inbound localizer heading at the first movement of the localizer pointer.

787-8 - 787-10

The magnetic course/bearing information from the VOR/ADF pointers on the navigation display or the mini-map may be used to supplement the attitude display localizer deviation indication during initial course interception. Begin the turn to the inbound localizer heading at the first movement of the localizer pointer.

After course intercept, the track line and read-out on the navigation display may be used to assist in applying proper drift correction and maintaining desired course. Bank as needed to keep the localizer pointer centered and the track line over the course line. This method automatically corrects for wind drift with very little reference to actual heading required.

Large bank angles are rarely required while tracking inbound on the localizer. Use 5° to 10° of bank angle.

When the glide slope pointer begins to move (glide slope alive), lower the landing gear, extend flaps 20, and decelerate to flaps 20 speed. Intercepting the glide slope, extend landing flaps and establish the final approach speed. When established on the glide slope, preset the missed approach altitude in the altitude window. On final approach, maintain VREF + 5 knots or an appropriate correction for headwind component. Check altitude crossing the FAF. Begin timing, if required. To stabilize on the final approach speed as early as possible, it is necessary to exercise precise speed control during the glide slope intercept phase of the approach. The rate of descent varies with the glide slope angle and ground speed. 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 TO/GA is selected. Refer to Go-Around and Missed Approach - All Approaches, this chapter.

10.15 AFDS Autoland Capabilities

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

777-200 - 777-300ER

Note: For autoland use flaps 20 or 30.

787-8 – 787-10

Note: For autoland use flaps 20, 25 or 30.

Note: Autoland should not be attempted unless the final approach course path is aligned with the runway centerline. If the localizer beam is offset from the centerline the AFDS ROLLOUT mode may cause the airplane to depart the runway.

10.15.1 Autolands on Contaminated Runways

AFDS ROLLOUT mode performance cannot be assured when used on contaminated runways. The ROLLOUT mode relies on a combination of aerodynamic rudder control, nose wheel steering and main gear tracking to maintain the runway centerline using localizer signals for guidance. On a contaminated runway, nose wheel steering and main gear tracking effectiveness, and therefore airplane directional control capability, is reduced. To determine the maximum crosswind, use the most restrictive of the autoland crosswind limitation, or during low visibility approaches, the maximum crosswind authorized by the controlling regulatory agency. Consideration should also be given to the Landing Crosswind Guidelines published in chapter 6 of this manual or operator guidelines.

If an autoland is accomplished on a contaminated runway, the pilot must be prepared to disengage the autopilot and take over manually should ROLLOUT directional control become inadequate.

10.16 Low Visibility Approaches

10.16.1 Category II/III Operations

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

Category II approaches may be conducted using the autopilot with one or two engines.

777-200 - 777-300ER

The airplane has been demonstrated to meet Category III criteria with two engines operating or with one engine operating for flaps 20 or flaps 30 landing.

787-8 - 787-10

The airplane has been demonstrated to meet Category III criteria with two engines operating or with one engine operating for flaps 20, 25, or flaps 30 landing.

10.17 AFDS Faults

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

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

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

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

Above Alert Height

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

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

At or Below Alert Height

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

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

If the autopilot is unintentionally disengaged below alert height, the landing may be completed if suitable visual reference is established.

If a go-around is initiated with the autopilot disengaged, push the TO/GA switch. If the TO/GA switch is not pushed, the flight directors remain in the approach mode.

10.18 ILS Approach – Landing Geometry

The following diagrams use these conditions:

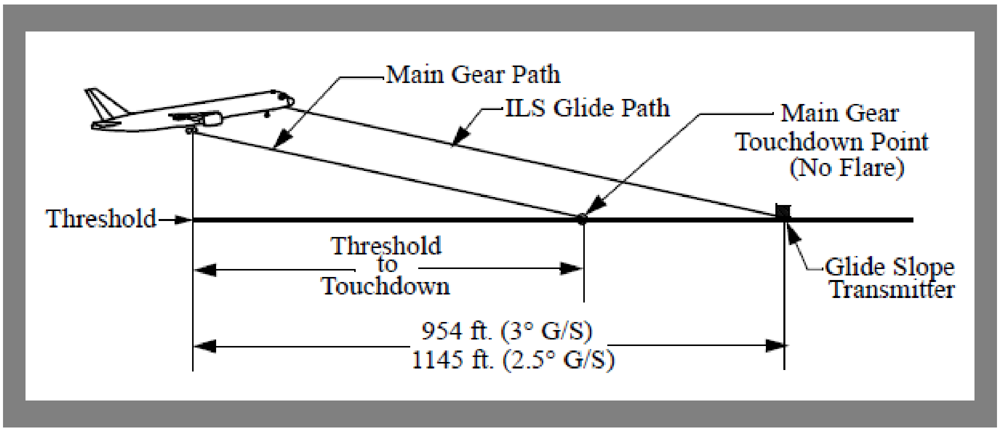
- data is based on typical landing weight

777-200 - 777-300ER

- 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

787-8 - 787-10

- airplane body attitudes are based on flaps 30, VREF 30 + 5 knots and should be reduced by ½° for each 5 knots above this speed
- pilot eye height is measured when the main gear is over the threshold
- airplane ILS antenna crosses threshold at 50 feet.



777-200 – 777-300ER

777 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	2.4	58	30	681
	3.0	1.9	58	30	567
- 200LR	2.5	1.3	58	32	738
	3.0	0.9	57	32	611
- 300	2.5	1.9	58	29	669
	3.0	1.4	57	29	557
- 300ER	2.5	2.2	58	29	674
	3.0	1.7	58	29	561

787-8 - 787-10

787 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)	
- 8	2.5	1.8	55	31	701
	3.0	1.3	54	31	584
- 9	2.5	1.5	54	30	692
	3.0	1.0	53	30	576
- 10	2.5	1.6	54	29	661
	3.0	1.1	53	29	550

10.19 Non-Normal Operations

This section describes pilot techniques associated with engine inoperative approaches. Techniques discussed minimize workload, improve crew coordination, and enhance flight safety. However, a thorough review of applicable Non-Normal Checklists associated with engine inoperative flight is a prerequisite to understanding this section.

10.19.1 One Engine Inoperative

AFDS management and associated procedures are the same as for the normal ILS approach. Flight director (manual) or autopilot and/or autothrottle may be used. Weather minima for an ILS with one engine inoperative are specified in the applicable AFM and/or the operator’s Operational Specification or equivalent.

For a discussion about how yaw is controlled during an approach with one engine inoperative, refer to the section titled Engine Inoperative, Rudder Trim - All Instrument Approaches later in this chapter.

777-200 – 777-300ER

Refer to the PI chapter of the QRH to determine if a flaps 30 landing is permissible. Intercept the localizer with flaps 5 at flaps 5 speed. When the glide slope is alive, lower the landing gear and extend flaps to 20. If a flaps 20 landing will be made, set final approach speed and decelerate. If a flaps 30 landing will be made, at glide slope capture, select landing flaps, set final approach speed, and decelerate.

787-8 – 787-10

Refer to the PI chapter of the QRH to determine if a flaps 30 landing is permissible. Intercept the localizer with flaps 5 at flaps 5 speed. When the glide slope is alive, lower the landing gear and extend flaps to 20. If a flaps 20 landing will be made, set final approach speed and decelerate. If a flaps 25 or 30 landing will be made, at glide slope capture, select landing flaps, set final approach speed, and decelerate.

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

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

10.19.2 Engine Inoperative, Rudder Trim - All Instrument Approaches

777-200 – 777-300ER

During a multiple autopilot approach, the TAC automatically applies rudder inputs to control yaw until LAND 3 or LAND 2 annunciates. If the TAC is inoperative, the pilot must use rudder pedal pressure to control yaw, followed by rudder trim to maintain an in-trim condition until LAND 3 or LAND 2 annunciates. When LAND 3 or LAND 2 annunciates, regardless of the status of the TAC, rudder inputs are controlled by the autopilots. Directional control (yaw) is not affected by rudder trim with the autopilot in the LOC or ROLLOUT modes.

787-8 – 787-10

During a multiple autopilot approach, the flight control system automatically applies rudder inputs to controls yaw until LAND 3 or LAND 2 annunciates. When LAND 3 or LAND 2 annunciates, rudder inputs are controlled by the autopilots. Manual rudder trim is inhibited with LAND 2 or LAND 3 annunciated.

777-200 - 777-300ER

When the TAC is inoperative, the pilot must use rudder pedal pressure to control yaw, followed by rudder trim to maintain an in-trim condition until LAND 3 or LAND 2 annunciates. 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.

777-200 - 777-300ER

When the TAC is inoperative, manually centering the rudder trim before landing allows most of the rudder pedal pressure to be removed when the thrust of the operating engine is retarded to idle at touchdown. Full rudder authority and rudder pedal steering capability are not affected by rudder trim.

777-200 - 777-300ER

When the TAC is inoperative, it may not be advisable to manually center the rudder trim due to crew workload or 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.

10.19.3 Engine Failure On Final Approach

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

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

777-200 - 777-300ER

The ability to continue the approach with an engine failure on final approach when Category III minima are necessary may also be a factor. If the approach is continued at flaps 20 or 30, increase the thrust to maintain the appropriate speed or ensure autothrottle operation is satisfactory.

787-8 - 787-10

The ability to continue the approach with an engine failure on final approach when Category III minima are necessary may also be a factor. If the approach is continued at flaps 20, 25 or 30, increase the thrust to maintain the appropriate speed or ensure autothrottle operation is satisfactory.

If a go-around is required, follow the Go-Around and Missed Approach procedures for one engine inoperative, retracting the flaps to 20. Adequate performance is available at flaps 20. Subsequent flap retraction should be made at a safe altitude in level flight or a shallow climb.

777-200, 777-300, 787-8 - 787-10

It is usually preferable to continue the approach using flaps 25 or 30. At weights near the landing climb capability limit it may be preferable to continue the approach using flaps 20. This provides a better thrust margin, less thrust asymmetry and improved go-around capability. If the decision is made to reduce the flap setting, thrust should be increased at the same time as the flap selection. Command speed should be increased to 15 knots over the previously set flaps 25 or 30 final approach speed. This sets a command speed that is equal to at least VREF for flaps 20 + 5 knots.

777-200LR, 777-F, 777-300ER

It is usually preferable to continue the approach using flaps 25 or 30. At weights near the landing climb capability limit it may be preferable to continue the approach using flaps 20. This provides a better thrust margin, less thrust asymmetry and improved go-around capability. If the decision is made to reduce the flap setting, thrust should be increased at the same time as the flap selection. Command speed should be increased to 20 knots over the previously set flaps 25 or 30 final approach speed. This sets a command speed that is equal to at least VREF for flaps 20 + 5 knots.

777-200, 777-300, 787-8 - 787-10

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

777-200LR, 777-F, 777-300ER

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

10.20 GLS Approach

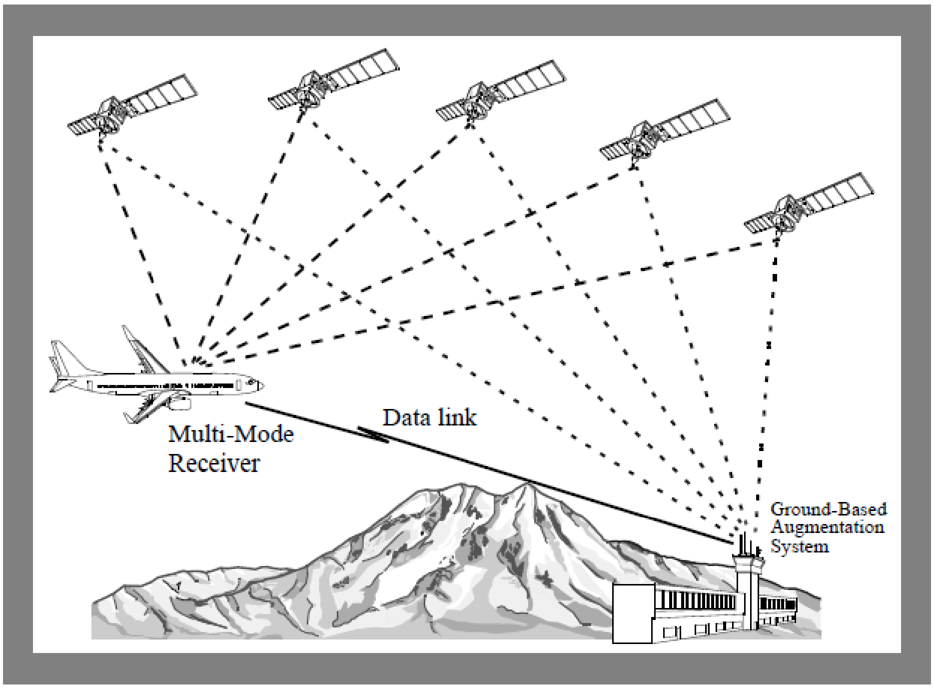
787-8 – 787-10

The aviation industry has developed a positioning and landing system based on the Ground Based Augmentation System (GBAS). The GBAS Landing System (GLS) integrates satellite and ground-based navigation information to provide extremely accurate and stable position information for approach and landing guidance.

General

GLS consists of three major elements:

- a global satellite constellation (e.g., the U.S. GPS) that supports worldwide navigation position fixing
- a GLS facility that provides approach path definition with local navigation satellite correction signals near airports qualified for GLS approaches
- avionics in each airplane that process and provide guidance and control based on the satellite and local area augmentation signals.



GLS approach procedures and techniques are identical to those of an ILS approach. GLS approaches are extraordinarily steady and smooth when compared with the current ILS system, even when critical areas necessary for the ILS approaches are unprotected during GLS approaches. There is no beam bending, no FM frequency interference, no interference from preceding aircraft, and no ground areas near the runway that need to be protected from surface traffic.

GLS approaches are certified to Category II approach minimums and have been demonstrated through autoland and rollout.

CAUTION: British Airways does not have AOC approval to conduct GLS autolands.

10.20.1 Approach

MCP mode selection requires the same pilot actions for ILS and GLS approaches. The approach selection for GLS is accomplished by selecting the GLS approach in the FMC and tuning a GLS channel versus selecting the ILS approach and tuning an ILS frequency.

GLS annunciations are identical to those used for ILS except that GLS is shown as the navigation reference on the PFD.

Crew actions while flying a GLS approach are just like those when flying an ILS approach. Note that both the Normal and Non-Normal Operations for GLS approaches are aligned with the Normal and Non-Normal Operations for an ILS approach.

10.21 Non - ILS Instrument Approaches

Non-ILS approaches are defined as:

- RNAV approach - an instrument approach procedure that relies on airplane area navigation equipment for navigational guidance. The FMS on Boeing airplanes is FAA-certified RNAV equipment that provides lateral and vertical guidance referenced from an FMS position. The FMS uses multiple sensors (as installed) for position updating to include GPS, DME-DME, VOR-DME, LOC-GPS, and IRS.
- RNAV visual approach - a visual approach that relies on airplane navigation equipment to align the aircraft with a visual final. The approach is selected in the FMC and flown in the same way as an RNAV approach until reaching the visual segment.
- GPS approach - an approach designed for use by airplanes using stand-alone GPS receivers as the primary means of navigation guidance. However, Boeing airplanes using FMS as the primary means of navigational guidance, have been approved by the FAA to fly GPS approaches provided an RNP of 0.3 or smaller is used.

Note: A manual FMC entry of 0.3 RNP is required if not automatically provided.

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

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

10.21.1 Non - ILS Instrument Approaches – General

Over the past several decades there have been a number of Controlled Flight Into Terrain (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 Continuous Descent Final Approach (CDFA) methods. Traditional methods of flying non-ILS approaches involve setting a vertical speed on final approach, leveling off at step-down altitudes (if applicable) and at MDA(H), followed by a transition to a visual final approach segment and landing. These traditional methods involve changing the flight path at low altitudes and are not similar to methods for flying ILS approaches. Further, these traditional methods often require of the crew a higher level of skill, judgment and training than the typical ILS approach.

The following sections describe methods for flying non-ILS CDFA. These methods provide a constant angle approach, which reduces exposure to crew error and CFIT accidents. These methods also make it much easier for the crew to achieve a stabilized approach to a landing once suitable visual reference to the runway environment has been established.

A typical Instrument Approach using VNAV, V/S, or FPA 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. A circling approach may be flown following an instrument approach using VNAV, V/S or FPA provided the MCP altitude is set in accordance with the circling approach procedure.

10.21.2 Types of Approaches

777-200 – 777-300ER

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

787-8 – 787-10

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

10.21.3 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, provides autopilot alerts and mode fail indications and enables lower RNP limits. Autopilot use is 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 increases in efficiency and protection provided by the automatic systems. However, to maintain flight crew proficiency, pilots may elect to use the flight director without the autopilot when in VMC conditions.

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

10.21.4 Raw Data Monitoring Requirements

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

777-200 – 777-300ER

During non-localizer based approaches where the FMC is used for course or path tracking (VOR, TACAN, NDB, RNAV, GPS, etc.), monitoring raw data is recommended, if available. When using the FMCS (LNAV) without GPS updating to conduct a terminal area procedure or an instrument approach, raw data must be monitored and checked to ensure correct navigation. For an instrument approach, this check should be done no later than the FAF.

787-8 – 787-10

During non-localizer based approaches where the FMC is used for course or path tracking (VOR, TACAN, NDB, RNAV, GPS, etc.), monitoring raw data is recommended, if available. When using the FMCS (LNAV) without INR-GPS updating to conduct a terminal area procedure or an instrument approach, raw data must be monitored and checked to ensure correct navigation. For an instrument approach, this check should be done no later than the FAF.

777-200 – 777-300ER

During VOR, DME or ADF approaches when only single FMC, single IRS or single GPS sources are available, radio data should be selected on both NDs and raw data must be monitored and checked for correct navigation. For an instrument approach, this check should be done no later than the FAF.

787-8 – 787-10

During VOR, DME or ADF approaches when only single FMC, single IRU, single DME or single INR-GPS sources are available, radio data should be selected on both NDs and raw data must be monitored and checked for correct navigation. For an instrument approach, this check should be done no later than the FAF.

Checking raw data for correct navigation may be accomplished by either of the following:

- selecting POS and comparing the displayed raw data with the navaid symbols on the map. Example: The VOR radials and raw DME data should overlay the VOR/DME stations shown on the map and the GPS position symbol should nearly coincide with the tip of the airplane symbol (FMC position)

777-200 – 777-300ER

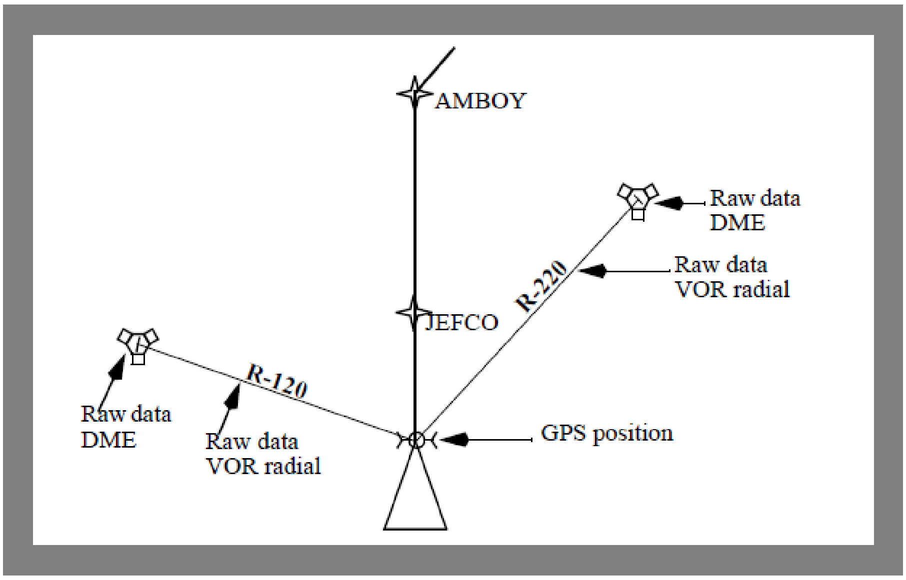
- displaying the VOR and/or ADF pointers on the map display and using them to verify your position relative to the map.

787-8 – 787-10

- displaying the VOR pointers on the map display and/or ADF pointers (as installed) on the mini-map display and using them to verify your position relative to the map.

10.21.5 Typical Navigation Display

The following diagram represents a typical navigation display with the POS display selected.



10.21.6 MAP Displays and Raw Data

The map mode should be used to the maximum extent practicable. The map display provides a plan view of the approach, including final approach and missed approach routing. The map increases crew awareness of progress and position during the approach.

The map is particularly useful when the inbound course does not align with runway centerline and allows the pilot to clearly determine the type of alignment maneuver required. The map can be used to integrate weather radar returns, terrain or traffic information within the approach path and airport area.

The preferred method for VOR or localizer tuning and final approach course selection is procedure tuning. This can be confirmed by observing the displayed frequency, identifier and course on the PFD or ND. The VOR automatically tunes for a VOR approach after passing the first waypoint on the approach procedure. Automatic procedure tuning also reduces crew workload in the terminal area by automatically tuning the missed approach VOR if a different one is required and aids the crew by reducing heads down time when last minute approach and/or runway changes are required. If required, the appropriate frequency and course may be preselected on the navigation radio page for display at the appropriate time. For localizer or localizer back course approaches, always use the front course.

777-200 – 777-300ER

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

787-8 - 787-10

Note: When appropriate, compare airplane position on the map with ILS, VOR, DME, and ADF (as installed) systems to detect possible map shift errors. Selecting POS on the map display is the recommended method for making this comparison. The VOR and ADF (as installed) pointers should be displayed on the mini-map.

10.21.7 RNAV Approaches

RNAV approaches may be flown provided the RNP being used is equal to or less than the RNP specified for the approach and is consistent with the AFM demonstrated RNP capability.

10.21.8 Approach Requirements Relating to RNP

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

- AFM indicates that the airplane has been demonstrated for selected RNP
- at least one GPS or one DME is operational
- any additional GPS or DME requirements specified by Operations Specification or by the selected terminal area procedure must be satisfied
- no NAV UNABLE RNP alert is displayed during the approach

- when operating with the following RNP values, or smaller:

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

- no NAV UNABLE RNP alert is displayed during the approach.

10.21.9 Use of LNAV

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

- Database Selection
- This method is required for RNAV and GPS approaches. An approach procedure selected through the FMC arrivals page provides the simplest method of selecting proper waypoints. Procedures in the database comply with obstruction clearance criteria for non-ILS approaches.
  - No waypoints may be added or deleted between the FAF and the MAP. If the approach to be flown is not in the database, another approach having the same plan view may be selected. For example, an ILS procedure might be selected if the plan view (route) is identical to an NDB approach. In this case, waypoint altitudes must be checked and modified as required. When an approach is flown by this “overlay” method, raw data should be monitored throughout the approach to assure obstacle clearance.

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

- If a waypoint is added to or deleted from a database procedure, FMC “on approach” logic (as described in the FCOM) is partially or completely disabled and the VNAV obstacle clearance integrity of the procedure may be adversely affected. If an additional waypoint reference is desired, use the FIX page and do not modify waypoints on the LEGS page.
- Manual Waypoint Entry
  - Due to potentially inadequate terrain clearance, manual waypoint entry should not be accomplished for RNAV or GPS approaches, nor should this method be used with VNAV after the FAF.
- Procedure turns and DME arcs cannot usually be manually entered (unless they can be defined by a series of waypoints). Deviation from the defined route may require use of “DIRECT TO” or “INTERCEPT COURSE TO” when intercepting the inbound course. Constant monitoring of raw data during the approach is required.
- The only permitted manual waypoint entry method in British Airways is the RWY EXT method, provided that the final approach track is aligned with the runway centreline.

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

LNAV cannot be used to track fix or radial data displayed on the map that is not part of the active route. A navaid/waypoint and the appropriate radial may be inserted on the FIX page to create a “course” line on the map that helps to improve situational awareness. A similar display may be created by manually tuning an appropriate VOR and selecting the desired course. These methods provide reference information on the map display only. They are not reflected on the LEGS page and cannot be tracked with LNAV. These methods should only be used when there is no opportunity to use an approach selected from the navigation database and should therefore be considered only when normal means of displaying approaches are not available. Pilots should be aware that the displayed course is an FMC calculated course and is not raw data information.

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

Note: Automatic procedure tuning is not available with manually entered waypoints

If the approach is not available in the navigation database, select the landing runway from the FMC arrivals page. The runway and associated extended centerline then displays on the map to aid in maintaining position awareness. Pilots should not become involved in excessive “heads down” FMC manipulation to build map displays while at low altitude. Raw data VOR, ILS, and ADF displays should be used to avoid distractions during higher workload phases of flight. Map building should be avoided below 10,000 feet AGL.

10.21.10 Use of VNAV

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

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

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

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

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

- ILS approaches coded with the appropriate threshold crossing height may be used as an overlay for other approaches such as LOC or NDB.

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

When appropriate, make cold temperature altitude corrections by applying a correction from an approved table to the waypoint altitude constraints. The FMC obtains the GP angle displayed on the LEGS page from the navigation database. This GP angle is based on the standard atmosphere and is used by the FMC to calculate the VNAV path which is flown using a barometric reference. When OAT is lower than standard, true altitudes are lower than indicated altitudes. Therefore, if cold temperature altitude corrections are not made, the effective GP angle is lower than the value displayed on the LEGS page. When cold temperature altitude corrections are made, VNAV PTH operation and procedure tuning function normally; however, the airplane follows the higher of the glide path angle associated with the approach (if available) or the geometric path defined by the waypoint altitude constraints.

When on final approach, VNAV should be used with speed intervention active to reduce workload. Adding speed constraints to the final approach waypoints is normally not needed and causes extra workload without providing any safety benefit. This also reduces the ability to make last minute approach changes. However, if needed speed constraints may be changed if the default value is not suitable.

To prevent unnecessary level offs while descending in VNAV before the final approach, reset the MCP altitude selector to the next lower constraint before altitude capture, when compliance with the altitude restriction is assured.

10.21.11 Use of Altitude Intervention during Approaches using VNAV

Altitude intervention is appropriate during approaches only if the AFDS enters VNAV ALT mode above the approach path and descent must be continued. Entering VNAV ALT mode can occur if passing a waypoint on the approach and the crew has failed to reset the MCP altitude to a lower altitude. If this occurs, set the MCP altitude to the next lower altitude constraint or the TDZE, as appropriate, and select altitude intervention. When VNAV altitude intervention is selected, VNAV path deviation indications on the map display disappear momentarily while the path is recalculated, but should reappear.

When on-approach logic is active and the airplane is below the VNAV path, when altitude intervention is selected, level flight is commanded until reaching the VNAV path, then the airplane captures the VNAV path.

When using VNAV PTH or VNAV SPD, the selection of altitude intervention will:

777-200 – 777-300ER

- approach waypoint altitude constraints are not deleted by the use of the MCP altitude intervention function.

777-200 – 777-300ER

When using VNAV ALT, selection of altitude intervention:

- may delete down path altitude constraints if the altitude constraint is within 150 feet of the current airplane altitude

- does not affect other altitude constraints.

777-200 – 777-300ER

10.21.12 Non - ILS Approach - One Engine Inoperative

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

10.21.13 Procedure Turn and Initial Approach

Cross the procedure turn fix at flaps 5 and flaps 5 maneuver airspeed. If a complete arrival procedure has been selected via the CDU, the initial approach phase may be completed using LNAV and VNAV path, or other appropriate modes.

10.22 Vertical Path Construction

This section describes typical final approach vertical profile (path) construction criteria as they relate to flying instrument approaches using VNAV. This information may also be useful to pilots who wish to fly the vertical path using V/S or FPA.

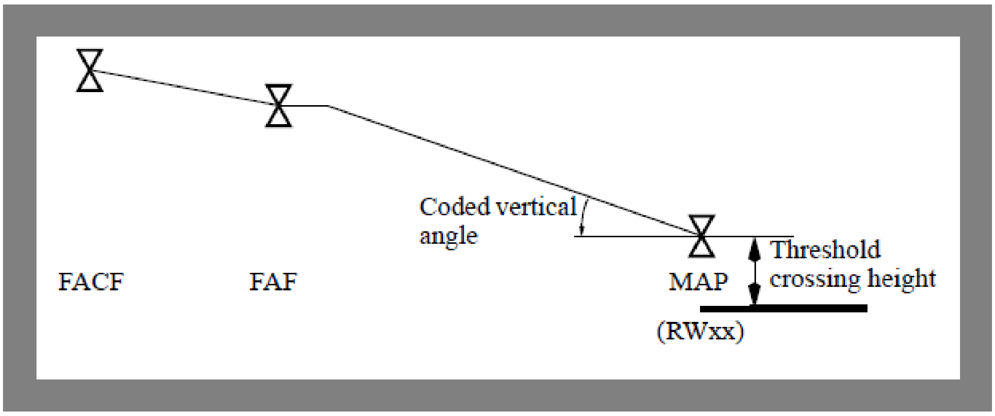
Where there is a glide path (GP) angle coded in the navigation database, the FMC builds the descent path upward and back in the direction of the FAF by starting at the location of the missed approach waypoint (MAP) and its associated altitude constraint. The FMC calculates this path using the coded GP angle, also called the vertical angle. The MAP is normally shown on the LEGS page as a RWxx or MXxx waypoint. In some cases a named waypoint is used as the MAP. A GP angle is coded in the navigation database for nearly all straight-in approach procedures.

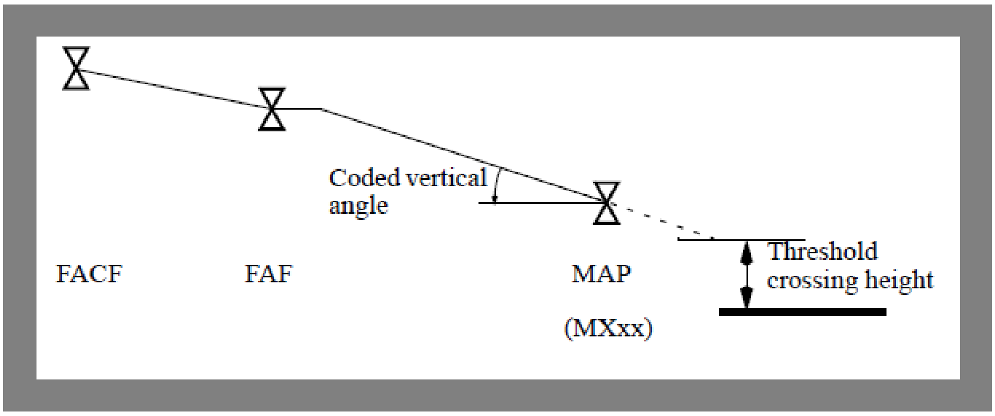
This GP angle is normally defined by the regulatory authority responsible for the approach procedure and provides a continuous descent at a constant flight path angle for a final approach path that complies with minimum altitudes at intermediate step-down fixes. The typical GP angle is approximately 3.00°, but can vary from 2.75° to 3.77°.

The projection of the vertical path upward and back toward the FAF along this coded GP angle stops at the next higher limiting altitude in the vertical profile. This limiting altitude is the more restrictive of the following:

- the “At” altitude on the constrained waypoint preceding the MAP
- the crossing altitude on the next “at or above” constrained waypoint preceding the MAP
- the speed transition or the speed restriction altitude, whichever is lower
- cruise altitude.

The following examples show typical VNAV final approach paths where there is a GP angle in the navigation database. The first example shows an RWxx missed approach waypoint. The second example below shows the VNAV final approach path where there is a missed approach waypoint before the runway. Note that in the second case the projected path crosses the runway threshold at approximately 50 feet. VNAV guidance is level flight, however, when the airplane passes the missed approach point. Both examples are for “At” altitude constraints at the FAF.





Note: The final approach course fix (FACF) is typically located on the final approach course approximately 7 NM before the FAF. The FAF referred to in the following procedures refers to the charted FAF and is intended to mean the point at which the final approach descent is begun.

For the non-ILS approach procedures with an “At” constraint altitude at the FAF, a short, level segment between the FAF and the final glide path (also called a “fly-off”) may result. For the ILS procedure, the constraint altitude at the FAF is computed to be the crossing altitude of the glide slope.

For procedures where both the FAF and FACF are coded with “at or above” altitude constraints, the crew should consider revising the FACF altitude constraint to “at” (hard constraint). This enables a shallower path before the FAF, permitting a normal deceleration for flap and gear extension. Example: In the diagram above, if both the FACF and the FAF contain “xxx/4000A” waypoint constraints, the crew should change “4000A” to “4000” at the FACF to modify the path for a more normal deceleration.

Crews can expect to see several other variations of approach path construction:

- approaches where the FAF has an “at or above” waypoint altitude constraint. The GP angle normally terminates at the FACF altitude constraint or the cruise altitude, whichever is lower. When this type of path is flown, the airplane passes above the FAF
- where there is more than one GP angle, such as for ILS approaches, the airplane uses the GP angle for the active leg to define the VNAV approach path. These types of paths are shown on the LEGS page as having two GP angle values, one approaching the FAF, the second approaching the runway (missed approach point).

Note: The coded GP angle is steeper than normal in temperatures warmer than ISA standard and is shallower than normal in temperatures colder than ISA standard.

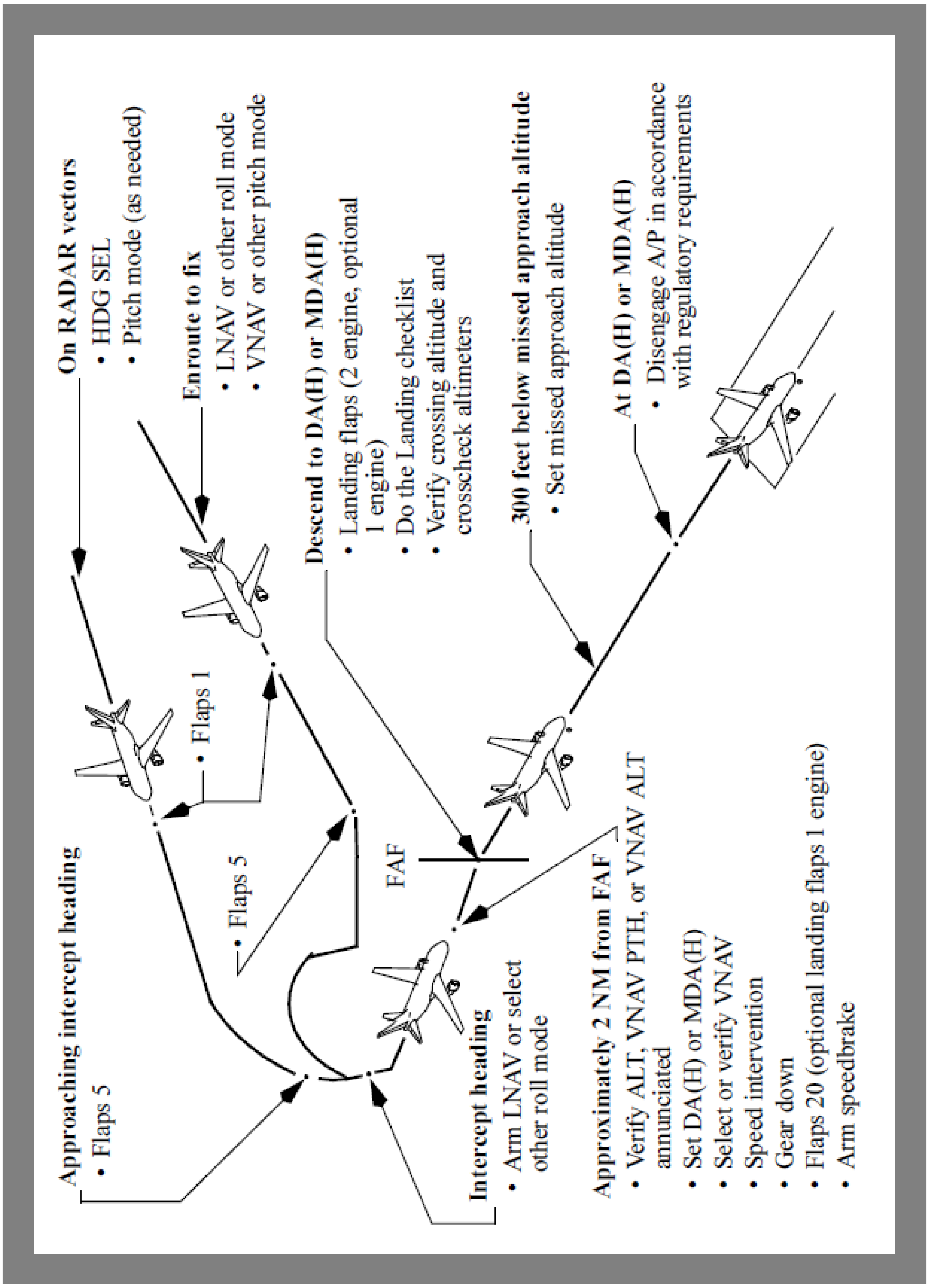
777-200 – 777-300ER

Note: ILS approaches may have step-down fixes published between the FAF and the MAP (for G/S OUT use) which are not included in the FMC database procedure. The vertical angle in the FMC database procedure may not satisfy the step-down minimum altitudes inside the FAF on these approaches. Use of VNAV PTH for these procedures is not recommended without operator approval. However, published localizer (LOC) only approaches are compatible with VNAV PTH.

787-8 – 787-10

Note: ILS approaches may have step-down fixes published between the FAF and the MAP (for G/S OUT use) which are not included in the FMC database procedure. The vertical angle in the FMC database procedure may not satisfy the step-down minimum altitudes inside the FAF on these approaches. Use of VNAV PTH or IAN for these procedures is not recommended without operator approval. However, published localizer (LOC) only approaches are compatible with VNAV PTH.

10.23 Instrument Approach Using VNAV



10.23.1 Approach Preparations for using VNAV

Select the approach procedure from the arrivals page of the FMC. Tune and identify appropriate navaids. Do not manually build the approach or add waypoints to the procedure. If additional waypoint references are desired, use the FIX page. To enable proper LNAV waypoint sequencing, select a straight-in intercept course to the FAF when being radar vectored to final approach. Verify/enter the appropriate RNP and set the DA(H) or MDA(H) using the baro minimums selector.

Note: The approach RNP value is determined from one of three sources: manual entry by the flight crew, FMC default, or the navigation database. A manual entry overrides all others. If the navigation database contains an RNP value for the final approach leg, the RNP will appear when the leg becomes active, or up to 30 NM prior if the previous leg does not have an associated RNP value. The FMC default approach RNP will appear (no manual entry or navigation database value) when passing the approach waypoint, including approach transitions, or when below 2,000 feet above the destination airport.

10.23.2 Transition to an Instrument Approach using VNAV

There are several techniques which help ensure a smooth descent transition to a non-ILS final approach where VNAV PTH will be used.

Note: The FAF is normally the waypoint shown on the LEGS page and map display just before the final approach segment. The following discussions assume the FAF altitude constraint is set in the MCP while descending toward the FAF.

If descending to the FAF altitude in FLCH, V/S, or FPA, by approximately 2 NM before the FAF verify that ALT is displayed before setting DA(H) or MDA(H) in the MCP. If the DA(H) or MDA(H) is set while FLCH, V/S, or FPA is still displayed, the airplane may descend below the FAF altitude constraint before intercepting the glide path. After DA(H) or MDA(H) is set, select or verify VNAV and select speed intervention.

If descending in VNAV PTH before final approach and the situation permits a continuous descent through final approach, remain in VNAV PTH while configuring the airplane for approach and landing. The airplane slows automatically to the FAF speed constraint. Reset the MCP to DA(H) or MDA(H) before the FAF (waypoint just before the final approach segment) to prevent level off, and select speed intervention.

If descending in VNAV SPD, the AFDS changes to VNAV PTH automatically when approaching the FAF if the airplane is on or below the path. When the flaps are extended to position 1 or greater and the airplane is below the path, VNAV PTH engages and the airplane levels off and remains level until intercepting the approach path. If above the path, the airplane continues to descend and capture the approach path from above. Reset the MCP to the DA(H) or MDA(H) when cleared for the approach. If VNAV ALT has engaged beyond the FAF, set DA(H) or MDA(H) in the MCP and select altitude intervention without delay to enable continued descent on the final approach path. Execute a missed approach if the deviation above path becomes excessive enough to prevent achieving a stabilized approach.

10.23.3 Final Approach using VNAV

Approaching intercept heading, select flaps 5 and ensure LNAV or other appropriate roll mode is armed or engaged. Approaching the FAF (approximately 2 NM), set the DA(H) or MDA(H) in the MCP altitude window, select VNAV and ensure VNAV PTH and appropriate roll mode is annunciated. Select gear down, flaps 20 and arm the speedbrake. Use VNAV speed intervention to control speed.

When using LNAV to intercept the final approach course, shallow intercept angles or intercept angles that result in an overshoot may result in delayed capture of the final approach course. The FAF should not be crossed and descent should not begin if the airplane is not on the final approach course.

Note: For approach procedures where the vertical angle (“GP” angle shown on the LEGS page) begins earlier in the approach (prior to the FAF), the MCP may be set to the DA(H) or MDA(H) once established on the vertical angle.

When initiating descent on the final approach path, 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.

With the MCP altitude set to DA(H) or MDA(H) and the airplane stabilized on the final approach path, the map altitude range arc assists in determining the visual descent point (VDP). As soon as the airplane is at least 300 feet below the missed approach altitude and stabilized on final approach in VNAV PTH, set the MCP altitude to the missed approach altitude. VNAV path deviation indications on the map display assist in monitoring the vertical profile. The autopilot tracks the path in VNAV PTH resulting in arrival at, or near, the visual descent point by the DA(H) or MDA(H).

On the VNAV approach, the missed approach altitude is set after established on the final descent and more than 300 feet below the missed approach altitude. Some approaches have missed approach altitudes that are lower than the altitude at which the FAF is crossed. The flight crew must wait until the airplane is at least 300 feet below the missed approach altitude before setting the missed approach altitude in the MCP to avoid level off from occurring during the final approach descent.

10.23.4 MCP Altitude Setting during Approach using VNAV

For approaches using VNAV PTH, where there is a published GP angle, the MCP altitude may be set according to Landing Procedure - Instrument Approach using VNAV found in Normal Procedures. The MCP altitude is set to the DA(H)/MDA(H) prior to the FAF altitude and reset on final approach to the missed approach altitude.

Since the selection of MDA can be made at any point prior to the FAF there needs to be a conscious assessment of when to set it. In making this assessment crews will need to balance the risk of forgetting to set it all, increased workload close to the FAF with the increased CFIT risk should a pitch mode other than VNAV be used, without resetting the MCP.

It is therefore recommended to set MDA in the MCP only when:

1. The correct profile has been confirmed in the FMC.
2. VNAV is the active pitch mode and remains so for the duration of the approach.
3. You have been cleared to fly the approach.

It is critical to ensure that if at any time a pitch mode other than VNAV is selected, the MCP altitude value MUST be reviewed. This is because the FMC vertical profile will not be followed, significantly increasing the risk of CFIT.

Additionally, whenever the lateral mode is not LNAV then the MCP altitude value MUST be reviewed. This is because the aircraft is potentially no longer on the published lateral profile, terrain separation is not assured, significantly increasing the risk of CFIT.

Whenever the missed approach altitude is set, ensure it is done so without pausing at an intermediate altitude or too slowly. If the aircraft descends through an altitude within 300 ft either side of that set in the MCP, the AFDS will capture it and command a level off. To avoid an inadvertent altitude capture, the recommendation is to set the altitude using 1,000 ft increments and where necessary adjust down using 100 ft increments.

10.23.5 Decision Altitude (DA(H)) or Minimum Descent Altitude (MDA(H))

When specifically authorized by the appropriate regulatory authority, non-ILS approaches may be flown to the following minima:

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

If not specifically authorized to use the MDA(H) as a DA(H), use the MDA(H) specified for the instrument procedure being flown.

The following diagram illustrates an approach procedure containing DA(H) minimums for approaches using Localizer Performance with Vertical guidance (LPV) and LNAV/VNAV. The diagram also shows MDA(H) minimums for an approach using LNAV only and a circling approach.

Note: Boeing airplanes are not equipped to utilize LPV minimums.

	STRAIGHT-IN LANDING RWY 28R						CIRCLE-TO-LAND	
	LPV DA(H) 263' (250')		LNAV/VNAV DA(H) 822' (809')		LNAV MDA(H) 1040' (1027')			
		ALS out		ALS out		ALS out	Max Kts	MDA(H)
A	RVR 24 or 1/2	RVR 40 or 3/4	2	2 3/4	RVR 40 or 3/4	RVR 60 or 1 1/4	90	1040' (1027') - 1 1/4
B					RVR 50 or 1	1 1/2	120	1040' (1027') - 1 1/2
C			2 1/4		2 1/2	3	140	1040' (1027') - 3
D			2 1/2				165	1060' (1147') - 3

Note: Some non-ILS approaches specify a VNAV DA(H). Regulations may require use of the autopilot in the VNAV PTH mode to permit use of the DA(H).

When reaching the DA(H) or MDA(H), be prepared to disengage the autopilot in accordance with regulatory requirements. Land or execute an immediate go-around.

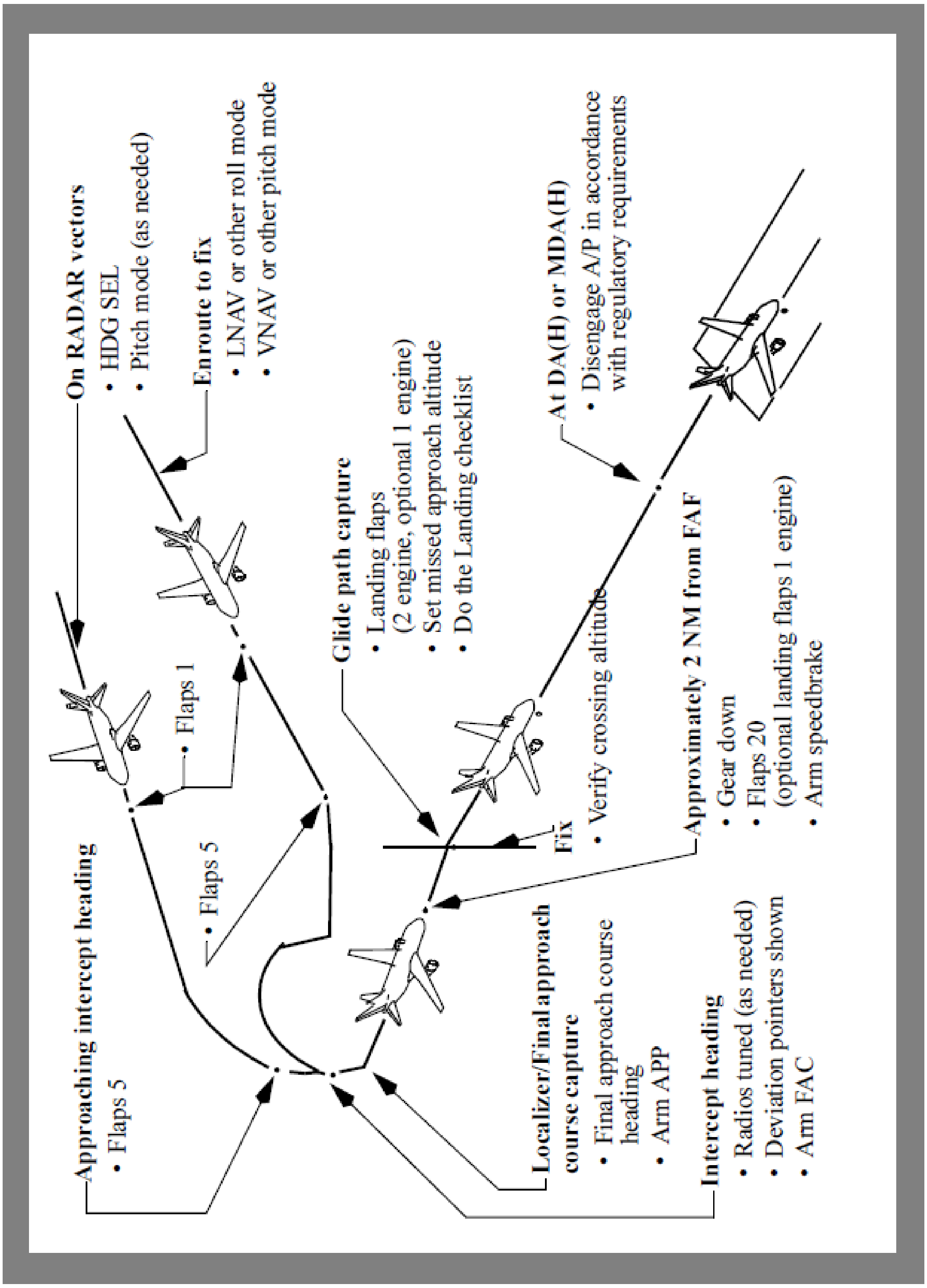
Do not continue the approach below DA(H) or MDA(H) unless the airplane is in a position from which a normal approach to the runway of intended landing can be made and suitable visual reference can be maintained. Upon arrival at DA(H) or MDA(H) or any time thereafter, if any of the above requirements are not met, immediately execute the missed approach procedure.

When suitable visual reference is established, maintain the descent path to the flare. Do not descend below the visual glide path. While VNAV PTH guidance may still be used as a reference once the airplane is below DA(H) or MDA(H), the primary means of approach guidance is visual.

Note: VNAV path guidance transitions to level flight once the missed approach fix is passed.

10.24 Instrument Approach Using IAN

787-8 – 787-10



10.24.1 Use of IAN – General

The approach profile illustrated depicts crew actions used during an approach using Integrated Approach Navigation (IAN). Since the techniques for approaches using IAN are similar to ILS approach techniques, only items considered unique to IAN are discussed in the remainder of this section. The approach profile illustrated assumes all preparations for the approach such as review of the approach procedure and setting of minima and radios, as required, are complete.

Airplanes with IAN are capable of using the MCP APP switch to execute instrument approaches based on flight path guidance from the FMC. Approaches using IAN provide the functions, indications and alerting features similar to an ILS approach. Although non-ILS approaches using LNAV and VNAV can still be performed, IAN is normally used in place of LNAV and VNAV because of standardized procedures.

10.24.2 Approach types that can use IAN:

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

Note: Dual engine or engine inoperative approaches are authorized.

10.24.3 IAN Requirements and Restrictions

- QFE operation is not authorized
- RNP appropriate for the approach must be used
- approaches using IAN are not authorized for RNAV (RNP) AR
- raw data monitoring is required during localizer based approaches
- waypoints in the navigation database from the FAF onward may not be modified except cold temperature altitude corrections are permitted in the FMC for waypoints up to and including the MAP.

10.24.4 IAN Recommendations

- the use of IAN is recommended for straight-in approaches only
- due to the nature of RNAV (RNP) AR instrument approaches (RF legs to final, short final straight segments, etc.), the use of LNAV/VNAV procedures rather than IAN procedures is recommended
- if operators choose to use IAN for non-straight-in or RNAV (RNP) AR approaches, it is recommended that:
- APP be selected only after verifying that LNAV is engaged and the airplane is on path. IAN capture logic prevents premature FAC capture
- the airplane is equipped with the option to inhibit G/P capture prior to LOC/FAC capture.
- during FMC based non-ILS approaches, raw data monitoring is recommended when available in accordance with the techniques described in the Non-ILS approach section in this chapter.

10.24.5 Flight Mode Annunciations and other IAN Features

FMAs vary depending on the source of the navigation guidance used for the approach, navigation radio or FMC.

For localizer based approaches:

Approach	FMA
ILS with G/S out, LOC, LDA, SDF	LOC and G/P
B/C LOC	B/CRS and G/P

If the FMC is used for lateral (course) guidance:

Approach	FMA
GPS, RNAV	FAC and G/P
VOR, NDB, TACAN	FAC and G/P

10.24.6 Approach Preparations for using IAN

IAN may be used with the flight director, autopilot, or flown with raw data. The procedure turn, initial approach, and final approach are similar to the ILS.

For FMC based approaches, a proper series of legs/waypoints describing the approach route including an appropriate vertical path or glide path (GP) angle must appear on the LEGS page. A GP angle displayed on the LEGS page means the vertical path complies with final approach step-down altitudes (minimum altitude constraints). A typical GP angle suitable for an approach using IAN is one that approximates 3° and crosses the runway threshold at approximately 50 feet.

The appropriate procedure must be selected in the FMC. If final approach course guidance is derived from the localizer, the radios must be tuned to the appropriate frequency. If final approach course guidance is derived from the FMC, the ILS or GLS should not be tuned. When flying a localizer approach with the glide slope out or unreliable (LOC GS out), the G/S prompt is selected OFF to ensure that the FMC generated glide path is flown.

Note: For all approaches, including B/C LOC approaches, the inbound front course must be verified.

10.24.7 Final Approach using IAN

When on an intercept heading and cleared for the approach, select the APP mode. Set missed approach altitude after glide path capture.

APP mode should not be selected until:

- the guidance to be used for the final approach is tuned and identified (as needed)
- the airplane is established on the localizer or final approach course (as needed)
- both lateral and vertical deviation pointers appear on the attitude display in the proper position
- clearance for the approach has been received

Note: The IAN GP is a barometric vertical path and does not guarantee compliance with FMC altitude constraints prior to the FAF. However, the IAN GP will be at or above altitude constraints between the FAF and the missed approach waypoint that are included in the FMC database procedure.

Unlike an ILS approach, where configuration for landing is initiated when the glide slope comes alive, during an IAN approach, configuration for landing is initiated approximately 2 NM from the FAF. Waiting until the glide path is alive may give the crew too little time to accomplish all recommended actions before intercepting the glide path. This is because the IAN glide path full scale deflection is variable depending upon the vertical RNP value in use. At low vertical RNP values, the vertical deviation pointer does not move until just before intercepting the glide path. Initiating the landing configuration at approximately 2 NM from the FAF gives the crew time to slow and select landing flaps at the FAF.

Deviation scales are proportional to RNP. Unlike the ILS localizer and glide slope deviation scales, the IAN deviation scales do not become more sensitive as the airplane approaches the runway. They provide consistent sensitivity throughout the final approach segment based on the RNP.

GPWS glide slope alerting is provided on IAN airplanes during ILS and approaches using IAN. GPWS glide slope alerts provide indications when the airplane deviates below the glide slope (ILS) or glide path (IAN) before reaching a full scale deflection. During the approach, any time a full scale vertical or lateral deflection occurs or a NAV UNABLE RNP alert occurs and suitable visual reference has not been established, a missed approach must be executed.

If the final approach course is offset from the runway centerline, maneuvering to align with the runway centerline is required. When suitable visual reference is established, continue following the glide path (GP) angle while maneuvering to align with the runway.

With the autopilot engaged below 100 feet radio altitude, a NO AUTOLAND status annunciation is displayed on the PFD and on the HUD to remind the crew that the autopilot must be disengaged before landing.

10.24.8 Decision Altitude (DA(H)) or Minimum Descent Altitude (MDA(H))

When specifically authorized by the appropriate regulatory authority, non-ILS approaches may be flown to the following minima:

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

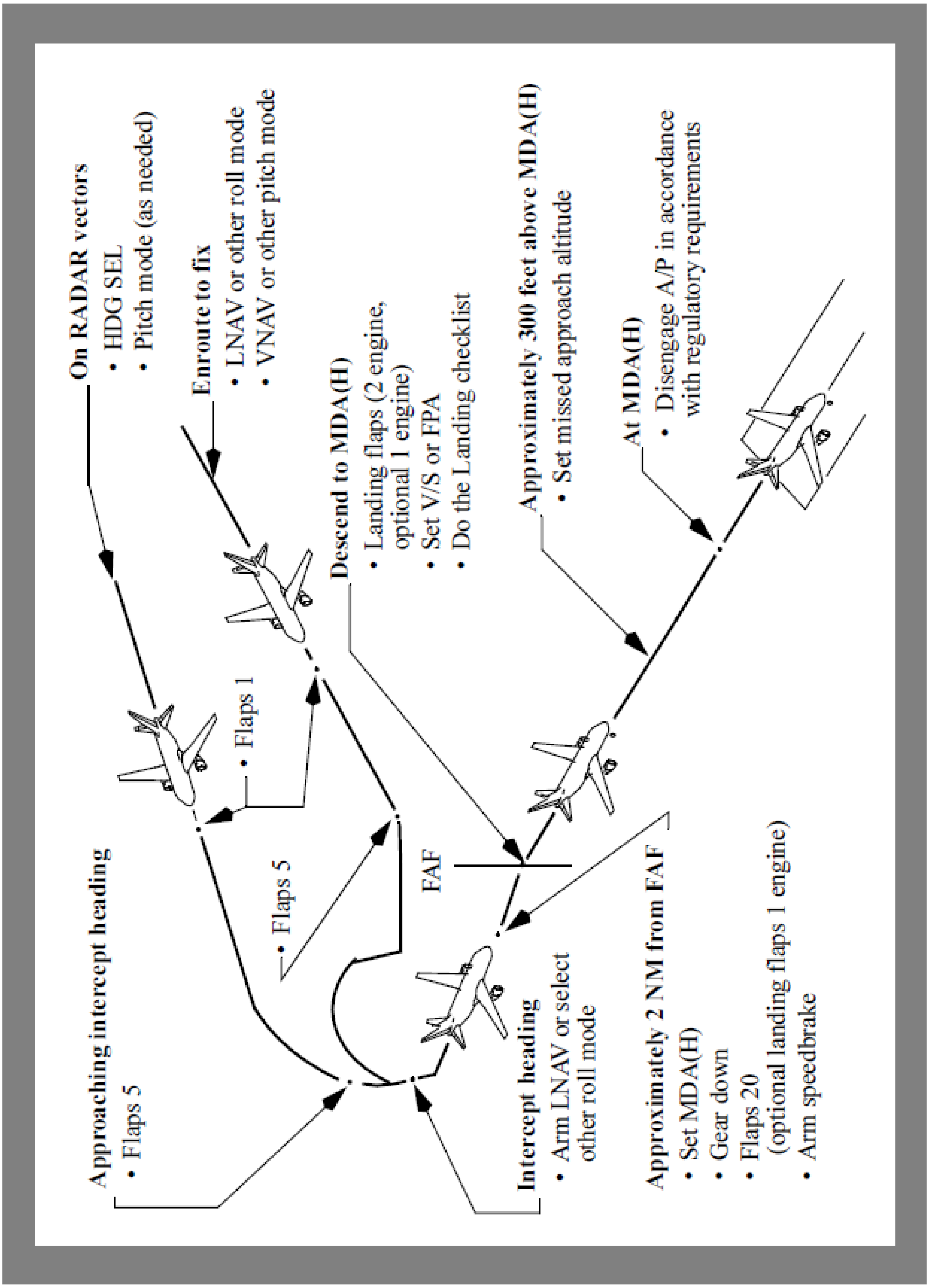
If not specifically authorized to use the MDA(H) as a DA(H), use the MDA(H) specified for the instrument procedure being flown.

When approaching DA(H) or MDA(H) the pilot monitoring should expand the instrument scan to include outside visual cues. Do not continue the approach below DA(H) or MDA(H) unless the airplane is in a position from which a normal approach to the runway of intended landing can be made and suitable visual reference can be maintained. Upon arrival at DA(H) or MDA(H) or any time thereafter, if any of the above requirements are not met, immediately execute the missed approach procedure.

The final approach is similar to the ILS final approach, however approaches using IAN do not support autoland. Therefore, when reaching the DA(H) or MDA(H), be prepared to land manually or execute an immediate go-around. If the approach is continued, be prepared to disengage the autopilot in accordance with regulatory requirements.

When suitable visual reference is established, maintain the glide path to the flare. Do not descend below the visual glide path. While glide path guidance may still be used as a reference once the airplane is below DA(H) or MDA(H), the primary means of approach guidance is visual.

10.25 Instrument Approach Using V/S or FPA



10.25.1 Approach Preparations for using V/S or FPA

Select the approach procedure from the arrivals page of the FMC. Tune and identify appropriate navaids. If additional waypoint references are desired, use the FIX page. To enable proper LNAV waypoint sequencing, select a straight-in intercept course to the FAF when being radar vectored to final approach. Verify/enter the appropriate RNP and set the MDA(H) using the baro minimums selector.

10.25.2 Final Approach using V/S or FPA

Approaching intercept heading, select flaps 5 and ensure LNAV or other appropriate roll mode is armed or engaged. Approaching the FAF (approximately 2 NM), set the MCP altitude window to the first intermediate altitude constraint, or MDA(H) if no altitude constraint exists. If the altitude constraint is not at an even 100 foot increment, set the MCP altitude to the nearest 100 foot increment below the altitude constraint. The MDA(H) may be set within 10 feet as long as the minimums are set using the minimums selector. Select gear down, flaps 20, arm the speedbrake and adjust speed.

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, select V/S or FPA mode and descend at appropriate vertical speed, or flight path angle, to arrive at the MDA(H) at a distance from the runway (VDP) to allow a normal landing profile. If V/S mode is used, 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.

If FPA mode is used, initial selection of an appropriate FPA should be made considering the final approach descent angle or glide path angle published on the approach chart, if available. If no descent angle or glide path angle is available from the approach chart, set -3.0° initially. FPA mode allows the pilot to select a flight path (e.g -3.0°.) which automatically compensates for headwind or tailwind component. This may permit reduced workload.

When stabilized in a descent on final approach, use one of the following techniques to make small incremental changes to the resulting vertical speed or FPA to achieve a constant angle descent to minimums. There should be no level flight segment at minimums.

Several techniques may be used to achieve a constant angle path that arrives at MDA(H) at or near the VDP:

- the most accurate technique is to monitor the VNAV path deviation indication on the map display and adjust descent rate or FPA to maintain the airplane on the appropriate path. This technique requires the path to be defined appropriately on the legs page and that the header GPx.xx is displayed for the missed approach point or there is a RWxx or MXxx, or named waypoint on the legs page with an altitude constraint which corresponds to approximately 50 feet threshold crossing height. When this method is used, crews must ensure compliance with each minimum altitude constraint on the final approach segment (step-down fixes)

- select a descent rate or FPA that places the altitude range arc at or near the step-down fix or visual descent point (VDP). This technique requires the step-down fix or MDA(H) to be set in the MCP and may be difficult to use in turbulent conditions. See the Visual Descent Point section for more details on determining the VDP
- using 300 feet per NM for a 3° path, determine the desired HAA which corresponds to the distance in NM from the runway end. The PM can then call out recommended altitudes as the distance to the runway changes (Example: 900 feet - 3 NM, 600 feet - 2 NM, etc.). The descent rate or FPA should be adjusted in small increments for significant deviations from the nominal path.

Be prepared to land or go-around from the MDA(H) at the VDP. Note that a normal landing cannot be completed from the published missed approach point on many instrument approaches.

When more than 300 feet below the missed approach altitude, select the missed approach altitude in the MCP. Leaving the MDA(H), be prepared to disengage the autopilot in accordance with regulatory requirements. Turn both F/Ds OFF. Complete the landing.

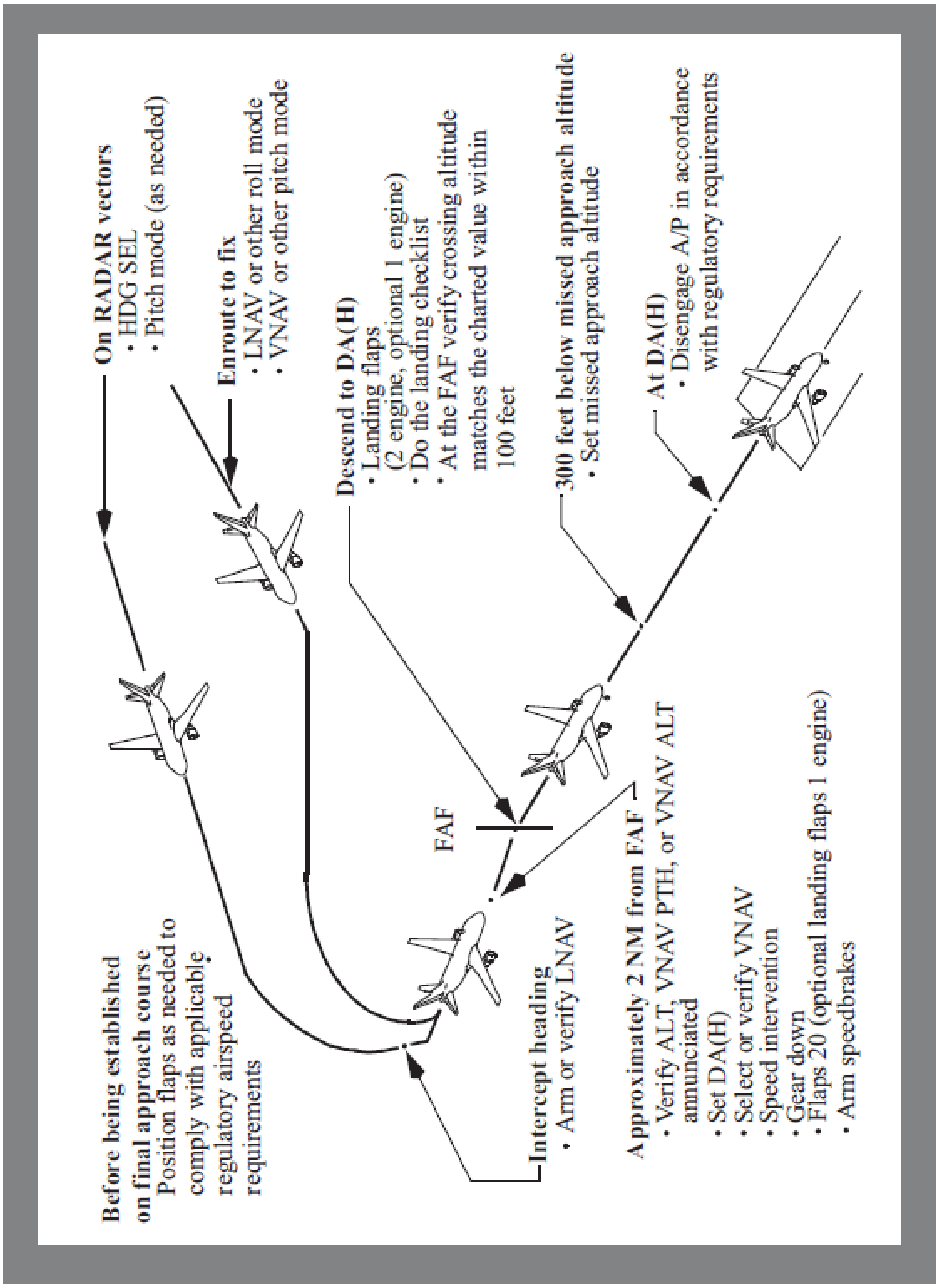
10.26 Instrument Approach - RNAV (RNP) AR

777-200 – 777-300ER

WARNING: Procedure not authorized for British Airways' 777 fleet.

787-8, 787-9, 787-10

The following flight pattern is authorized for British Airways 787 fleet.



10.26.1 Instrument Approach - RNAV (RNP) AR – General

This section applies only to British Airways Virtual's 787 fleet, which has approval to conduct RNAV (RNP) AR instrument approaches.

WARNING: Procedure not authorized for British Airways Virtual's 777 fleet.

10.26.2 Approach Preparations using RNAV (RNP) AR

Select the approach procedure from the arrivals page of the FMC. If there is an "at or above" altitude restriction before the FAF, it may be changed to an "at" altitude restriction using the same altitude. Speed modifications are allowed as long as the maximum published speed is not exceeded.

Prior to beginning the approach, the crew must brief the approach and complete needed preparations. These include, but are not limited to, the following items, which may be included in an approach review card or other type of briefing aid:

- equipment that must be operational prior to starting the approach
- selection of the approach procedure, normally without modifications, from the navigation database

787-8 – 787-10

Note: In US airspace, and other airspace where DME positioning has been verified to be adequate, DME-DME inhibiting is not required.

The crew must select or verify the approach RNP. If there are multiple RNPs published for the approach procedure, the RNP availability prediction obtained at dispatch or transmitted to the crew will determine the lowest value that can be used by the crew. The crew should note if RNP availability outages affect selection of any of the published RNP values. RNP availability restrictions, due to known satellite outages, terrain masking, or other factors, can sometimes affect the availability of lower RNPs (less than 0.15 nm) but will only rarely affect use of RNPs above 0.15 nm. The highest available RNP should be selected by the crew that is permitted by the prevailing weather conditions. Weather permitting, if the approach default RNP from the FMC is 0.3 nm and is a published RNP for the procedure, it should be used so that the FMC can automatically select the approach RNP and change to the missed approach RNP if a missed approach is needed. Crew entry of the RNP will prevent automatic RNP changes until the crew deletes the RNP entry.

For airplanes with NPS, the flight crew may enter 125 feet for vertical RNP. While there are no vertical RNP values published on the approach chart, the use of 125 feet will cause the NPS amber deviation exceedance alert to occur at 75 feet or slightly less deviation, since vertical ANP will be at least 50 feet at all times.

Ensure that there is no NAV UNABLE RNP alert displayed before starting the approach. If the altimeter setting is changing rapidly, the crew should obtain an update just before starting the approach.

Select LNAV no later than the IAF. If on radar vectors, arm LNAV when approaching or established on an intercept heading to the final approach course. VNAV PTH must be engaged for all segments that contain a GP angle, as shown on the LEGS page, and must be selected no later than the FAF or published glide path intercept point.

10.26.3 Cold Temperature Altitude Corrections

In the design of RNP AR procedures, the allowable temperature range is normally specified and the procedure design accounts for operations and obstacle clearance for any temperature within the specified range. If the actual temperature is within the specified temperature range, the pilot can fly the RNP AR procedure and there are no temperature corrections needed. If the actual temperature is outside the specified temperature range, then the crew cannot fly the RNP AR procedure.

10.26.4 Final Approach using RNAV (RNP) AR

WARNING: Procedure not authorized for British Airways Virtual's 777 fleet.

When initiating descent on the final approach path, select landing flaps, slow to final approach speed, and do the Landing checklist. Speed limits published on the approach chart must be complied with to enable adequate bank angle margins for the smaller radius-to-fix (RF) legs when strong winds exist. Bank angles will rarely exceed 15° when flying short radius RF legs unless the ground speed is very high due to strong tailwinds or high airplane speed.

The FMC and the alerting system monitors position accuracy and integrity (also called actual navigation performance), so there is no need for the crew to monitor the reception of GPS signals or the ANP. If the GPS signal is lost during the approach due to loss of both GPS receivers or satellite position data, the ANP will grow and a NAV UNABLE RNP alert occurs. The ANP is an FMC calculation based on RAIM, method of updating, and other factors, and constantly fluctuates in value. As long as ANP does not exceed RNP, there is no practical or reliable way for the crew to interpret the fluctuations of ANP. If ANP grows large enough to exceed RNP, a NAV UNABLE RNP alert occurs.

Once established on final approach, the RNAV (RNP) approach is flown like any other non-ILS approach using LNAV and VNAV.

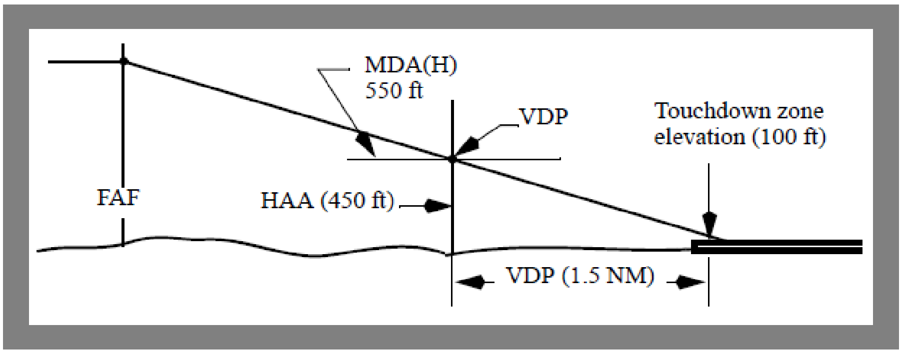
10.26.5 Maximum Lateral and Vertical Deviations for RNAV (RNP) AR Operations

RNP-based approach operations are normally designed to a lateral containment standard that equals twice the value of the RNP that is published for the procedure. To provide an adequate safety margin to account for path tracking errors, crews are expected to maintain course within 1.0 x RNP. For example, an RNP 0.15 approach will have a lateral containment limit of 0.30 nm, and a lateral deviation limit of 0.15 nm. Vertically, the deviation limit from the path is 75 feet, which only applies from the FAF to the missed approach point, unless the approach is annotated otherwise. Prior to the FAF, the vertical limit below the path is determined by the minimum altitude at the next (active) waypoint published on the approach chart. If a deviation above the path occurs, the crew should apply the criteria for a stabilized approach to determine the need for a missed approach.

10.26.6 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

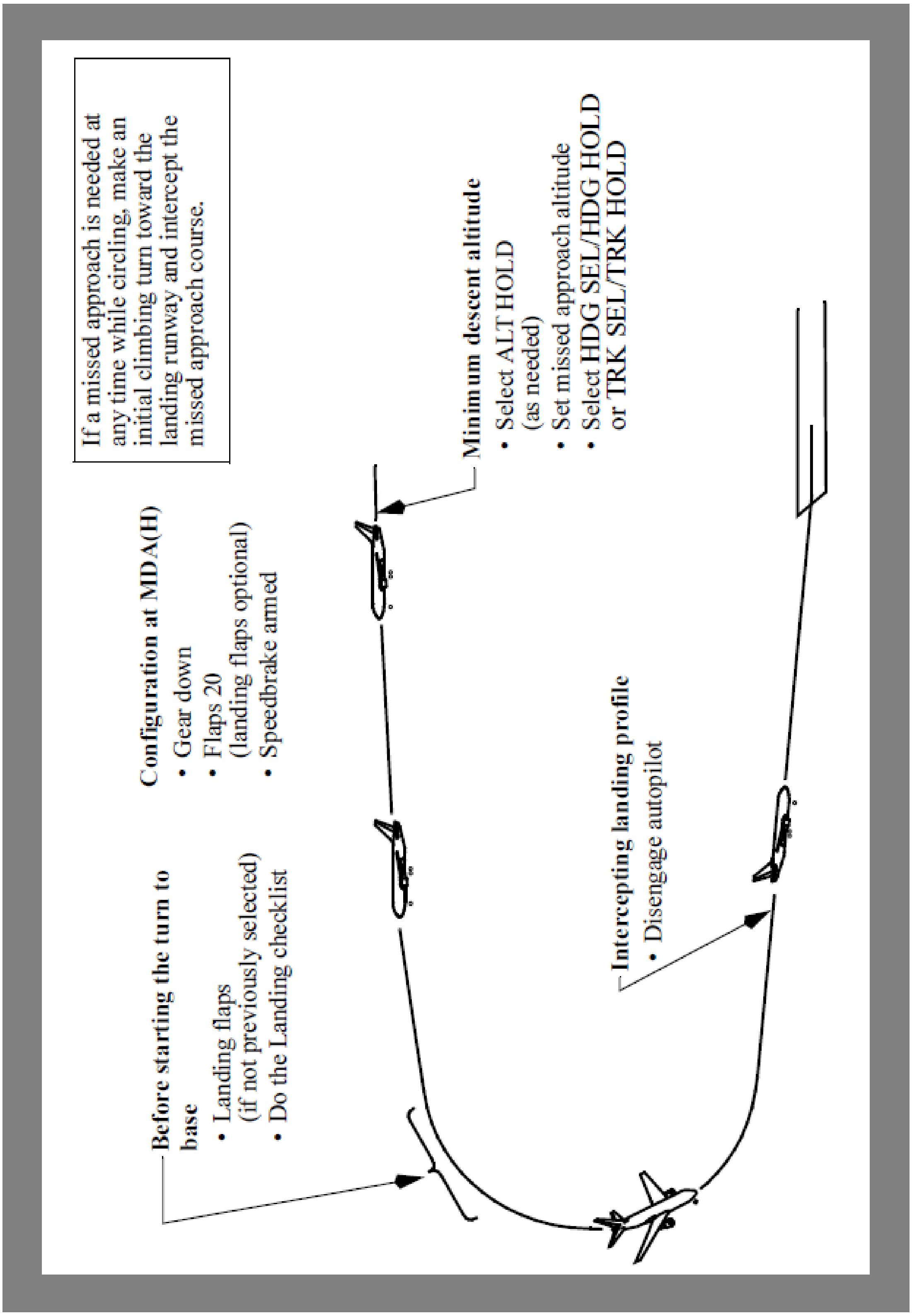
Note: If flying a VNAV path approach and the airplane remains on the published path, then the VDP is automatically complied with when the airplane arrives at the DA(H) or MDA(H). It is not necessary to determine the point to begin the visual descent for VNAV path approaches for this reason.

When flying an instrument approach using V/S or FPA, if the pilot adjusts the altitude range arc to approximately the VDP distance in front of the runway by varying the vertical speed or flight path angle, the airplane will remain close to or on the proper path for typical non-ILS approaches.

10.26.7 Missed Approach - Non-ILS

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

10.27 Circling Approach



10.27.1 Circling Approach – General

The circling approach should be flown with landing gear down, flaps 20, and at flaps 20 maneuver speed. Use the weather minima associated with the anticipated circling speed. As an option the approach may be flown with flaps 25 or 30.

The circling approach may be flown following any instrument approach procedure. During the instrument approach, use VNAV, V/S, or FPA modes to descend to the circling MDA(H). Use of the APP mode for descent to the circling MDA(H) is not recommended for several reasons:

- the AFDS does not level off at MCP altitude
- exiting the APP mode requires initiating a go-around or disengaging the autopilot and turning off the flight directors.

Maintain MDA(H) using ALT HOLD or VNAV ALT mode. Use HDG SEL/HDG HOLD or TRK SEL/TRK HOLD for the maneuvering portion of the circling approach.

When in ALT HOLD or VNAV ALT at the MDA(H) and before commencing the circling maneuver, set the missed approach altitude.

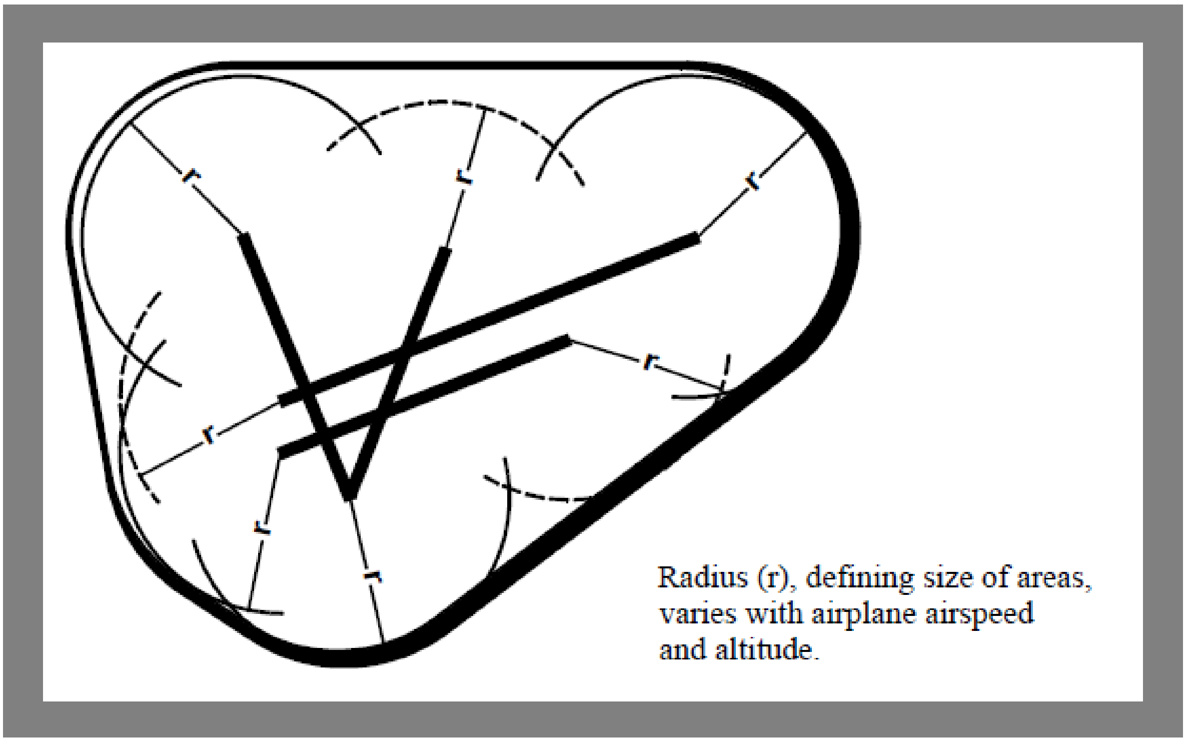
Before starting the turn to base leg, select landing flaps if not previously selected and begin decelerating to the approach speed plus wind additive. To avoid overshooting final approach course, adjust the turn to final to initially aim at the inside edge of the runway threshold. Timely speed reduction also reduces turning radius to the runway. Do the Landing checklist. Do not descend below MDA(H) until intercepting the visual descent profile to the landing runway.

When intercepting the landing profile, disengage the autopilot 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 or FMC to allow continued use of the autopilot. After intercepting the visual profile, cycle both F/D to OFF. Complete the landing.

Note: 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.

10.27.2 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.

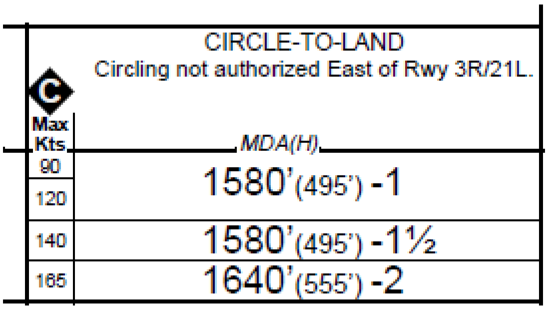
10.27.3 FAA Expanded Circling Maneuvering Airspace Radius

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

10.27.4 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.

10.27.5 Circling Approach - One Engine Inoperative

If a circling approach is anticipated, maintain gear down, flaps 20 and a minimum of VREF 20 plus wind additive while circling. Do not descend below MDA(H) until intercepting the visual descent profile.

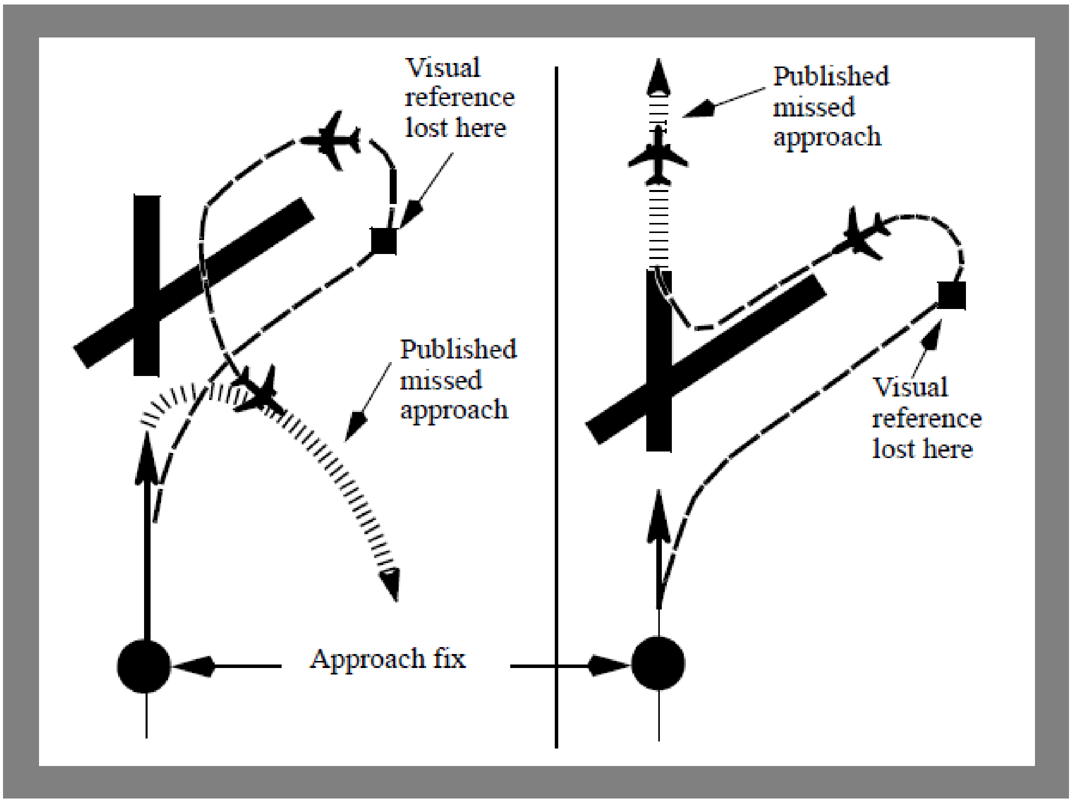
If landing with flaps 30, maintain gear down, flaps 20, and flaps 20 maneuver speed from the final approach fix until initiating the turn to base. Before starting the turn to base leg, select flaps 30, reduce speed to VREF 30 plus wind additive and intercept the landing profile. Do not descend below MDA(H) until intercepting the visual descent profile.

Under some flight conditions such as high temperatures, high pressure altitudes, and high airplane weight, limit thrust may be required to maintain level flight with the gear down and flaps 20. When these conditions are encountered consider retracting the landing gear for the circling portion of the approach after the descent to MDA(H). The GPWS gear override switch may be used to prevent nuisance warnings.

10.27.6 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.

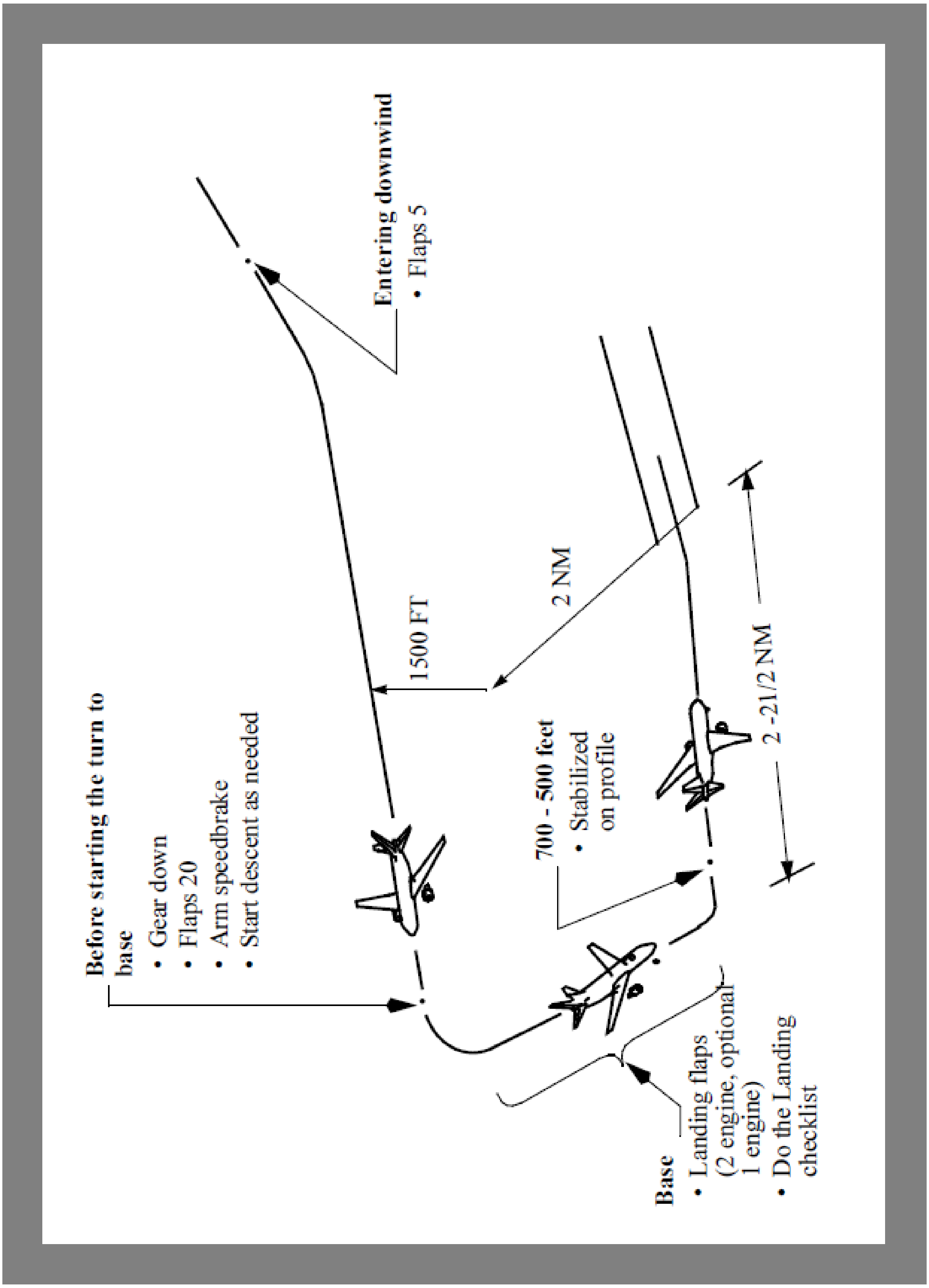
Different patterns may be required to become established on the prescribed missed approach course. This depends on airplane position at the time the missed approach is started. The following figure illustrates the maneuvering that may be required. This ensures the airplane remains within the circling 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 Go-Around and Missed Approach - All Approaches, this chapter.

10.28 Visual Traffic Pattern



10.28.1 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.

10.28.2 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.

10.28.3 Downwind and Base Leg

Typically 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 starting the turn to base leg, extend the landing gear, select flaps 20, arm the speedbrake, and slow to flaps 20 maneuver speed or approach speed plus wind additive if landing at flaps 20. If the approach pattern must be extended, delay lowering gear and selecting flaps 20 until approaching the normal visual approach profile. Turning base leg, adjust thrust as required while descending at approximately 600-700 fpm.

Extend landing flaps 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).

10.28.4 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. Use of the autothrottle is recommended. However, if controlling thrust manually, attempt to keep thrust changes small to maintain speed and avoid large trim changes. With the airplane in trim and at approach 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.

777-200 - 777-300ER

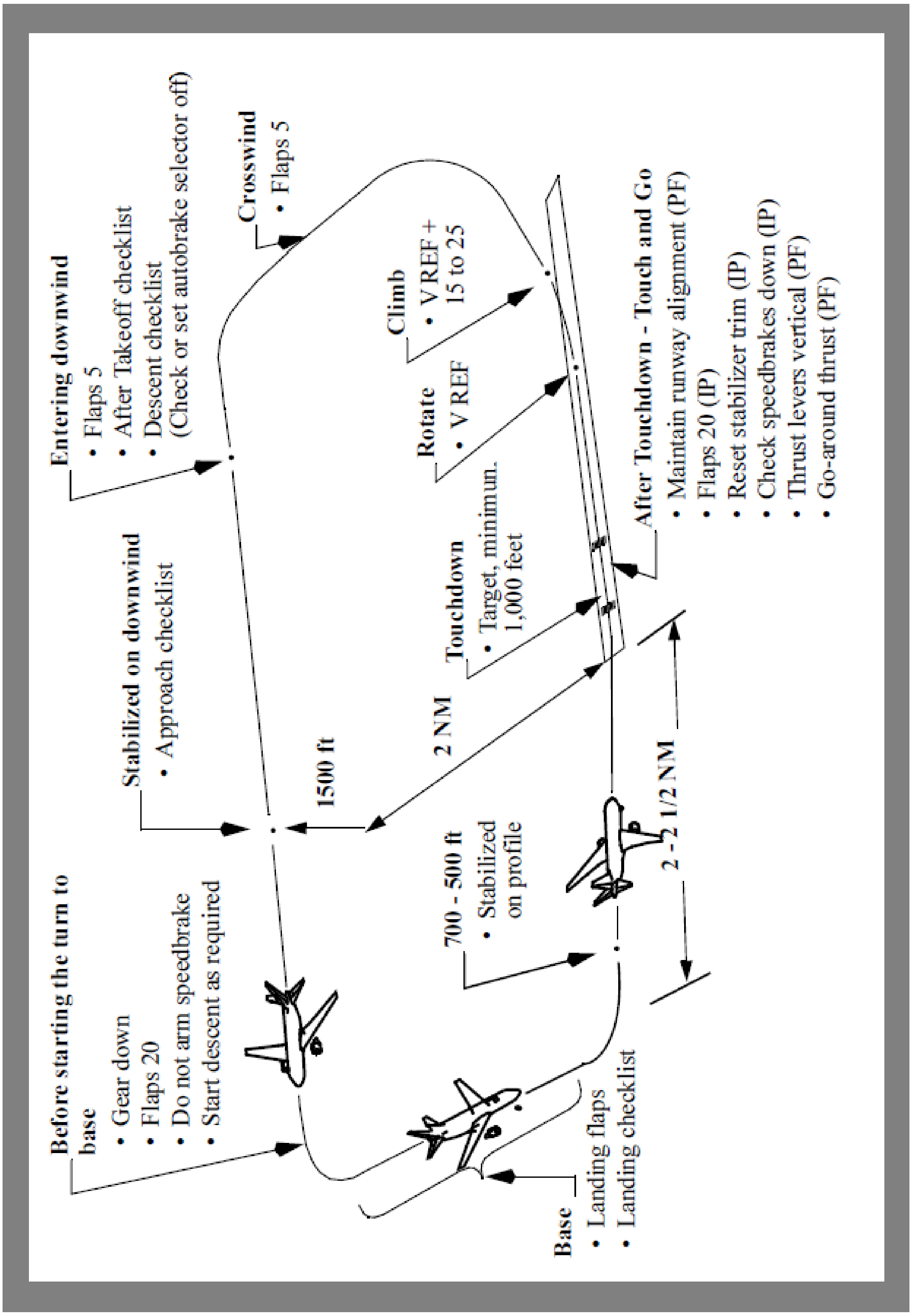
With one engine and TAC inoperative, the rudder trim may be centered before landing. This allows most of the rudder pedal pressure to be removed when the thrust of the operating engine is retarded to idle at touchdown.

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.

10.28.5 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.

10.29 Touch and Go Landings



10.29.1 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.

10.29.2 Approach

Accomplish the pattern and approach procedures as illustrated. For repetitive touch and go landings, leaving the landing gear extended throughout the maneuver will help prevent tire and brake overheating. However, be prepared to retract the landing gear if an actual engine failure occurs during go-around. Do not arm the speedbrakes. Select the autobrakes OFF.

10.29.3 Landing

The trainee should do a normal final approach and landing. After touchdown, the instructor selects flaps 20, sets stabilizer trim, ensures speedbrakes are down and at the appropriate time instructs the trainee to move the thrust levers to approximately the vertical position (so engines stabilize before applying go-around thrust). When the engines are stabilized, the instructor instructs the trainee to set thrust.

Note: Flaps 20 is recommended after touchdown to minimize the possibility of a tail strike during the takeoff.

787-8 - 787-10

Note: The speedbrake aural will sound, the SPEEDBRAKE annunciation will display on the PFD and HUD and the Master Warning light will illuminate after landing until the thrust levers are advanced.

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 siren may sound momentarily if the flaps have not retracted to flaps 20 and the thrust levers are advanced to approximately the vertical position.

787-10

Note: A nuisance SEMI LEVER GEAR LOCK status message may show during landings, or if a go-around is initiated after touchdown. This nuisance status message does not have any operational impact, and the flight can continue.

10.30 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
- check the rudder trim
- set airspeed bugs for the flap setting to be used.

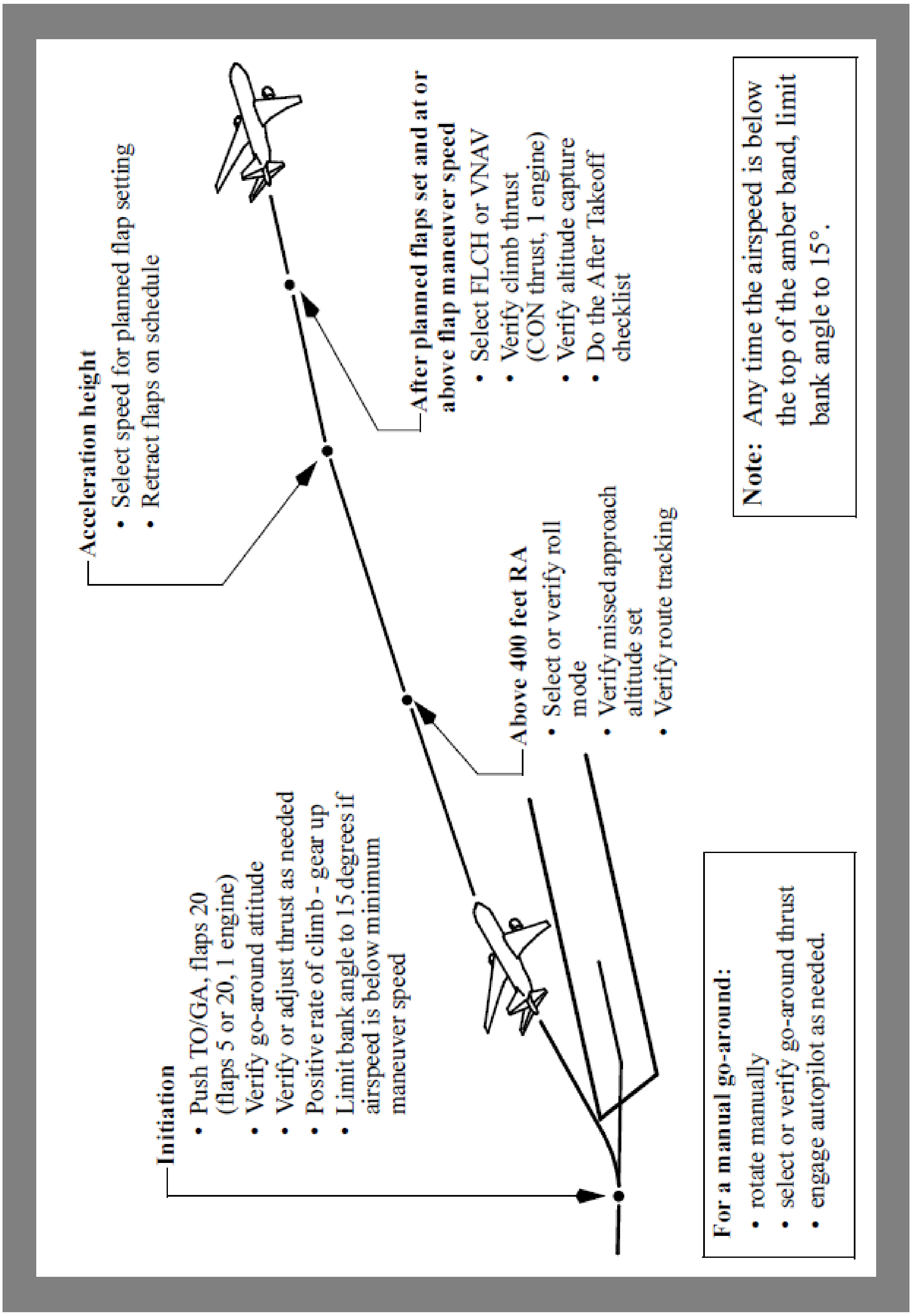
Perform a normal takeoff.

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.

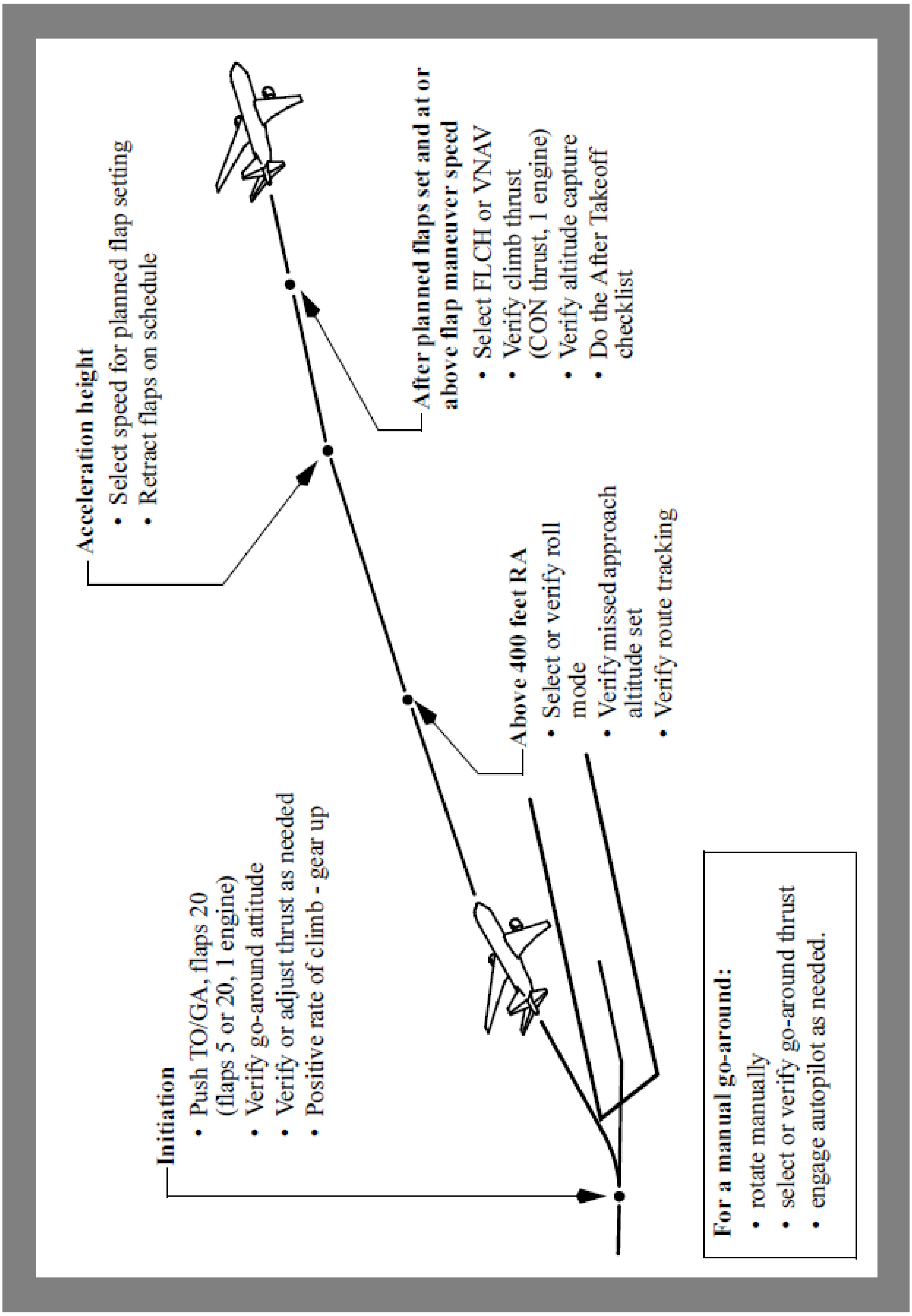
Note: Flying the pattern with the gear extended assists in tire and brake cooling.

10.31 Go-Around and Missed Approach - All Approaches

777-200 – 777-300ER



787-8 – 787-10


Initiation
• Push TO/GA, flaps 20 (flaps 5 or 20, 1 engine)
• Verify go-around attitude
• Verify or adjust thrust as needed
• Positive rate of climb - gear up
Above 400 feet RA
• Select or verify roll mode
• Verify missed approach altitude set
• Verify route tracking
Acceleration height
• Select speed for planned flap setting
• Retract flaps on schedule
After planned flaps set and at or above flap maneuver speed
• Select FLCH or VNAV
• Verify climb thrust (CON thrust, 1 engine)
• Verify altitude capture
• Do the After Takeoff checklist
For a manual go-around:
• rotate manually
• select or verify go-around thrust
• engage autopilot as needed.

10.31.1 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.

If a missed approach is required following an autopilot approach, leave the autopilots engaged. Push either TO/GA switch, call for flaps 20, ensure go-around thrust for the nominal climb rate is set and monitor autopilot performance. Retract the landing gear after a positive rate of climb is indicated on the altimeter.

At typical landing weights, actual thrust required for a normal go-around is usually considerably less than maximum go-around thrust. This provides a thrust margin for windshear or other situations requiring maximum thrust. If full thrust is desired after thrust for the nominal climb rate has been established, push TO/GA a second time.

If a missed approach is required following a manual instrument approach or visual approach, push either TO/GA switch, call for flaps 20, ensure/set go-around thrust, and rotate smoothly toward 15° pitch attitude. Then follow flight director commands and retract the landing gear after a positive rate of climb is indicated on the altimeter.

777-200 - 777-300ER

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.

787-8 - 787-10

During an automatic go-around initiated above 100 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.

777-200 - 777-300ER

The TO/GA pitch mode initially commands a go-around attitude and then transitions to speed as the rate of climb increases. This speed is normally between command speed and command speed + 25 knots. The TO/GA roll mode maintains existing ground track. If an LNAV path is available, LNAV automatically activates above 50 feet radio altitude if the autopilot is not engaged and above 200 feet radio altitude when the autopilot is engaged. Above 400 feet AGL, verify that LNAV is engaged for airplanes equipped with the TO/GA to LNAV feature, or select a roll mode as appropriate.

787-8 - 787-10

The TO/GA pitch mode initially commands a go-around attitude and then transitions to speed as the rate of climb increases. This speed is normally between command speed and command speed + 25 knots. The TO/GA roll mode maintains existing ground track. If an LNAV path is available, LNAV automatically activates above 50 feet radio altitude if the autopilot is not engaged and above 200 feet radio altitude when the autopilot is engaged. Above 400 feet AGL, verify that LNAV is engaged or select a roll mode as appropriate.

Note: Route discontinuities after the missed approach point will prevent the TO/GA to LNAV function from engaging.

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: Pitch and roll modes cannot be engaged until above 400 feet AGL.

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.

Command speed should not be increased until a safe altitude and acceleration height is attained. Accelerate to flap retraction speed by repositioning the command speed to the maneuver speed for the desired flap setting. Retract flaps on the normal flap/speed schedule. When the flaps are retracted to the desired position and the airspeed is at or above the flap maneuver speed, select FLCH or VNAV and ensure CLB thrust is set. Verify the airplane levels off at selected altitude and proper speed is maintained.

If VNAV is used during go-around, the FMC missed approach profile should contain the appropriate holding speeds and altitudes. Speed intervention may be used to further modify airspeed as needed. If VNAV ALT is displayed, a premature level off may occur and selection of FLCH may be required to complete the climb to the missed approach altitude.

10.31.2 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 AFDS control laws limit F/D and autopilot pitch commands for passenger comfort
- there may not be enough altitude below the intended level off altitude to complete the normal capture profile and an overshoot may occur unless crew action is taken.

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

- use the autothrottle
- push TO/GA switch once to command thrust sufficient for a minimum 2,000 fpm climb rate
- if full go-around thrust is used, reduce to climb thrust earlier than normal
- disconnect the AFDS and complete the level off manually if there is a possibility of an overshoot
- if the autothrottle is not available, be prepared to use manual thrust control as needed to manage speed and prevent flap overspeed.

10.31.3 Go-Around after Touchdown

If a go-around is initiated before touchdown and touchdown occurs, continue with normal go-around procedures. The F/D go-around mode will continue to provide go-around guidance commands throughout the maneuver.

If a go-around is initiated after touchdown but before thrust reverser selection, continue with normal go-around procedures. As thrust levers are advanced auto speedbrakes retract and autobrakes disarm. The F/D go-around mode will not be available until go-around is selected after becoming airborne.

Once reverse thrust is initiated following touchdown, a full stop landing must be made. If an engine stays in reverse, safe flight is not possible.

787-10

Note: A nuisance SEMI LEVER GEAR LOCK status message may show during touch and go landings, or if a go-around is initiated after touchdown. This nuisance status message does not have any operational impact, and the flight can continue.

10.31.4 Go-Around and Missed Approach - One Engine Inoperative

777-200 - 777-300ER

The missed approach with an engine inoperative should be accomplished in the same manner as a normal missed approach except use flaps 5 for the go-around flap setting for a flaps 20 approach or use flaps 20 as the go-around flap setting for a flaps 25 or 30 approach. After TO/GA is engaged, the AFDS commands a speed that is normally between command speed and command speed + 15 knots. The rudder is automatically positioned by the TAC to compensate for differential thrust with minimal input required from the pilot. Select maximum continuous thrust when flaps are retracted to the desired flap setting.

777-200 - 777-300ER

Note: If accomplishing a manual go-around with the TAC inoperative, the pilot must control yaw with rudder and trim. Some rudder pedal pressure may be required even with full rudder trim.

787-8 - 787-10

The missed approach with an engine inoperative should be accomplished in the same manner as a normal missed approach except use flaps 5 for the go-around flap setting for a flaps 20 approach or use flaps 20 as the go-around flap setting for a flaps 25 or 30 approach. After TO/GA is engaged, the AFDS commands a speed that is normally between command speed and command speed + 15 knots. The rudder is automatically positioned to compensate for differential thrust with no input required from the pilot. Select maximum continuous thrust when flaps are retracted to the desired flap setting.

777-200 - 777-300ER

For a multi-autopilot go-around, yaw is initially controlled by the autopilots. When selecting another roll mode, pitch mode, or when altitude capture occurs above 400 feet AGL the autopilot reverts to single autopilot operation and the rudder control is maintained by the TAC.

777-200 - 777-300ER

Note: If the TAC is inoperative, be prepared to immediately apply rudder input when the autopilot reverts to single autopilot operation.

787-8 - 787-10

For a multi-autopilot go-around, yaw control reverts back to the flight control system upon TO/GA initiation.

10.31.5 Engine Failure During Go-Around and Missed Approach

If an engine fails during a go-around, it is important that airspeed loss be recovered to prevent a high asymmetric thrust condition at lower than recommended airspeed. Follow flight director guidance to recover and maintain recommended airspeed. Use the same procedures as used for an engine failure during a flaps 20 takeoff.

777-200 - 777-300ER

Note: VREF 30 plus wind additive at flaps 20 may result in an airspeed that provides less than full maneuver margin (top of the amber band).

787-8 - 787-10

Note: VREF 30 plus wind additive at flaps 20, with go-around thrust, provides full maneuver margin (top of the amber band).

10.31.6 Rejected Landing

A rejected landing is considered to be different from the Go-Around and Missed Approach procedure described earlier in this chapter due to the behaviour of the AFDS TOGA mode. When the aircraft is close to the ground, the AFDS TOGA mode may not be available and requires a cognitive thought process to check its availability. The result is that a crew that elects to carry out a standard go-around by pressing the TOGA switches when close to touch down could find that AFDS guidance (which commands the Flight Director and Autothrottle), is not available. Additionally, the crew may spend valuable time attempting to identify why it is not available.

Initiation of a rejected landing has the potential to increase the startle effect on the crew already startled by the preceding event. The intent is that a rejected landing has minimal crew action in order to get the aircraft safely climbing away. Once this is achieved, the Go-Around and Missed Approach procedure is carried out. Adding this action to the end of the Rejected Landing procedure helps crews rebuild the AFDS which assists with manual flying, reconfiguring the aircraft and allows full use of the autopilot once again.

During the autoland case, the desire is to retain the capability for an automatic go-around whilst the AFDS TOGA mode remains available. This is in order to reduce the risk of unnecessary manual go-arounds close to the ground in limiting visibility. Once the AFDS TOGA mode is no longer available then the automatics must be disengaged in order to fly a rejected landing.

As the aircraft enters the flare, either during a manual or an automatic landing, the AFDS commands the autothrottle to idle thrust. During a rejected landing, it is important to disconnect the autothrottle prior to applying full manual thrust because not doing so will result in the autothrottle continuing to drive the thrust levers back to idle.

FMA awareness during a rejected landing is critical as it will allow crews to trap any omissions or abnormal selections. This is particularly important during an autoland because it will provide the first indication that the TOGA mode has not engaged, requiring manual flying from that point onwards.

WARNING: After reverse thrust is initiated, a full stop landing must be made.

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11 Landing

11.1 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 and maintain directional control after landing. Additionally, information on factors affecting landing distance and landing geometry is provided.

11.2 Visual Approach Slope Indicator (VASI/T - VASI)

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

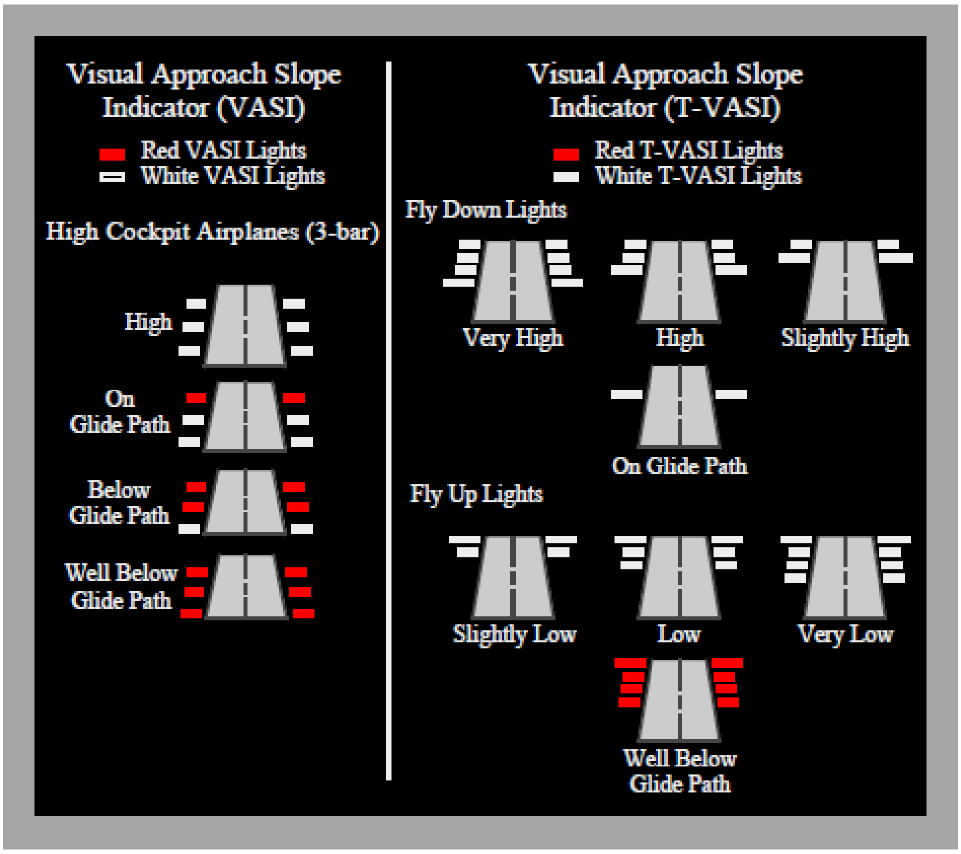
When using a two-bar VASI, the difference between the eye reference path and the gear path results in a low approach with marginal threshold height. Therefore, the two-bar VASI system should not be used to determine proper approach profile. It may provide useful information in alerting the crew to low profile situations.

Some airports have a three-bar VASI which provides two visual glide paths. The additional light bar is located upwind from a standard two-bar installation. When the airplane is on the glide path, the pilot sees the two white bars and one red bar.

Three-bar VASI may be safely used in relation to threshold crossing 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.

11.2.1 Three Bar VASI/T – VASI



11.2.2 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.

Note: The use of a two bar VASI system is not recommended. A two bar VASI system provides a visual aim point that results in main landing gear touchdown at, or very near, the end of the runway threshold.

Two Bar/Three Bar VASI Landing Geometry

The following diagrams use these conditions:

- data is based upon typical landing weight

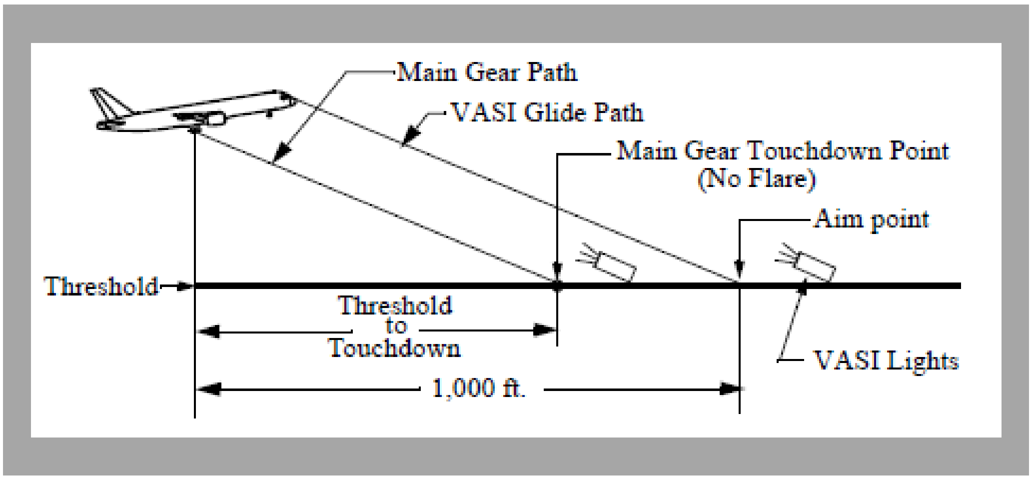
777-200 - 777-300ER

- 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.

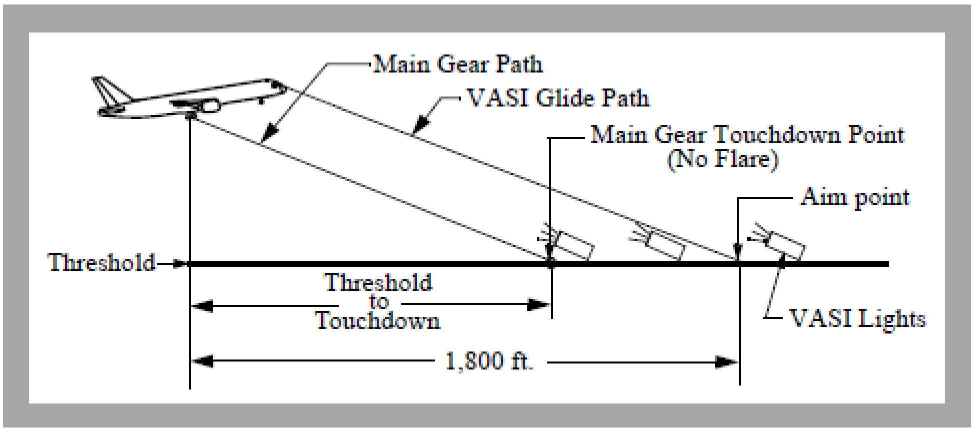
787-8 - 787-10

- airplane body attitudes are based on flaps 30, VREF 30 + 5 knots and should be reduced by ½° for each 5 knots above this speed.
- pilot eye height is measured when the main gear is over the threshold.

Two Bar VASI Landing Geometry



Three Bar (Upper Glide Path) VASI Landing Geometry

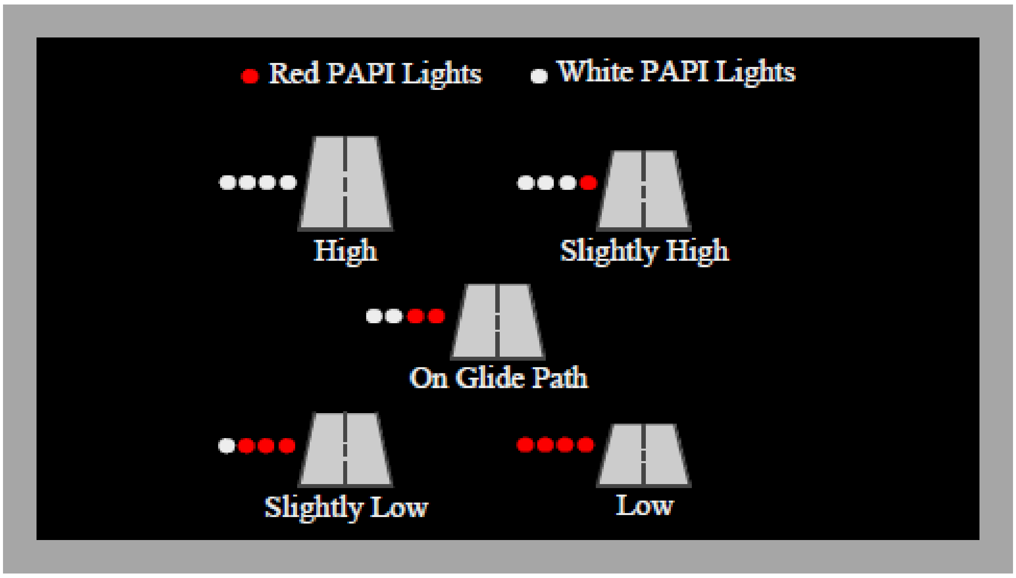


11.3 Precision Approach Path Indicator

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 in relation to threshold crossing 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.

11.3.1 PAPI Landing Geometry



11.4 Landing Geometry

11.4.1 Visual Aim Point

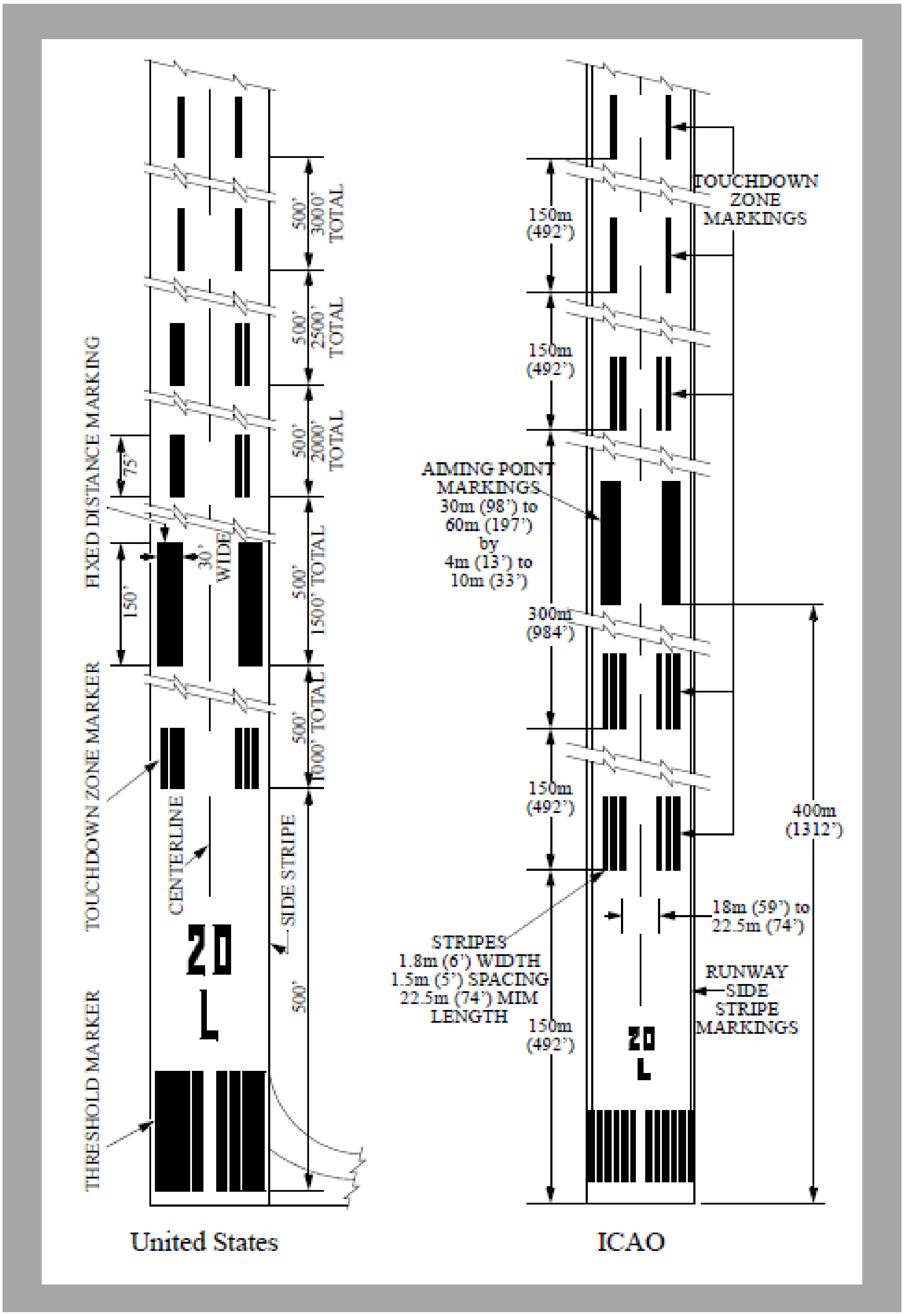
During visual approaches many techniques and methods are used to ensure main landing gear touchdown at the desired point on the runway. One of the most common methods used is to aim at the desired gear touchdown point on the runway, then adjust the final approach glide path until the selected point appears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

In first generation jet transports (e.g. B-707, DC-8), this method is acceptable because of the small difference between landing gear path and eye level path. Flare distance accounts for the small difference in paths. Gear touchdown occurs very near the visual aim point. However, in today's larger airplanes, the difference in gear path and eye-level path has increased because of the longer wheelbase and the increased flight deck height. Consequently, the main gear do not touchdown on the runway at the selected visual aim point.

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.

11.5 Runway Markings (Typical)

The following runway markings are for runways served by a precision approach.



11.6 Threshold Height

Threshold height is a function of glide path angle and landing gear touchdown target. Threshold height for main gear and pilot eye level is shown in the Two Bar/Three Bar VASI Landing Geometry tables on a previous page. Special attention must be given to establishing a final approach that assures safe threshold clearance and gear touchdown at least 1,000 feet down the runway. If automatic callouts are not available, the radio altimeter should be used to assist the pilot in judging terrain clearance, threshold height and flare initiation height.

11.7 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 1 to 2 nm before the threshold, or approximately 300 to 600 feet above field elevation.

When the threshold passes out of sight under the airplane nose 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 to 30 feet above the runway by increasing pitch attitude approximately 2° - 3°. This slows the rate of descent.

If the autothrottle is engaged, the thrust lever begins to reduce toward idle at 25 feet. If the autothrottle is not engaged, 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. 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. 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 tail strike.

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.

11.8 Airspeed Control

If engaged, the autothrottle retards the thrust so as to reach idle at touchdown. The 5 knot additive is bled off during the flare.

If the autothrottle is disconnected, or is planned to be disconnected prior to landing, maintain reference speed plus any wind additive until approaching the flare. Minimum command speed setting is VREF + 5 knots. With proper flare technique and thrust management the 5 knot additive and some of the steady wind additive may be bled off prior to touchdown. Plan to maintain gust correction until touchdown. Touchdown should occur at no less than VREF - 5 knots.

11.9 Landing Flare Profile

The following diagrams use these conditions:

- 3° approach glide path
- flare distance is approximately 1,000 to 2,000 feet beyond the threshold
- typical landing flare times range from 4 to 8 seconds and are a function of approach speed

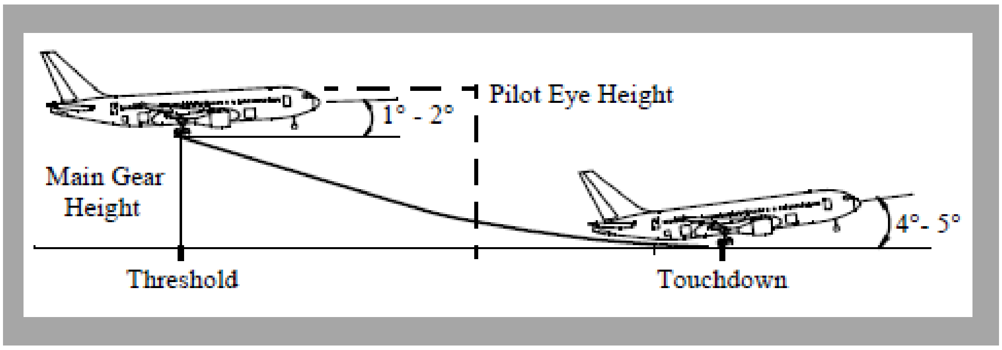
777-200 - 777-300ER

- airplane body attitudes are based upon typical landing weights, flaps 30, VREF 30 + 5 knots (approach) and VREF 30 + 0 (touchdown), and should be reduced by 1° for each 5 knots above this speed

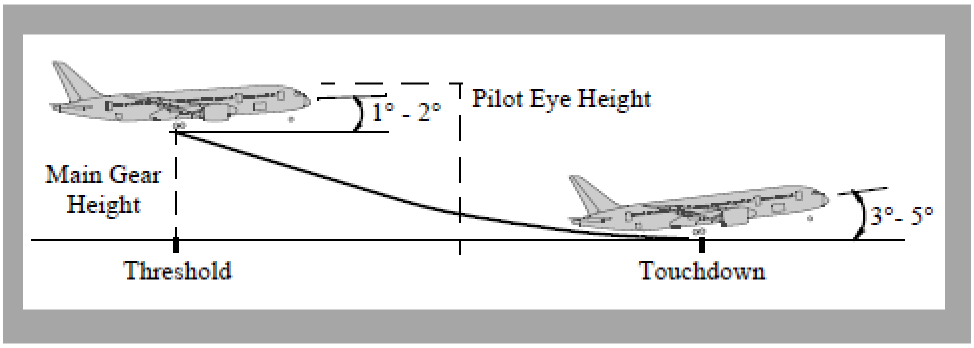
787-8 - 787-10

- airplane body attitudes are based upon typical landing weights, flaps 30, VREF 30 + 5 knots (approach) and VREF 30 + 0 (touchdown), and should be reduced by ½° for each 5 knots above this speed
- threshold height for main gear and pilot eye level is shown in the Two Bar/Three Bar VASI Landing Geometry tables on previous page.

777-200 - 777-300ER



787-8 – 787-10



Note: Approaches at low gross weights can result in pitch attitudes that are lower than normal. This is especially noticeable when VREF is limited for engine out controllability. As a result, the airplane could have a tendency to float unless it is flown onto the runway at the proper touchdown speed.

11.10 Normal Touchdown Attitude

Touchdown Body Attitudes 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 25 and flaps 30. The figures also show that touchdown at a speed below normal touchdown speed, in this case VREF - 10 knots, seriously reduces aft body-runway clearance.

Conditions

- Forward CG limit
- Sea level standard day
- -150 fpm sink rate at touchdown

11.11 Bounced Landing Recovery

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.

If higher than idle thrust is maintained through initial touchdown, the automatic speedbrake deployment may be disabled even when the speedbrakes are armed. This can result in a bounced landing.

If the speedbrakes started to extend on the initial touchdown, they will retract once the airplane becomes airborne again on a bounce, even if thrust is not increased. The speedbrakes must then be manually extended after the airplane returns to the runway.

11.12 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, Go-Around after Touchdown in the FCTM, for more information on this subject.

11.13 Hard Landing

Boeing airplanes are designed to withstand touchdown rates well above typical touchdown rates seen during daily operations. Even a perceived hard landing is usually well below these design criteria. Boeing policy is that a pilot report is the only factor that consistently identifies a hard landing. If the pilot believes that a hard landing may have occurred, it should be reported. A maintenance inspection will determine if further maintenance action is needed.

11.14 Landing Roll

Avoid touching down with thrust above idle since this may establish an airplane nose up pitch tendency and increase landing roll.

After main gear touchdown, initiate the landing roll procedure. Fly the nose wheels smoothly onto the runway without delay. If the speedbrakes do not extend automatically move the speedbrake lever to the UP position 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 a tail strike, do not allow the pitch attitude to increase after touchdown. However, applying excessive nose down elevator during landing can result in substantial forward fuselage damage. Do not use full down elevator. 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.

11.14.1 Speedbrakes

The speedbrakes spoil the lift from the wings, which places the airplane weight on the main landing gear, providing excellent brake effectiveness. If the speedbrakes are not raised after touchdown, braking effectiveness may be reduced initially as much as 60%, since very little weight is on the wheels and brake application may cause rapid antiskid modulation.

The speedbrakes can be fully raised after touchdown while the nose wheels are lowered to the runway with no adverse pitch affects. Normally, speedbrakes are armed to extend automatically. Both pilots should monitor automatic speedbrake extension after touchdown. In the event auto extension fails, the speedbrakes need to be manually extended. After touchdown, fly the nose wheels smoothly to the runway while slowly raising the speedbrake to the up position.

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 speedbrakes during landing and builds good habit patterns which can prevent failure to observe a malfunctioned or disarmed speedbrake system.

11.15 Directional Control and Braking during Landing Roll

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

Use a combination of rudder, differential braking, and control wheel input to maintain runway centerline during strong crosswinds, gusty wind conditions or other situations. Maintain these control input(s) until reaching taxi speeds.

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

11.16 Factors Affecting Landing Distance

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 antiskid braking provides the minimum stopping distance.

Floating above the runway before touchdown must be avoided because it uses a large portion of the available runway. The 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.

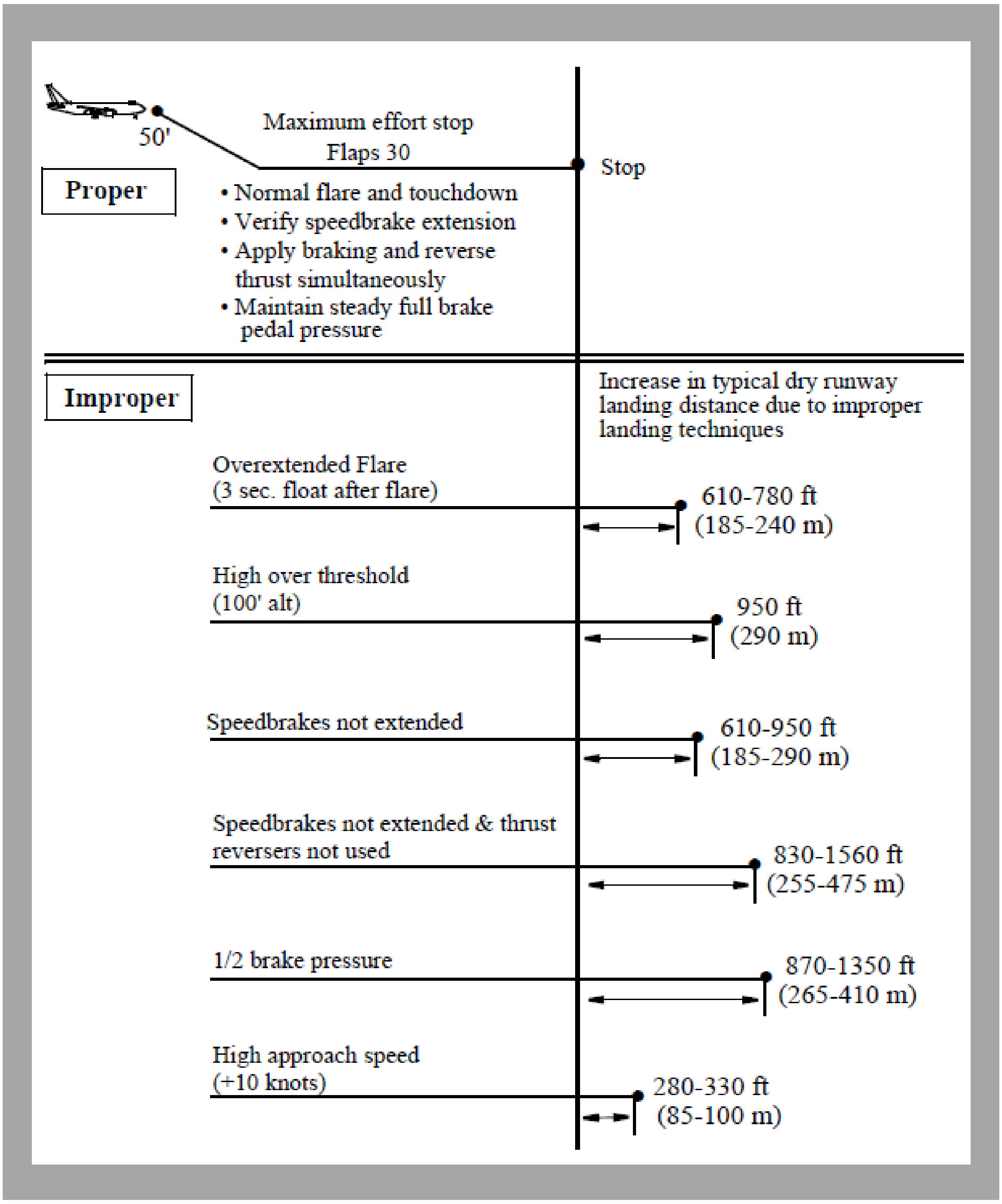
Height of the airplane over the runway threshold also has a significant effect on total landing distance. For example, on a 3° glide path, passing over the runway threshold at 100 feet altitude rather than 50 feet could increase the total landing distance by approximately 950 feet. This is due to the 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.

11.16.1 Factors Affecting Landing Distance (Typical)

The following diagrams 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.

777-200 - 777-300ER



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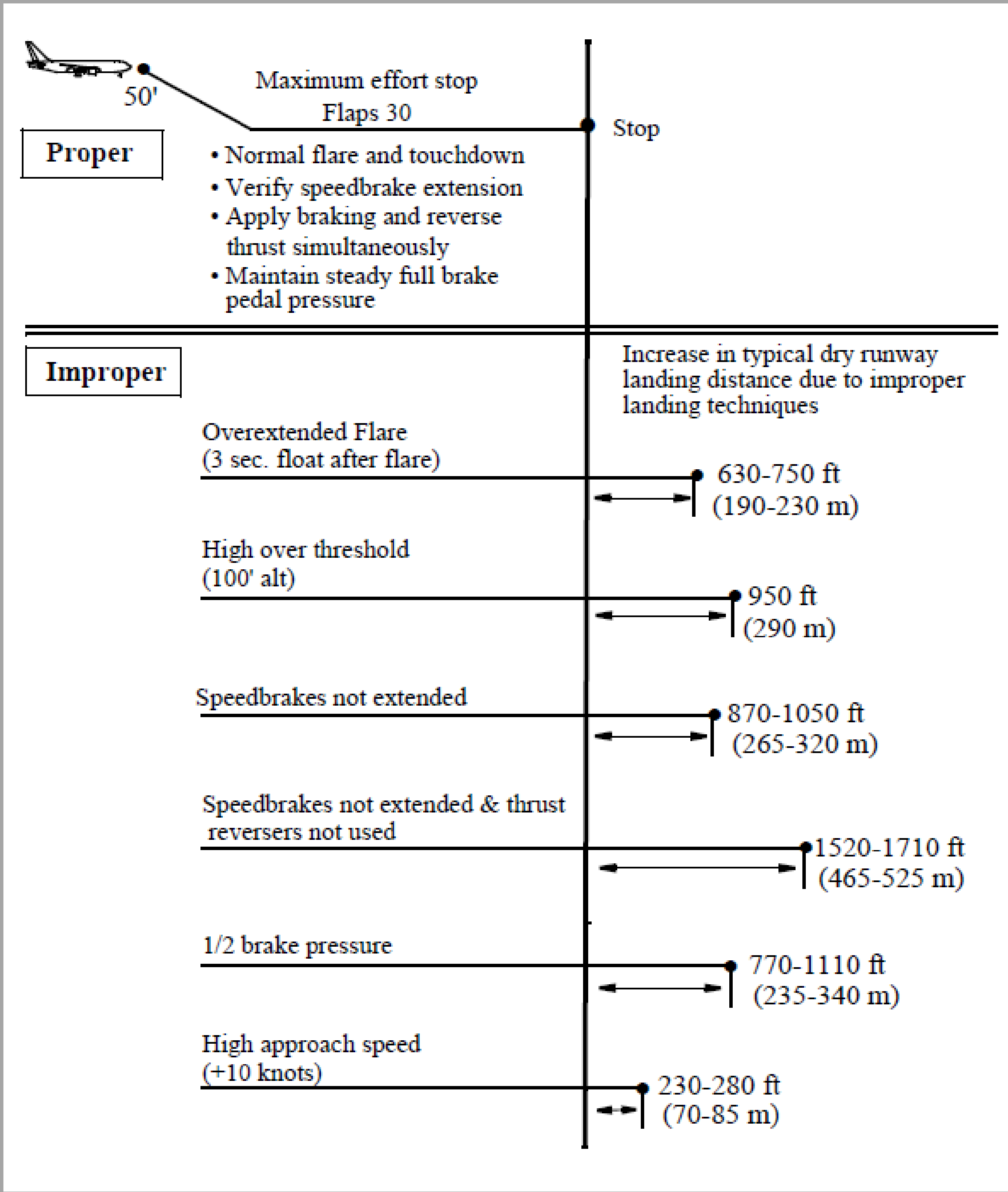

50'
Maximum effort stop
Flaps 30
Stop
Proper
• Normal flare and touchdown
• Verify speedbrake extension
• Apply braking and reverse thrust simultaneously
• Maintain steady full brake pedal pressure
Improper
Increase in typical dry runway landing distance due to improper landing techniques
Overextended Flare (3 sec. float after flare)
630-750 ft (190-230 m)
High over threshold (100' alt)
950 ft (290 m)
Speedbrakes not extended
870-1050 ft (265-320 m)
Speedbrakes not extended & thrust reversers not used
1520-1710 ft (465-525 m)
1/2 brake pressure
770-1110 ft (235-340 m)
High approach speed (+10 knots)
230-280 ft (70-85 m)

11.17 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).

11.17.1 Automatic Brakes

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

Settings include:

- MAX AUTO: Used when minimum stopping distance is required. Deceleration rate is less than that produced by full manual braking
- 3 or 4: Should be used for wet or slippery runways or when landing rollout distance is limited
- 1 or 2: These settings provide a moderate deceleration 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.

11.17.2 Transition to Manual Braking

The speed at which the transition from autobrakes to manual braking is made depends on 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:

- 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).

11.17.3 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 degrades braking effectiveness. Maintain steadily increasing brake pressure, allowing the antiskid system to function at its optimum capability.

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, as compared to the calculated PI-QRH landing distance which allows for a two second delay. 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.

11.17.4 Braking with Antiskid Inoperative

When the antiskid system is inoperative, the NNC provides the following guidance:

- ensure that the nose wheels are 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
- use minimum braking consistent with runway length and conditions to reduce the possibility of tire blowout
- do not pump the brakes - 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.

When the antiskid 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.

Antiskid-off braking requires even greater care during lightweight landings.

11.17.5 Carbon Brake Life

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

For normal landing conditions, autobrakes 2 or 3 optimizes brake wear, passenger comfort, and stopping performance. Autobrakes 2 or 3 results in higher brake surface temperature and shorter stopping distances, which can increase carbon brake life.

During landing, one hard, high energy, long-duration brake application produces the same amount of wear as a light, low-energy, short application. This is different from steel brakes that wear as a function of the energy input during the stop.

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

11.17.6 Brake Cooling

A series of taxi-back or stop and go landings without additional in-flight brake cooling can cause excessive brake temperatures. The energy absorbed by the brakes from each landing is cumulative.

Extending the gear a few minutes early in the approach normally provides sufficient cooling for a landing.

The brake temperature monitoring system may be used for additional flight crew guidance in assessing brake energy absorption. This system indicates a stabilized value approximately fifteen minutes after brake energy absorption. Therefore, an immediate or reliable indication of tire or hydraulic fluid fire, wheel bearing problems, or wheel fracture is not available. The brake temperature monitor readings may vary between brakes during normal braking operations.

11.17.7 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:

- do the overweight landing checklist (as needed)
- 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
- use autothrottles to avoid having to use a wind additive in excess of VREF + 5 knots
- ensure all of the headwind additive is bled off before touchdown to avoid landing with excessive airspeed
- use a normal gear touchdown aim point
- do not allow the 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 wheel 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.

11.18 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 apply reverse thrust as required. 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.

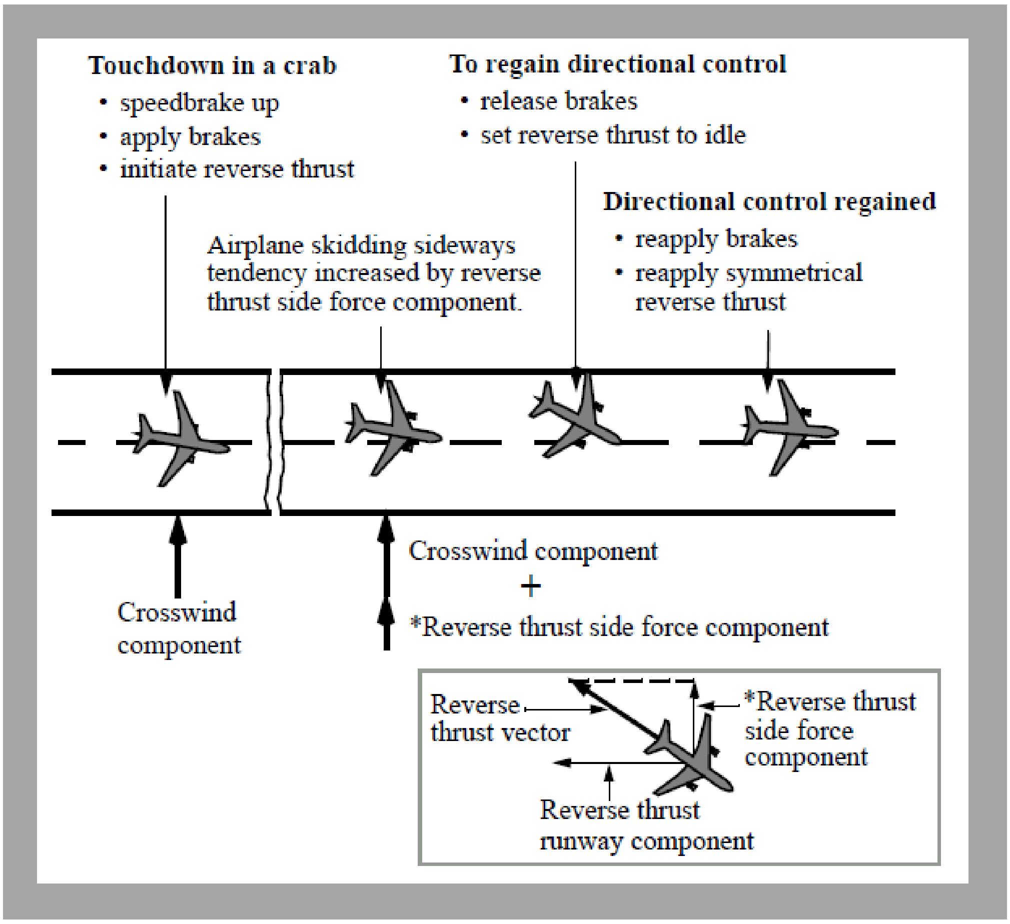
Maintain reverse thrust as required, up to maximum, until stopping on the remaining runway is assured.

When stopping is assured and the airspeed approaches 60 KIAS 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 reverse 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 KIAS 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.

11.18.1 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.

11.18.2 Reverse Thrust - EEC in the Alternate Mode

Use normal reverse thrust techniques.

11.18.3 Reverse Thrust - Engine Inoperative

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

777-200 - 777-300ER

Note: TAC does not operate during reverse thrust operation.

11.19 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.

11.19.1 Landing Crosswind Guidelines

Crosswind guidelines are not considered limitations. Appendix contains the British Airways Virtual crosswind policy.

On slippery runways, crosswind guidelines are a function of runway surface condition. These guidelines assume adverse airplane loading and proper pilot technique.

11.19.2 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.

11.19.3 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.

11.19.4 Touchdown In Crab

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.

11.19.5 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.

11.20 Overweight Landing

Accomplish the Overweight Landing NNC.

777-200 - 777-300ER

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 20, 25, or 30 landings at all gross weights. Brake energy limits will not be exceeded under any normal or non-normal landing conditions.

787-8 - 787-10

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 20, 25 landings at all gross weights. Brake energy limits will not be exceeded under any normal or non-normal landing conditions.

777-200 - 777-300ER

The Overweight Landing NNC includes a check of landing weight against the landing climb limit weight. Guidance is provided to use flaps 20 for landing when the landing weight is greater than the landing climb limited weight or one engine is inoperative. If the landing weight is less than the landing climb limited weight but above the maximum landing weight and both engines are operative, an additional landing approach speed check must be made. This landing approach speed check is required to ensure that there is at least a 10 knot margin between the flaps 30 landing approach speed (VREF 30 plus additives for wind and gusts) and the flaps 30 placard speed. If a 10 knot margin exists, then flaps 30 is the recommended landing flap. However, if a 10 knot margin does not exist, then flaps 25 is the recommended landing flap and VREF 25 plus additives for wind and gusts is the recommended landing approach speed. Refer to the Overweight Landing NNC for the actual landing approach speed limits.

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The Overweight Landing NNC includes a check of landing weight against the landing climb limit weight. Guidance is provided to use flaps 20 for landing when the landing weight is greater than the landing climb limited weight or one engine is inoperative. If the landing weight is less than or equal to the landing climb limited weight but above the maximum landing weight and both engines are operative, then flaps 25 is the recommended landing flap and VREF 25 plus additives for wind and gusts is the recommended landing approach speed. Refer to the Overweight Landing NNC for the actual landing approach speed limits.

787-8

If flaps 25 is used as the landing flap, the maximum amount of additives for wind and gusts should be limited such that a maximum approach speed of 175 knots is not exceeded. This ensures that a 5 knot margin to the flaps 25 placard speed is maintained.

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If flaps 25 is used as the landing flap, the maximum amount of additives for wind and gusts should be limited such that a maximum approach speed of 185 knots is not exceeded. This ensures that a 5 knot margin to the flaps 25 placard speed is maintained.

If stopping distance is a concern, reduce the landing weight as much as possible.At the captain’s discretion, consider fuel jettison or reduce weight by holding at low altitude with a high drag configuration (gear down) to achieve maximum fuel burn-off.

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 maneuver 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 additive 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 stopping distance guidance is contained in the PI chapter of the QRH. If adequate stopping distance is available based upon approach speed, runway conditions, and runway length, the recommended autobrake setting should be used.

11.20.1 Overweight Autolands Policy

Overweight autolands are not recommended. Autopilots on Boeing airplanes are not certified for automatic landings above maximum landing weight. At higher than normal speeds and weights, the performance of these systems may not be satisfactory and has not been thoroughly tested. An automatic approach may be attempted, however the pilot should disengage the autopilot prior to flare height and accomplish a manual landing.

In an emergency, should the pilot determine that an overweight autoland is the safest course of action, the approach and landing should be closely monitored by the pilot and the following factors considered:

- touchdown may be beyond the normal touchdown zone; allow for additional landing distance
- touchdown at higher than normal sink rates may result in exceeding structural limits
- plan for a go-around or manual landing if autoland performance is unsatisfactory; automatic go-arounds can be initiated until just prior to touchdown, and can be continued even if the airplane touches down after initiation of the go-around.

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12 Maneuvers

12.1 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, 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.

12.2 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 time and distance traveled from when 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.

12.3 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.

Note: Stick shaker is close to initial buffet for all weights and altitudes. Stick shaker activation may occur if the airplane is maneuvered beyond buffet.

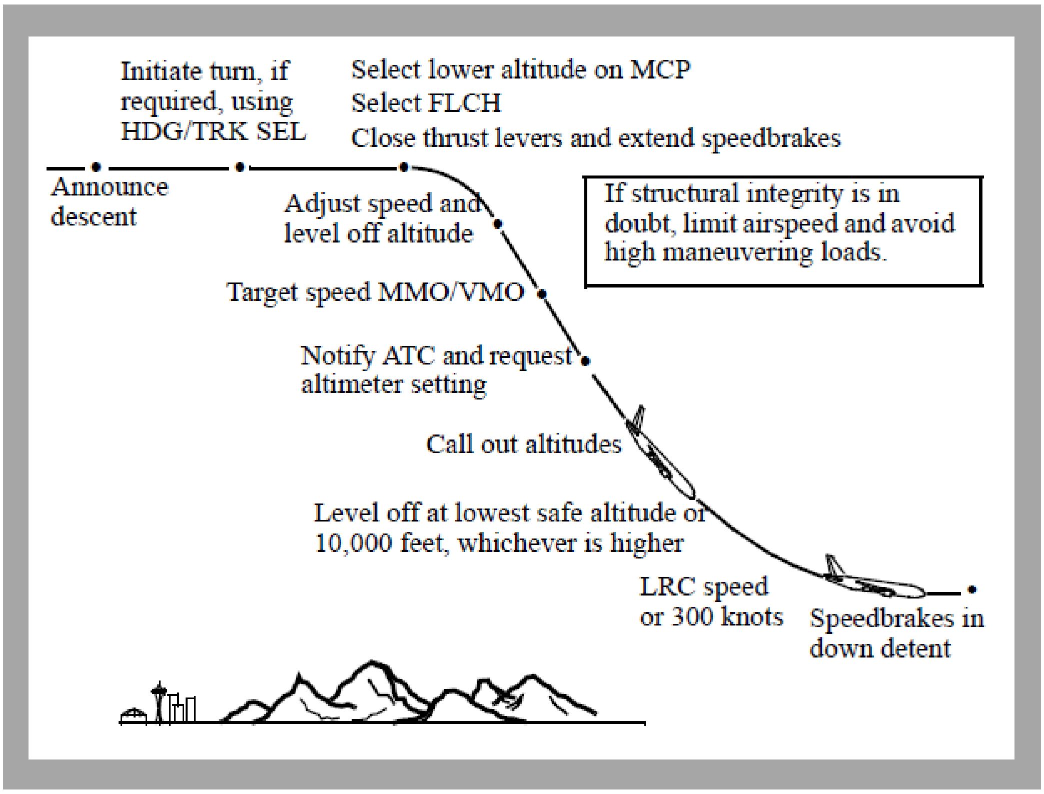
Establish an airspeed of 0.81M to 0.84M. Induce “g” buffet by smoothly increasing the bank angle until the buffet is noticeable. Increase the rate of descent while increasing the bank angle to maintain airspeed. Do not exceed 30° of bank. If buffet does not occur by 30° of bank, increase control column 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.

12.4 Rapid Descent

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.

This maneuver is designed to bring the airplane down smoothly to a safe altitude, in the minimum time, with the least possible passenger discomfort.

Note: Use of the autopilot is recommended.



If the descent is performed because of a rapid loss of cabin pressure, crewmembers should place oxygen masks on and establish communication at the first indication of a loss of cabin pressurization. Verify cabin pressure is uncontrollable, and if so begin descent. If structural damage exists or is suspected, limit airspeed to current speed or less. Avoid high maneuvering loads.

Perform the maneuver 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 10,000 feet, whichever is higher. Lowest safe altitude is the Minimum Enroute Altitude (MEA), Minimum Off Route Altitude (MORA), or any other altitude based on terrain clearance, navigation aid reception, or other appropriate criteria.

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

12.4.1 Autopilot Entry and Level Off

Flight Level Change (FLCH)

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

Initiate a turn, if required, using HDG/TRK SEL. Set a lower altitude in the altitude window. Select FLCH, close the thrust levers and smoothly extend the speedbrakes. If turn radius is a factor, the pilot should manually select the desired bank angle required to complete the maneuver in a safe manner. Autothrottles should be left engaged. The airplane pitches down smoothly while the thrust levers retard to idle. Adjust the speed as needed 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 310 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 disengage 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”.

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.

12.4.2 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.

12.4.3 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.

12.4.4 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.

12.5 Approach to Stall or Stall

Stall Recovery A stall in the 777 or 787 airplane is a highly improbable event due to alerting and envelope protection. The following guidance is provided to familiarize the flight crew with recovery techniques in the event the airplane is mishandled, or experiences an upset, to the point where recovery is needed. This guidance is not intended as a description of a training scenario. Operators should consult with their regulators to establish the extent to which approach to stall and stall recovery training is necessary.

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 of attack to complete a positive and efficient recovery.

The first indication of an impending stall is the AIRSPEED LOW EICAS message.

A stall warning should be readily identifiable by the pilot, either by an artificial indication (stick shaker) or natural indication (initial buffet). During the initial stages of a stall, local airflow separation results in buffeting, giving a natural warning of an approach to stall. Stick shaker operation will usually precede initial buffet as a stall warning indication. In some cases, near cruise altitude and cruise Mach, stick shaker may be simultaneous with initial buffet. Recovery from an approach to stall should be initiated at the earliest recognizable stall warning, either AIRSPEED LOW EICAS message, stick shaker or initial buffet.

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
  - artificial (stick shaker)
  - natural (buffet which could be heavy at times) or
- buffeting, which could be heavy
- lack of pitch authority
- lack of roll control
- inability to arrest descent rate.

12.5.1 Approach to Stall or Stall Recovery

Envelope protection features within the AFDS and flight control systems reduce the likelihood of inadvertently exceeding the wing stalling angle of attack. However, even though the autopilot and autothrottle are operating correctly, the airplane could fly into a condition where an approach to stall is momentarily experienced. The AFDS is designed to recover the airplane from this condition. The Approach to Stall or Stall Recovery maneuver calls for the crew to disengage the autopilot and autothrottle if the response is not acceptable. The following indications are examples of unacceptable performance:

- an approach to a stall is encountered and in the pilot's judgment the AFDS is not responding correctly or rapidly enough
- the airplane enters a fully developed stall
- the airplane enters an upset condition.

Note: If the crew disengages the autopilot and autothrottle when the airplane is in an approach to stall or stall condition, the entire Approach to Stall

Recovery or Stall Recovery maneuver as described in the QRH should be completed.

To initiate the recovery, the angle of attack must be reduced below the wing stalling angle of attack. Smoothly apply nose down elevator to reduce the angle of attack until the wings are unstalled (buffet or stick shaker stops). Application of forward column pressure (as much as full forward may be required) should provide sufficient elevator control to produce a nose-down pitch rate.

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.

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 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.

12.5.2 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 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.

12.6 Terrain Avoidance

The Ground Proximity Warning System (GPWS) PULL UP Warning occurs when an unsafe distance or closure rate is detected with terrain below the airplane. The Look-ahead terrain alerting (as installed) also provides an aural warning when an unsafe distance is detected from terrain ahead of the airplane. Immediately accomplish the Terrain Avoidance maneuver found in the non-normal maneuvers section in the QRH.

Do not attempt to engage the autopilot and/or autothrottle until terrain clearance is assured.

12.6.1 Terrain Avoidance - RNAV (RNP) AR Operations

WARNING: Procedure not authorized for British Airways Virtual’s 777 fleet.

787-8 – 787-10

During RNAV (RNP) AR operations in close proximity to terrain on departure or approach, crews may experience occasional momentary terrain caution-level alerts. If these alerts are of short duration and have ceased, crews should verify they are on the required path and consider continuing the procedure using LNAV and VNAV. Depending upon where initiation occurs, the risks of terrain contact while executing a terrain avoidance maneuver may be higher than continuing on the required track.

Terrain warning-level alerts always require immediate action. The most appropriate crew actions regarding airplane bank angle and track during a terrain avoidance maneuver depend on where the maneuver is initiated. Operators should determine the most appropriate course of action for each leg of the procedure, if necessary, so crews are prepared to react correctly at all times.

12.7 Traffic Alert and Collision Avoidance System

Traffic Alert and Collision Avoidance System The Traffic Alert and Collision Avoidance System (TCAS) is designed to enhance crew awareness of nearby traffic and issue advisories for timely visual acquisition or appropriate vertical flight path maneuvers to avoid potential collisions. It is intended as a backup to visual collision avoidance, application of right-of-way rules and ATC separation.

12.7.1 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.

12.7.2 Traffic Advisory

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.

12.7.3 Resolution Advisory

When TCAS determines that separation from approaching traffic may not be sufficient, TCAS issues a Resolution Advisory (RA) aural warning and a pitch command. Maneuvering is required if any portion of the airplane symbol is within the red region on the attitude indicator. Flight crews should follow RA commands using established procedures unless doing so would jeopardize the safe operation of the airplane. If an 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 (e.g. waypoints). This is especially true in RVSM airspace. Climb or descent profiles should not be modified in anticipation of avoiding an RA unless specifically requested by ATC.

RA maneuvers require only small pitch attitude changes which should be accomplished smoothly and without delay. Properly executed, the RA maneuver is mild and does not require large or abrupt control movements. Remember that the passengers and flight attendants may not all be seated during this maneuver. The flight director is not affected by TCAS guidance. Therefore, when complying with an RA, flight director commands may be followed only if they result in a vertical speed that satisfies the RA command.

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 take priority 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.

12.7.4 HUD Advisories

787-8 - 787-10

TCAS RAs alert the pilot of traffic conflicts by displaying preventive and corrective advisory symbols on the HUD. These advisories indicate that corrective action is required (corrective advisory) or that a potential threat exists (preventive advisory). Corrective advisories require the pilot to take positive evasive action to position the flight path vector so it satisfies the command for vertical separation. Preventive advisories do not require any immediate evasive action to be taken by the pilot, but indicate an unsafe zone. The pilot should keep the flight path vector clear of the unsafe zone.

At times there may be a situation where traffic is both above and below the airplane. In these cases, both corrective and preventive advisories may be displayed.

12.8 Windshear

12.8.1 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.

12.8.2 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.

12.8.3 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 the FCOM.

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13 Non-Normal Operations

13.1 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. 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.

13.2 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 EICAS messages 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 then diversion to the nearest airport where a safe landing can be accomplished is required. If the NNC or the Checklist Instructions do not direct landing at the nearest suitable airport, the pilot must determine if continued flight to destination may compromise safety.

13.2.1 Troubleshooting

Troubleshooting can be defined as:

- taking steps beyond a published NNC in an effort to improve or correct a non-normal condition
- initiating an annunciated checklist without an EICAS alert message 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.

Note: Flight crew entry into an electronics compartment in flight is not recommended.

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.

13.2.2 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 and speedbrakes unless precluded by the NNC.

Note: The use of autobrakes is recommended because maximum autobraking may be more effective than maximum manual braking due to timely application upon touchdown and symmetrical braking.

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.

13.2.3 Landing at the Nearest Suitable Airport

“Plan to land at the nearest suitable airport” is a phrase used in the QRH. This section explains the basis for that statement and how it is applied.

In a non-normal situation, the pilot-in-command, having the authority and responsibility for operation and safety of the flight, must make the decision to continue the flight as planned or divert. In an emergency situation, this authority may include necessary deviations from any regulation to meet the emergency. In all cases, the pilot-in-command is expected to take a safe course of action.

The 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 should 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 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.

13.3 Engines, APU

13.3.1 Engine Oil System Indications

Oil pressure is considered as the most significant of several oil system indicators. Oil temperature, oil quantity and oil pressure indications enable the flight crew to recognize a deteriorating oil system. While engine operation is governed by both oil pressure and oil temperature limits, there is no minimum oil quantity limit. Therefore, there is no low oil quantity NNC.

If abnormal oil quantity indications are observed, check oil pressure and oil temperature. If oil pressure and oil temperature indications are normal, operate the engine normally. Accomplish the appropriate NNC for any non-normal oil pressure or oil temperature EICAS messages.

13.3.2 Engine Failure versus 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. Reference items should be accomplished on a non-interfering basis with other normal duties after the flaps have been retracted and conditions permit.

13.3.3 Loss of Engine Thrust Control

777-200 - 777-300ER

All turbo fan engines are susceptible to this malfunction whether engine control is hydro-mechanical, hydro-mechanical with supervisory electronics (e.g. PMC) or Full Authority Digital Engine Control (FADEC). Engine response to a loss of control varies from engine to engine. Malfunctions have occurred in-flight and on the ground. The major challenge the flight crew faces when responding to this malfunction is recognizing the condition and determining which engine has malfunctioned. The Engine Limit or Surge or Stall NNC is written to include this malfunction.This condition can occur during any phase of flight.

787-8 - 787-10

All turbo fan engines, including those with Full Authority Digital Engine Control (FADEC), are susceptible to this malfunction. The major challenge the flight crew faces when responding to this malfunction is recognizing the condition and determining which engine has malfunctioned. The thrust control system has been designed to cover the case of an engine not responding to thrust lever movement. This condition can occur during any phase of flight.

777-200 - 777-300ER

Failure of engine or fuel control system components or loss of thrust lever position feedback has caused loss of engine thrust control. Control loss may not be immediately evident since many engines fail to some fixed RPM or thrust lever condition. This fixed RPM or thrust lever condition may be very near the commanded thrust level and therefore difficult to recognize until the flight crew attempts to change thrust with the thrust lever. Other engine responses include: shutdown, operation at low RPM, or thrust at the last valid thrust lever setting (in the case of a thrust lever feedback fault) depending on altitude or air/ground logic. In all cases, the affected engine does not respond to thrust lever movement or the response is abnormal.

787-8 - 787-10

Failure of engine or fuel control system components or loss of thrust lever position feedback can cause loss of engine thrust control. Control loss may not be immediately evident since an engine may fail to some fixed RPM. This fixed RPM 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: engine flameout, surge, or operation at idle. In all cases, the affected engine does not respond to thrust lever movement.

Since recognition may be difficult, if a loss of engine control is suspected, the flight crew should continue the takeoff or remain airborne until the NNC can be accomplished. This helps with directional control and may preclude an inadvertent shutdown of the wrong engine. In some conditions, such as during low speed ground operations, immediate engine shutdown may be necessary to maintain directional control.

13.3.4 Recommended Technique for an In-Flight Engine Shutdown

Any time an engine shutdown is needed 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 affected engine and ensures that the operating engine is not shut down. Do not rush through the shutdown checklist, even for a fire indication.

Coordinate activation of the fuel control switch as follows:

- PM places a hand on and verbally identifies the fuel control switch for the engine that will be shutdown
- PF verbally confirms that the PM has identified the correct fuel control switch
- PM moves the fuel control switch 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.

13.3.5 Bird Strikes

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.

13.3.6 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.

13.3.7 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 extract 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.

13.3.8 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.

13.4 Flight Controls

13.4.1 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.

777-200 - 777-300ER

Note: When leading edge devices or trailing edge flaps are not in the proper position for flaps 20 or 30, autolands are not certified.

787-8 - 787-10

Note: When leading edge devices or trailing edge flaps are not in the proper position for flaps 20, 25, or 30, autolands are not certified.

13.4.2 Flaps and Slats Up Landing

777-200 - 777-300ER

The probability of both leading and trailing edge devices failing to extend is extremely remote. System reliability and design have reduced the need for some traditional non-normal landing procedures. As a result, an all flaps up landing NNC was not required for airplane certification and does not appear in the AFM or QRH.

787-8 - 787-10

The probability of both leading and trailing edge devices failing to extend is extremely remote. Training and evaluating to this condition is not required. A Flaps + Slats Fail NNC has been developed for this condition. If a flaps up and slats up landing situation were to be encountered in service, the pilot should consider the following techniques.

787-8 - 787-10

After selecting a suitable landing airfield and prior to beginning the approach, consider reduction of airplane gross weight (burn off fuel or fuel jettison) to reduce touchdown speed.

787-8 - 787-10

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

787-8 - 787-10

Use an ILS or GLS 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 final approach speed and maintain this speed until the landing is assured.

The final approach speed may be in the amber band which will require setting the autothrottle system to OFF to avoid autothrottle automatic activation. In the event of a go-around, pilots should be prepared to manually set go-around thrust.

The rate of descent on final approach is approximately 1,000 fpm due to the higher ground speed. Final approach body attitude is approximately 4° higher than normal. Do not make a flat approach (shallow glide path angle) or aim for the threshold of the runway. This may result in main gear touching down short of the runway. Use an aim point approximately 1,800 feet down the runway.

Note: Use of the autopilot during approach phase is acceptable. Do not autoland. Speedbrakes are not recommended for airspeed reduction below 800 feet. If landing is anticipated beyond the normal touch down zone, go around.

Landing

787-8 - 787-10

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. Immediate initiation of reverse thrust at main gear touchdown (reverse thrust is more effective at high speeds) and full reverse thrust allows the autobrake system to reduce brake pressure to the minimum level. Full reverse thrust is needed for a longer period of time. Less than maximum reverse thrust increases brake energy requirements and may result in excessive brake temperatures.

Use of autobrakes is recommended. Autobrake setting should be consistent with runway length. Use manual braking if deceleration is not suitable for the desired stopping distance.

13.4.3 Slats Drive Failure (Leading Edge) - Landing

Failure of the primary hydraulic drive for the leading edge slats causes the slats to automatically revert to the secondary mode (electric drive). The EICAS message SLATS PRIMARY FAIL is displayed. If the slats fail to respond in the electric drive mode or an asymmetry exists, the EICAS message SLATS DRIVE is displayed. The SLATS DRIVE NNC accommodates the most severe malfunction of no leading edge slats on one wing.

Flaps 1 position on the flap indicator is for leading edge devices. When flaps are extended to 1 and the leading edge devices fail to extend, the flap display expands.

The flap indicator shows no trailing edge flap movement. Flap extension is limited to flaps 20 if slats are not fully extended.

13.4.4 Flap Drive Failure (Trailing Edge) - Landing

Failure of the primary hydraulic drive for the trailing edge flaps causes the flaps to automatically revert to the secondary mode (electric drive). The EICAS message FLAPS PRIMARY FAIL is displayed. If the flaps fail to respond in the electric drive mode or an asymmetry exists, the EICAS message FLAPS DRIVE is displayed. Accomplish the FLAPS DRIVE NNC. The inboard and outboard TE Flaps move as a single group. Flap load relief is not available in secondary mode of operation.

The VREF listed in the FLAPS DRIVE NNC allows normal maneuvering throughout the initial phases of the approach. On final, maintain VREF plus wind additive. If speed is allowed to decrease to VREF, 40° bank capability is not available.

The pitch attitude on final is several degrees higher than for normal configuration.

Do not allow the airspeed to go below VREF during the flare or the tail of the airplane may contact the runway. Do not allow the airplane to “float” just above the runway surface. Fly the airplane onto the runway at the recommended touchdown point. Expeditiously accomplish the landing roll procedure after touchdown.

13.4.5 Flap Extension using the Secondary or Alternate System

When extending the flaps using the secondary or 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 secondary or 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.

13.5 Flight Instruments, Displays

13.5.1 Display Failure

Display Units and HUDs can fail and cause the blanking of a display. Depending on the mode of failure, the duration of the display blanking can range from less than a second to up to the duration of the flight.

If a Display Unit or HUD blanks, pilots should immediately seek information from other displays. The display system typically will automatically reconfigure to maximize the display of information to the Pilots. If there is an undetected Display Unit failure, the pilots can manually reconfigure the system using the PFD/MFD source selector.

In the unlikely event of a simultaneous failure of all displays, the pilots should accomplish the Loss of All Displays NNC. While accomplishing this NNC, the ISFD, which is totally independent, provides the primary flight display information.

13.5.2 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.

777-200 - 777-300ER

If abnormal airspeed is recognized, immediately set the target pitch attitude and thrust setting for the aircraft configuration from the Airspeed Unreliable memory items. 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.

787-8 - 787-10

If abnormal airspeed is recognized, immediately set the target pitch attitude and thrust setting for the aircraft configuration from the AIRSPEED UNRELIABLE memory items. 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 thrust 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.

777-200 - 777-300ER

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 needed, then recheck thrust and pitch, and trim as needed. Do not change configuration until the airplane is trimmed and stabilized at the current configuration.

Flap load relief can prevent the flaps from extending or remaining at the desired flap setting for landing. The flap load relief function uses indicated airspeed, which may be unreliable. The Airspeed Unreliable checklist procedures configure the airplane as necessary by using alternate flaps if needed to prevent unwanted flap load relief.

Unreliable airspeed may cause noticeable effects in the normal speed stability of the airplane since the normal pitch control law uses indicated airspeed. If the indicated airspeed falls below 50 knots, the flight control system changes to the secondary mode, which does not depend on airspeed.

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. These indications can be used as a crosscheck. Many air traffic control radars can also measure ground speed.

777-200 - 777-300ER

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 tables. At 2,000 feet above the selected level off altitude, reduce rate of descent to 1,000 FPM. On reaching the selected altitude, establish attitude and thrust for the airplane configuration. If possible, allow the airplane to stabilize before changing configuration and altitude.

Approach

777-200 - 777-300ER

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.

787-8 - 787-10

If available, accomplish an ILS or GLS 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.

Go-Around or Missed Approach - Airspeed Unreliable

Prior to Approach

777-200 - 777-300ER

If an airspeed unreliable event occurs prior to the approach and a valid airspeed indicator is not available, ensure completion of the Airspeed Unreliable NNC and refer to the QRH-PI tables for appropriate pitch and thrust settings for all phases of flight. If a go-around or missed approach is necessary, do not push TO/GA. Execute a go-around using go-around thrust and pitch values from the QRH-PI tables. Upon reaching a safe altitude set the target pitch attitude and thrust settings from the QRH-PI table for the current airplane configuration and phase of flight.

787-8 - 787-10

If an airspeed unreliable event occurs prior to the approach and a valid airspeed indicator is not available, ensure completion of the AIRSPEED UNRELIABLE NNC and refer to the QRH-PI tables for appropriate pitch and thrust settings for all phases of flight. If a go-around or missed approach is necessary, do not push TO/GA. Execute a go-around using go-around thrust and pitch values from the QRH-PI tables. Upon reaching a safe altitude set the target pitch attitude and thrust settings from the QRH-PI table for the current airplane configuration and phase of flight.

On Approach

777-200 - 777-300ER

If an airspeed unreliable event occurs during approach, and a go-around or missed approach is necessary, do not push TO/GA. Disengage the autopilot and disconnect autothrottle, execute a go-around using go-around thrust and 15° pitch attitude. Upon reaching a safe altitude set the target pitch attitude and thrust settings from the Airspeed Unreliable NNC and accomplish the checklist.

787-8 - 787-10

If an airspeed unreliable event occurs during approach, and a go-around or missed approach is necessary, do not push TO/GA. Disengage the autopilot and disconnect autothrottle, execute a go-around using go-around thrust and 15° pitch attitude. Upon reaching a safe altitude set the target pitch attitude and thrust settings from the AIRSPEED UNRELIABLE NNC and accomplish the checklist.

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)
777	10	85	4	70
787	10	85	4	70

13.6 Fuel

13.6.1 Fuel Balance

The primary purpose of 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 primary purpose for fuel balance alerts is to inform the crew that imbalances beyond the current state may result in increased trim drag and higher fuel consumption. The FUEL IMBALANCE NNC should be accomplished when a fuel balance alert is received.

There is a common misconception among flight crews that the fuel crossfeed valve should be opened immediately after an in-flight engine shutdown to prevent fuel imbalance. This practice is contrary to 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 IMBALANCE NNC 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.).

13.6.2 Fuel Leak

Any time an unexpected fuel quantity indication, FMC or EICAS fuel message, or imbalance condition is experienced, a fuel leak should be considered as a possible cause. Maintaining a fuel log and comparing actual fuel burn to the flight plan fuel burn can help the pilot recognize a fuel leak.

787-8 - 787-10

Significant fuel leaks, although fairly rare, are difficult to detect. The Fuel Leak NNC includes steps for a leak that is between the front spar and the engine (an “engine fuel leak”) or a leak from the tank to the outside (a “tank leak”). An engine fuel leak is the most common type of fuel leak since fuel lines are exposed in the strut. Most other fuel lines, such as a crossfeed manifold, are contained within the tanks. A significant fuel leak directly from a tank to the outside is very rare due to the substantial wing structure that forms the tanks.

777-200 - 777-300ER

Significant fuel leaks, although fairly rare, are difficult to detect. The Fuel Leak NNC includes steps for a leak that is between the front spar and the engine (an “engine fuel leak”) or a leak from the tank to the outside (a “tank leak”). The NNC for the 777-200 non-ER airplane includes steps for a leak into the center wing dry bay area. An engine fuel leak is the most common type of fuel leak since fuel lines are exposed in the strut. Most other fuel lines, such as a crossfeed manifold, are contained within the tanks. A significant fuel leak directly from a tank to the outside is very rare due to the substantial wing structure that forms the tanks.

There is no specific fuel leak annunciation on the flight deck. A fuel leak must be detected by changes or discrepancies in expected fuel consumption, or by some annunciation that occurs because of a fuel leak. Any unexpected and sustained change in fuel quantity or fuel balance should alert the crew to the possibility of a fuel leak.

Some fuel-related checklists (for example, FUEL IMBALANCE) list reasons that a fuel leak should be suspected. This list is not exhaustive and, in all cases the flight crew should use there knowledge of the fuel system and current operating conditions to determine whether a fuel leak should be suspected. Some reasons are:

- The total fuel remaining on EICAS is less than the planned fuel remaining. The total fuel can be less than planned fuel for a number of reasons, such as a fuel leak, unforecast headwinds, fuel sloshing (such as from high angles of pitch). Sloshing fuel would be a temporary effect. Flight crews should consider these when deciding whether or not to suspect a fuel leak.
- An engine has excessive fuel flow. A faulty fuel flow meter or an engine fuel leak downstream of the fuel flow meter will cause an excessive fuel flow indication. Total fuel remaining compared to planned fuel remaining should be considered when deciding whether or not to suspect a fuel leak.
- One main tank is abnormally low compared to the other main tanks and the expected fuel remaining in the tanks. One tank indicating abnormally low can be caused by a fuel leak, engine out or a crossfeed problem. With an engine out, if the totalizer and calculated values are tracking as expected, a fuel leak would not be suspected. A fuel pump with higher pressure and a faulty crossfeed valve can cause one tank to provide fuel to more than one engine, causing one tank to indicate low. In this case,

the fact that total fuel should still match planned fuel, a fuel leak would not be suspected.

- On PROGRESS page 2 the totalizer is less than the calculated fuel. The TOTALIZER fuel is the sum of the individual tank quantities. The CALCULATED fuel is the totalizer value at engine start minus fuel used. Fuel used is calculated using the engine fuel flow sensors. This can be caused by a fuel leak or a tank fuel quantity indicator failure. If a tank fuel quantity indicator has failed, the crew would not suspect a fuel leak.

If a fuel 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 the 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.

13.6.3 Low Fuel

Low Fuel Operations In-flight A low fuel condition exists when the EICAS message FUEL QTY LOW is displayed.

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.

The FUEL QTY LOW NNC specifically calls for a flaps 20 approach and landing rather than a normal landing configuration as in other models. Testing and analysis shows that elevator authority at flaps 30 approach speeds is not adequate to enable the crew to successfully flare the airplane for landing in the unlikely event both engines failed in the landing configuration.

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 main tank fuel pump low pressure light illuminates, do not turn the fuel pump switches off.

13.6.4 Fuel Jettison

Fuel jettison should be considered when situations dictate landing at high gross weights and adequate time is available to perform the jettison. When fuel jettison is to be accomplished, consider the following:

- ensure adequate weather minimums exist at airport of intended landing
- fuel jettison above 4,000 feet AGL ensures complete fuel evaporation
- downwind drift of fuel may exceed one NM per 1,000 feet of drop
- avoid jettisoning fuel in a holding pattern with other airplanes below.

13.7 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 alternate gear extension, the gear cannot be raised. Flaps can be extended or retracted using the secondary drive system. However, the rate of flap travel is significantly reduced.

Flaps 20 is used for landing with multiple hydraulic systems inoperative to improve flare authority, control response and go-around capability. The airplane may tend to float during the flare. Do not allow the airplane to float. Fly the airplane onto the runway at the recommended point.

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.

13.8 Landing Gear

13.8.1 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 airplane after landing to inspect the wheels, tires, and brakes before continued taxi
- availability of support facilities should the airplane need repair.

13.8.2 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 needed for directional control. With a single tire failure, towing is not necessary unless unusual vibration is noticed or other failures have occurred.

In the case of a flat nose wheel tire, slowly and gently lower the nose wheels to the runway while braking lightly. Runway length permitting, use idle reverse thrust. Autobrakes 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. 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 significant increases in temperatures on the remaining tires.

13.9 Overspeed

VMO/MMO is the airplane maximum certified operating speed and should not be exceeded intentionally. However, crews can occasionally experience an inadvertent overspeed. Airplanes have been flight tested beyond VMO/MMO to ensure smooth pilot inputs will return the airplane safely to the normal flight envelope.

At high altitude, wind speed or direction changes may lead to overspeed events. Although autothrottle logic provides for more aggressive control of speed as the airplane approaches VMO or MMO, there are some conditions that are beyond the capability of the autothrottle system to prevent short term overspeeds.

When correcting an overspeed during cruise at high altitude, avoid reducing thrust to idle which results in slow engine acceleration back to cruise thrust and may result in over-controlling the airspeed or a loss of altitude. If autothrottle corrections are not satisfactory, leave the autopilot engaged, deploy partial speedbrakes slowly until a noticeable reduction in airspeed is achieved. When the airspeed is below VMO/MMO, retract the speedbrakes at the same rate as they were deployed. The thrust levers can be expected to advance slowly to achieve cruise airspeed; if not, they should be pushed up more rapidly.

During descents at or near VMO/MMO, most overspeeds are encountered after the autopilot initiates capture of the VNAV path from above or during a level-off when the speedbrakes were required to maintain the path. In these cases, if the speedbrakes are retracted during the level-off, the airplane can momentarily overspeed. During descents using speedbrakes near VMO/MMO, delay retraction of the speedbrakes until after VNAV path or altitude capture is complete. Crews routinely climbing or descending in windshear conditions may wish to consider a 5 to 10 knot reduction in climb or descent speeds to reduce overspeed occurrences. This will have a minimal effect on fuel consumption and total trip time.

When encountering an inadvertent overspeed condition, crews should leave the autopilot engaged and use the speedbrakes as needed unless it is apparent that the autopilot is not correcting the overspeed. However, if manual inputs are required, disengage the autopilot. Be aware that disengaging the autopilot to avoid or reduce the severity of an inadvertent overspeed may result in an abrupt pitch change.

During climb or descent, if VNAV or FLCH 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, VNAV or FLCH may be re-selected.

13.10 Tail Strike

777-200 - 777-300ER

Tail strike occurs when the lower aft fuselage or tail skid (as installed) contacts the runway during takeoff or landing. A significant factor that appears to be common is the lack of flight crew experience in the model being flown.

787-8 - 787-10

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.

A tail strike can be identified by the flight crew or cabin crew.

Any one of the following conditions can be an indication of a tail strike during rotation or flare:

- a noticeable bump or jolt
- a scraping noise from the tail of the airplane
- the TAILSKID or TAIL STRIKE EICAS message or light may be displayed.

Note: Anytime fuselage contact is suspected or confirmed, accomplish the appropriate NNC without delay.

Takeoff Risk Factors

Understanding the factors that contribute to a tail strike can reduce the possibility of a tail strike occurrence.

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 information is entered incorrectly either in the flight management system (FMS) or set incorrectly on the stabilizer. The flight crew can prevent this type of error and correct the condition by challenging the reasonableness of the load sheet numbers. Comparing the load sheet numbers against past experience in the 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

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

Flight recorder data shows that flight crews who continue with an unstabilized condition below 500 feet seldom stabilize the approach. When the airplane arrives in the flare, it often has either excessive or insufficient airspeed. The result is a tendency toward large thrust and pitch corrections in the flare, often culminating in a vigorous pitch change at touchdown resulting in tail strike shortly thereafter. If the pitch is increased rapidly when touchdown occurs as ground spoilers deploy, the spoilers add additional nose up pitch force, reducing pitch authority, which increases the possibility of a 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 thrust 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 a 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 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.

13.11 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.

13.12 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. In these situations the flight crew may be required to accomplish multiple NNCs, selected elements of several different NNCs applied as necessary to fit the situation, or be faced with little or no specific guidance except their own judgment and experience. Because these situations are rare, it is not practical or possible to create definitive flight crew NNCs to cover all events.

The following guidelines may aid the flight crew in determining the proper course of action should an in-flight event of this type be encountered. Although these guidelines represent what might be called “conventional wisdom”, circumstances determine the course of action which the crew perceives will conclude the flight in the safest manner.

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14 Appendices

14.1 Preface

Information contained in this appendix is provided by the operator of organizations that use the 777/787 Flight Crew Training Manual, in this case, this chapter is specific to British Airways Virtual.

14.2 Joint Variant Flying Guidance

Ref: FCTM, FCOM, FOTB, fleet experience.

The above documents and fleet experience have identified the following key areas of focus when conducting mixed fleet flying.

Review of fleet specific FCOM bulletins and FOTBs is recommended before flight.

Consideration should also be given to any differences in NNCs and TCET between variants.

Critical Data Procedure. The two aircraft have different procedures and care must be taken to ensure that FCOM NPs are followed. Significant error is unlikely, but minor errors may cause distraction.

14.2.1 777 – 787

HUD. Crews should maintain proficiency in flying using the HUD, whilst also maintaining head down instrument proficiency.

FMS management. Philosophically identical, but the interface for data entry is different and requires self-study recency.

14.2.2 787 – 777

SA. The 777 provides less information to flight crew. Good briefing skills will compensate for any potential reduction in SA.

Aircraft handling. SESMA statistics show that heavy landings are more common on the 777 than on the 787. A greater instrument scan rate prior to touchdown is required due to the lack of HUD.

14.3 Crosswind Takeoff

Crosswind guidelines are not considered limitations. These guidelines are based upon steady wind (no gust) conditions. British Airways Virtual's policy is that Captains are authorised to operate to the Takeoff Crosswind Guidelines, taking into account TOW, Runway Condition, %MAC, and extra workload associated with gusts. Co-pilots' Limits are defined in OM A.

14.4 Crosswind Landings

Crosswind guidelines are not considered limitations. These guidelines are based upon steady wind (no gust) conditions. British Airways Virtual's policy is that Captains are authorised to operate to the Landing Crosswind Guidelines, taking into account Runway Condition and extra workload associated with gusts. Co-pilots' Limits are defined in OM A.

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