PART IV –TRAINING MANUAL

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ABOUT THIS MANUAL

VERSION: 20 JULY, 2017

WARNING:
THIS MANUAL IS FOR 737 CAPTAIN EXPANSION FOR MS FSX AND LM PREPAR3D ONLY. DO NOT USE FOR FLIGHT.
DO NOT USE FOR TRAINING, COMMERCIAL OR INSTITUTIONAL PURPOSES.

The ‘737 Captain’ MANUAL is organized into four parts:
Each part is provided as a separate Acrobat® PDF document:

- Part I – Introduction
- Part II – Aircraft Systems
- Part III – Normal Procedures
- **Part IV –Training Manual** - this document.

All parts of the Manual are available free of charge via Sim Ops.

737 CAPTAIN' MANUAL PART IV –TRAINING MANUAL

GENERAL INFORMATION

OPERATIONAL PHILOSOPHY

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

QUALIFICATION REQUIREMENTS (CHECKRIDE)

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

FLAP USAGE

For takeoffs, when conditions permit, consider using larger flap settings to provide additional aft body clearance and shorter takeoff distance. Refer to the Typical Takeoff Tail Clearance table, chapter 3, to determine aft body clearance for different takeoff flap settings.
For normal landings, use flaps 30. When required, use flaps 40 to minimize landing speed and landing distance.

FLAP - SPEED SCHEDULE/MANEUVERING SPEEDS

The flap maneuvering speed schedule provides the recommended maneuvering speed for various flap settings. When recommended maneuvering speeds are followed, the schedule provides adequate margin to stick shaker for an inadvertent 15° overshoot beyond the normal 30° angle of bank.
The schedule provides speeds that are close to minimum drag and in climb are close to maximum angle of climb speed. In level flight it provides relatively constant pitch attitudes and requires little change in thrust at different flap settings.

FLAP MANEUVERING SPEED SCHEDULE

The flap maneuvering speed schedule is based on a fixed speed for each flap setting for a range of gross weights and provides adequate maneuver margin to stick shaker at all weights. Maneuvering speeds are shown for airplanes with rudder pressure reducer (RPR) active. If RPR is not active, refer to the DDPG for maneuvering speeds.

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

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

FLAP OPERATION

ACCELERATION HEIGHT - ALL ENGINES

The altitude selected for acceleration and flap retraction may be specified for each airport. Safety, obstruction clearance, airplane performance or noise abatement requirements are usually the determining factors. Some operators have adopted a 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.

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

ACCELERATION HEIGHT - ENGINE OUT

Acceleration height for a takeoff with an engine failure after V1 is based on accelerating to the recommended flaps up speed while retracting flaps and selecting maximum continuous thrust limits within five minutes after initiating takeoff. Some combinations of high gross weight, takeoff flap selection and airport elevation may require initiating flap retraction as low as 400 feet after takeoff with an engine failure.

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

COMMAND SPEED

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

TAKEOFF

Command speed remains set at V2 until changed by the pilot for acceleration and flap retraction. Manually select flaps up maneuver speed at flap retraction altitude.

CLIMB, CRUISE AND DESCENT

Command speed is set to the appropriate speed. The white airspeed bugs (if installed) are positioned to the appropriate airspeeds for approach and landing.

APPROACH

Command speed is set to the maneuvering speed for the selected flap position.

LANDING

For airplanes without an autothrottle the recommended method for approach speed correction is to add one half of the reported steady headwind component plus the full gust increment above the steady wind to the reference speed. One half of the reported steady headwind component can be estimated by using 50% for a direct headwind, 35% for a 45° crosswind, zero for a direct crosswind and interpolation in between.

When making adjustments for wind additives, the maximum command speed should not exceed VREF + 20 knots. This technique provides sufficient low speed maneuver margin. The following table shows examples of wind additives with a runway heading of 360°.

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

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

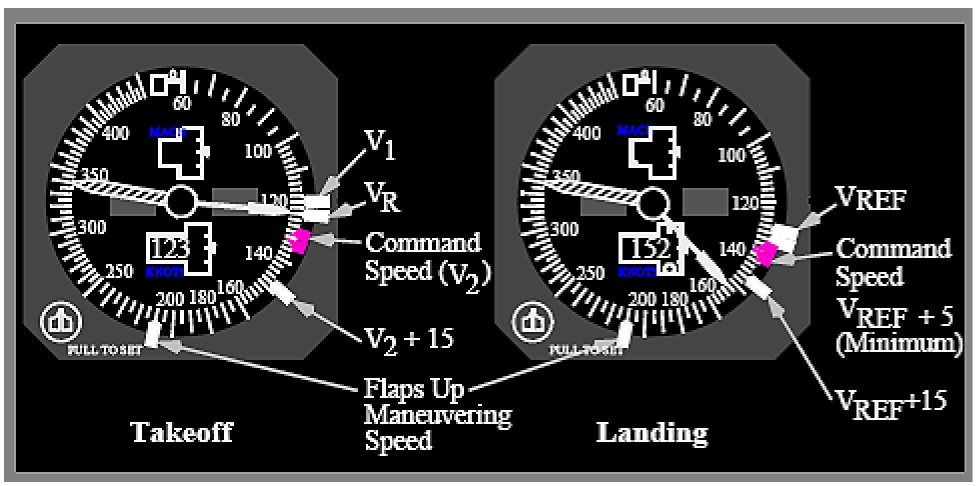
For airplanes without an autothrottle the minimum command speed setting is VREF + 5 knots. The gust correction should be maintained to touchdown while the steady headwind correction should be bled off as the airplane approaches touchdown.

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

REFERENCE BUGS

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

BUG SETTING (MASI)



TAKEOFF

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

APPROACH - LANDING

Position two white airspeed bugs at VREF for landing flaps and single white airspeed bug at VREF + 15 speed and the flaps up maneuvering speed.

RECOMMENDED RUDDER TRIM TECHNIQUE

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

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

Note: Large trim requirements should be documented for maintenance. Refer to the maintenance manual for guidance.

DRAG FACTORS DUE TO TRIM TECHNIQUE

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

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

PRIMARY RUDDER TRIM TECHNIQUE

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

The following steps define the primary rudder trim technique:

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

AUTOPILOT PROCEDURES

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

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

CONTROL WHEEL STEERING

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

MANUAL FLIGHT

The PM should make autopilot mode selections at the request of the PF. However, autopilot engagement requires relaxing forces on the control column and is normally done by the PF. On airplanes where the PM has access to set the applicable indicator, heading and altitude changes from ATC clearances and speed selections associated with flap position changes may be made without specific directions. However, these selections should be announced, such as, "HEADING 170 SET". The PF must be aware such changes are being made. This enhances overall safety by requiring that both pilots are aware of all selections, while still allowing one pilot to concentrate on flight path control.

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

AUTOMATIC FLIGHT

When the autopilot is in use, the PF should make the autopilot mode selections. The PM may select new altitudes if crew duties permit.

Using automatic systems allows the pilot to devote additional time to monitoring the airplane's flight path. Automatic systems give excellent results in the vast majority of situations. Both pilots must monitor approach progress display mode annunciations (SP-77) and the current flight plan. Deviations from expected performance are normally due to an incomplete understanding of their operations by the flight crew.

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

GROUND OPERATIONS

PREFACE

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

TAKEOFF BRIEFING

The takeoff briefing should be accomplished as soon as practical so it does not interfere with the final takeoff preparations.

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

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

PUSH BACK

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

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

Pushback or towing involves three phases:

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

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

BACKING WITH REVERSE THRUST

If no other means are available to move the airplane, thrust reversers may be used for backing. Wing flaps should be retracted to provide maximum clearance and visibility for the ground crew giving hand signals.
The air conditioning should be OFF to prevent ingestion of exhaust gases.

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

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

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

TAXI

TAXI GENERAL

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

PRIOR TO TAXI

- brief applicable items from airport diagrams and related charts
- ensure both crewmembers understand the expected taxi route
- write down the taxi clearance when received.

DURING TAXI

- progressively follow taxi position on the airport diagram
- during low visibility conditions, call out all signs to verify position
- if unfamiliar with the airport consider requesting a FOLLOW ME vehicle or progressive taxi instructions
- use standard radio phraseology
- read back all clearances. If any crewmember is in doubt regarding the clearance, verify taxi routing with the written clearance or with ATC. Stop the airplane if the clearance is in doubt
- when ground/obstruction clearance is in doubt, stop the airplane and obtain a wing-walker
- avoid distractions during critical taxi phases; plan ahead for checklist accomplishment and company communications
- consider delaying checklist accomplishment until stopped during low visibility operations
- do not allow ATC or anyone else to rush you
- verify the runway is clear (both directions) and clearance is received prior to entering a runway
- be constantly aware of the equipment, structures, and aircraft behind the airplane when the engines are above idle thrust
- consider using the taxi light to visually indicate movement
- at night use all appropriate airplane lighting

- when entering any active runway ensure the exterior lights specified in the FCOM are illuminated.

PRIOR TO LANDING

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

AFTER LANDING

- ensure taxi instructions are clearly understood, especially when crossing closely spaced parallel runways
- delay company communications until clear of all runways.

FLIGHT DECK PERSPECTIVE

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

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

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

THRUST USE

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

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

TAXI SPEED AND BRAKING

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

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

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

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

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

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

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

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

ANTISKID INOPERATIVE

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

NOSE WHEEL/RUDDER PEDAL STEERING

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

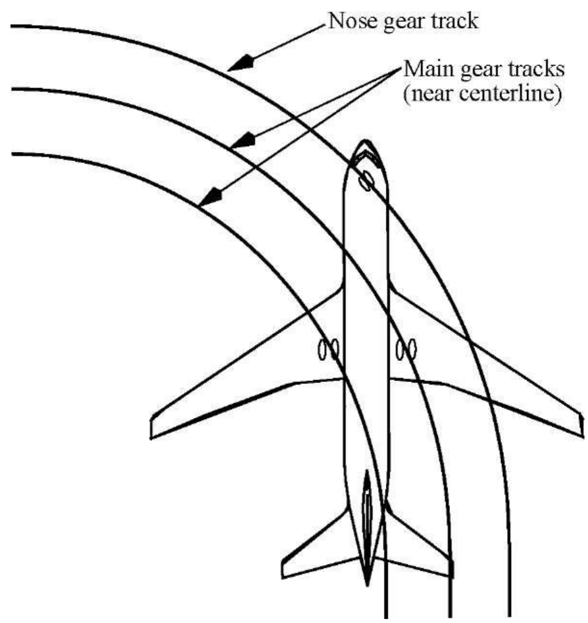
If nose wheel "scrubbing" occurs while turning, reduce steering angle and/or taxi speed. Avoid stopping the airplane in a turn as excessive thrust is required to start taxiing again.

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

TURNING RADIUS AND GEAR TRACKING

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

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



VISUAL CUES AND TECHNIQUES FOR TURNING WHILE TAXIING

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

Model	Pilot Seat Position (forward of nose gear) feet (meters)	Pilot Seat Position (forward of main gear) feet (meters)
737 - 200	4.8 (1.5)	42 (12.8)

TURNS LESS THAN 90 DEGREES

Steer the nose wheels far enough beyond the centerline of the turn to keep the main gear close to the centerline.

TURNS OF 90 DEGREES OR MORE

Initiate the turn as the intersecting taxiway centerline (or intended exit point) approaches approximately the center of the number 3 window. Initially use approximately full nose wheel steering wheel displacement. Adjust the steering wheel input as the airplane turns to keep the nose wheels outside of the taxiway centerline, near the outside radius of the turn. Nearing turn completion, when the main gear are clear of the inside radius, gradually release the steering wheel input as the airplane lines up with the intersecting taxiway centerline or intended taxi path.

TURNS OF 180 DEGREES

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

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

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

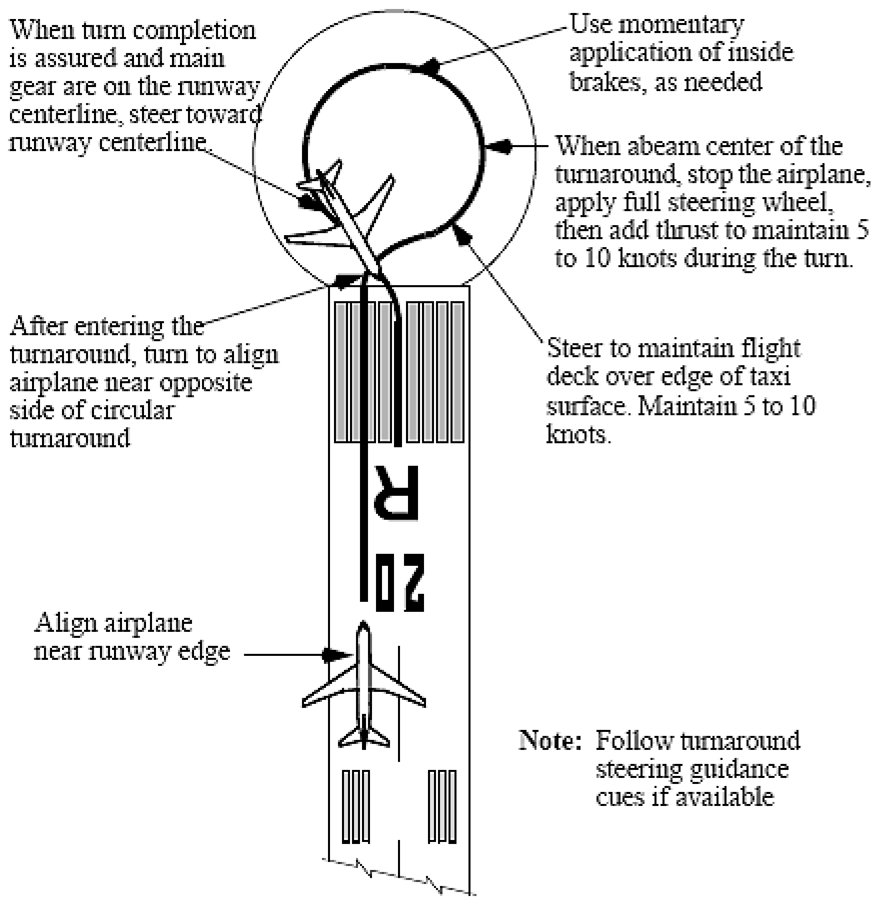
Approach the edge of the taxi surface at a shallow angle until the outboard side of the main gear wheels are near the edge. The main gear are just inside the engine nacelles. Maneuver to keep the engine nacelles over the prepared surfaces.

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

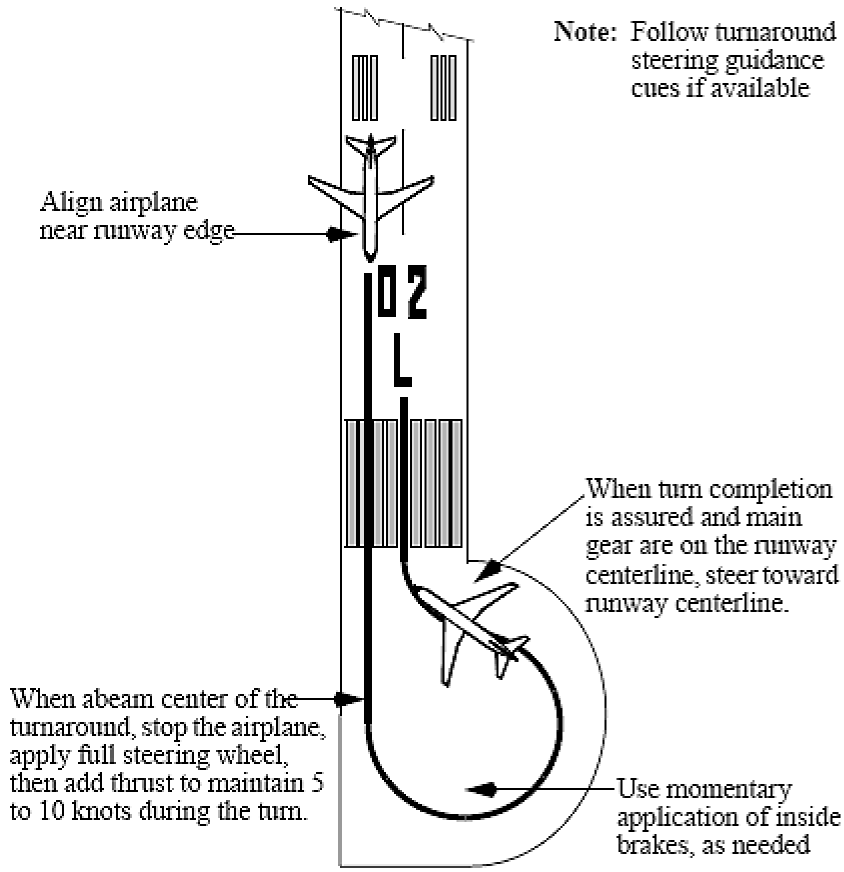
Turning radius can be reduced by following a few specific taxi techniques. Taxi the airplane so that the main gear tires are close to the runway edge.This provides more runway surface to make the turn. Stop the airplane completely with the thrust at idle. Hold the nose wheel steering wheel to the maximum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

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

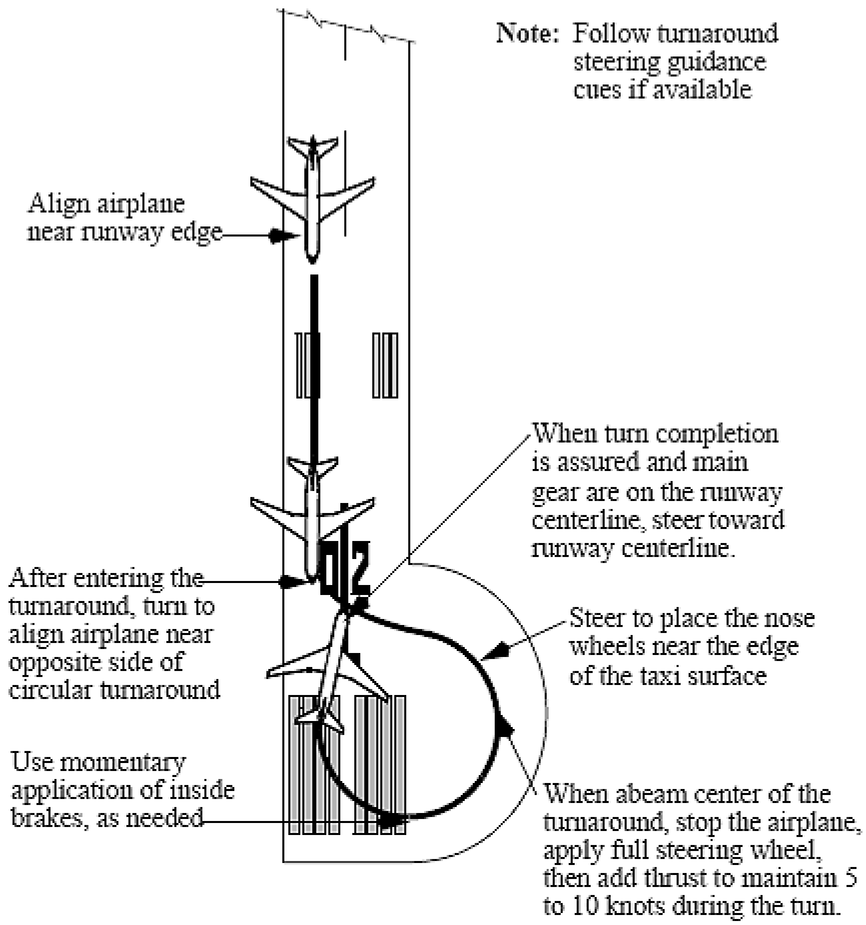
TECHNIQUES WHEN USING A CIRCULAR TURNAROUND



TECHNIQUES WHEN USING A HAMMERHEAD TURNAROUND



TECHNIQUES WHEN USING A HAMMERHEAD TURNAROUND



TAXI - ADVERSE WEATHER

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

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

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

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

To reduce the possibility of flap damage after making an approach in icing conditions or landing on a runway covered with snow or slush, do not retract the flaps to less than 15 until the flap area has been checked for debris by maintenance.

LOW VISIBILITY

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

TAXI - ONE ENGINE

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

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

TAKEOFF AND INITIAL CLIMB

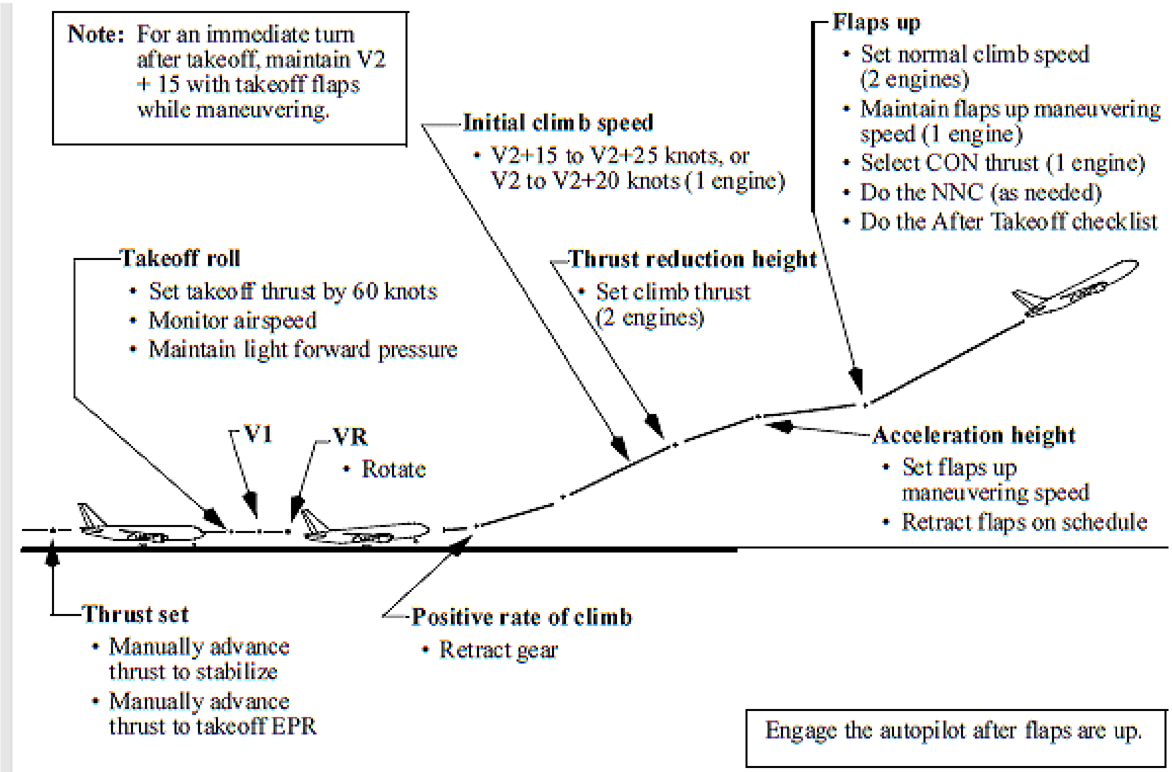
PREFACE

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

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

TAKEOFF

TAKEOFF PROFILE



TAKEOFF - GENERAL

This profile does not satisfy noise abatement guidelines established by the U.S. FAA. See the Noise Abatement Takeoff section for procedures that satisfy this requirement.

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

THRUST MANAGEMENT

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

INITIATING TAKEOFF ROLL

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

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

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

Rolling takeoffs are accomplished in two ways:

- if cleared for takeoff prior to or while entering the runway, maintain normal taxi speed. When the airplane is aligned with the runway centerline ensure the nose wheel steering wheel is released and apply takeoff thrust by advancing the thrust levers to approximately 1.4 EpR (levers in vertical position.). Allow the engines to stabilize momentarily then promptly advance the thrust levers to takeoff thrust (autothrottle TO/GA). There is no need to stop the airplane prior to adding thrust.
- if holding in position on the runway, ensure the nose wheel steering wheel is released, release brakes, then apply takeoff thrust as described above.

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

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

Allowing the engines to stabilize provides uniform engine acceleration to takeoff thrust and minimizes directional control problems. This is particularly important if crosswinds exist or the runway surface is slippery. The exact initial setting is not as important as setting symmetrical thrust.

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

If thrust is to be set manually, smoothly advance thrust levers toward takeoff thrust. Final thrust adjustments should be made, with reference to the digital readouts, by 60 knots. After 60 knots, do not reduce thrust except as needed to maintain engine parameters within limits (red line).

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

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

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

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

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

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

ROTATION AND LIFTOFF - ALL ENGINES

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

Above 80 knots, relax the forward control column pressure to the neutral position. For optimum takeoff and initial climb performance, initiate a smooth continuous rotation at VR toward 15° of pitch attitude. The use of stabilizer trim during rotation is not recommended.

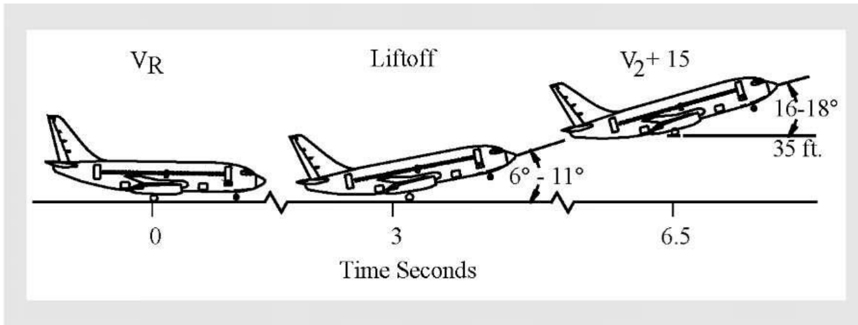
For airplanes equipped with the SP-77 autopilot, after liftoff use indicated airspeed and attitude as the primary pitch reference, cross checking other flight instruments as necessary.

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

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

TYPICAL ROTATION, ALL ENGINES

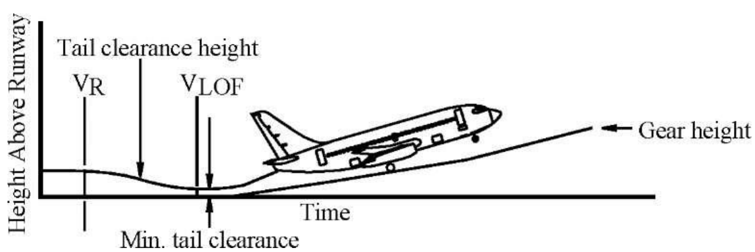
The following figure shows typical rotation with both engines operating.



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

TYPICAL TAKEOFF TAIL CLEARANCE

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

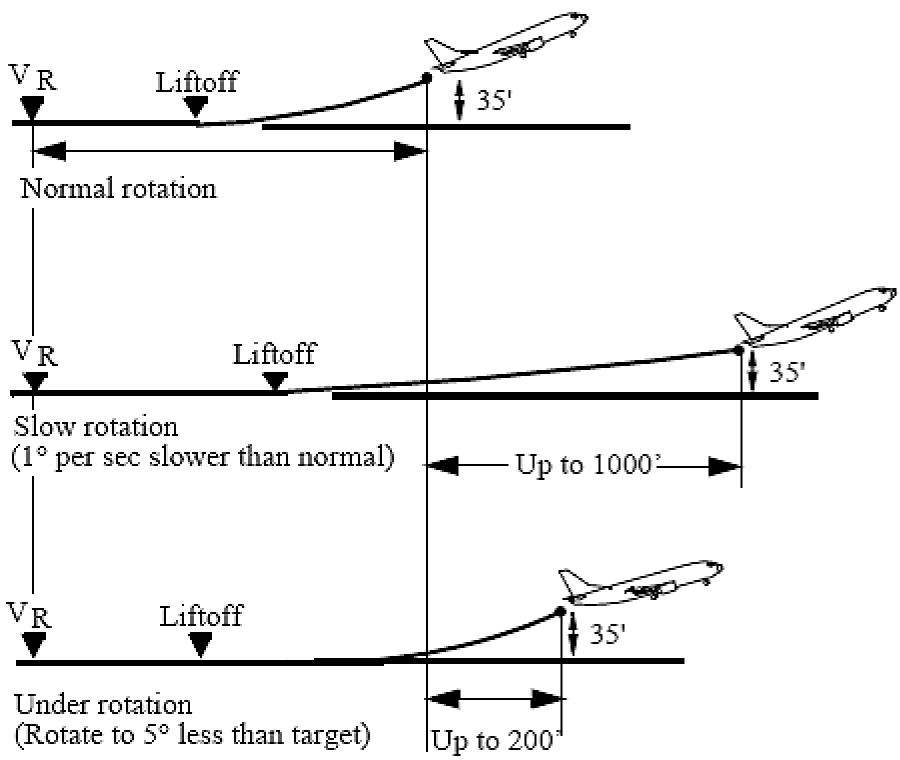


Model	Flap	Liftoff Attitude (degrees)	Minimum Tail Clearance inches (cm)	Tail Strike Pitch Attitude (degrees)
200	1 5 15 25	10.2 8.5 5.8 6.2	30 (77) 37(95) 47 (119) 46 (116)	15.5

EFFECT OF ROTATION SPEED AND PITCH RATE ON LIFTOFF

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

SLOW OR UNDER ROTATION (TYPICAL)



CENTER-OF-GRAVITY (C.G.) EFFECTS

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

CROSSWIND TAKEOFF

The crosswind guidelines shown below were derived through flight test data and engineering analysis, and piloted simulated guidelines.
Note: Engine surge can occur with a strong crosswind component if takeoff thrust is set prior to brake release. Therefore, the rolling takeoff procedure is strongly advised when crosswind exceeds 20 knots.

TAKEOFF CROSSWIND GUIDELINES

Crosswind guidelines are not considered limitations. Crosswind guidelines are provided to assist operators in establishing their own crosswind policies. Takeoff crosswind guidelines are based upon the most adverse airplane loading (light weight and aft center of gravity) and assume an engine out RTO. On slippery runways, crosswind guidelines are a function of runway surface condition, and assume proper pilot technique.

Runway Condition	Crosswind - Knots
Dry	40
Wet	25
Standing Water/Slush	16
Snow - No Melting	21
Ice - No Melting **	7

DIRECTIONAL CONTROL

Initial runway alignment and smooth symmetrical thrust application result in good crosswind control capability during takeoff. Light forward pressure on the control column during the initial phase of takeoff roll (below approximately 80 knots) increases nose wheel steering effectiveness. Any deviation from the centerline during thrust application should be countered with immediate smooth and positive control inputs. Smooth rudder control inputs combined with small control wheel inputs result in a normal takeoff with no overcontrolling. Large control wheel inputs can have an adverse effect on directional control near V1(MCG) due to the additional drag of the extended spoilers.

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

ROTATION AND TAKEOFF

Maintain wings level during the takeoff roll by applying control wheel displacement into the wind. During rotation continue to apply control wheel in the displaced position to keep the wings level during liftoff. The airplane is in a sideslip with crossed controls at this point. A slow, smooth recovery from this sideslip is accomplished after liftoff by slowly neutralizing the control wheel and rudder pedals.

GUSTY WIND AND STRONG CROSSWIND CONDITIONS

For takeoff in gusty or strong crosswind conditions, use of a higher thrust setting than the minimum required is recommended. When the prevailing wind is at or near 90° to the runway, the possibility of wind shifts resulting in gusty tailwind components during rotation or liftoff increases. During this condition, consider the use of thrust settings close to or at maximum takeoff thrust. The use of a higher takeoff thrust setting reduces the required runway length and minimizes the airplane exposure to gusty conditions during rotation, liftoff, and initial climb. Avoid rotation during a gust. If a gust is experienced near VR, as indicated by stagnant airspeed or rapid airspeed acceleration, momentarily delay rotation. This slight delay allows the airplane additional time to accelerate through the gust and the resulting additional airspeed improves the tail clearance margin. Do not rotate early or use a higher than normal rotation rate in an attempt to clear the ground and reduce the gust effect because this reduces tail clearance margins. Limit control wheel input to that required to keep the wings level. Use of excessive control wheel may cause spoilers to rise which has the effect of reducing tail clearance. All of these factors provide maximum energy to accelerate through gusts while maintaining tail clearance margins at liftoff. The airplane is in a sideslip with crossed controls at this point. A slow, smooth recovery from this sideslip is accomplished after liftoff by slowly neutralizing the control wheel and rudder pedals.

IMPROVED CLIMB PERFORMANCE TAKEOFF

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

LOW VISIBILITY TAKEOFF

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

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

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

ADVERSE RUNWAY CONDITIONS

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

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

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

A slippery runway (wet, compact snow, ice) also increases stopping distance during a rejected takeoff. Takeoff performance and critical takeoff data are adjusted to fit the existing conditions. If there is an element of uncertainty concerning the safety of an operation with adverse runway conditions, do not takeoff until the element of uncertainty is removed.

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

During wet runway or slippery conditions, the 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.

REJECTED TAKEOFF DECISION

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

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

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

Historically, rejecting a takeoff near V1 has often resulted in the airplane stopping beyond the end of the runway. Common causes include initiating the RTO after V1 and failure to use maximum stopping capability (improper procedures/techniques). Effects of improper RTO execution are shown in the diagrams located in the RTO Execution Operational Margins section, this chapter. The maximum braking effort associated with an RTO is a more severe level of braking than most pilots experience in normal service.

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

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

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

REJECTED TAKEOFF MANEUVER

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

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

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

GO/STOP DECISION NEAR V1

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

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

Pilots know that V1 is fundamental to making the Go/Stop decision. Under runway limited conditions, if the reject procedure is initiated at V1, the airplane can be stopped prior to reaching the end of the runway. See RTO Execution Operational Margins diagrams for the consequences of initiating a reject after V1 and/or using improper procedures.

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

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

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

What's important to note here is that the majority of past RTO accidents were not engine failure events. Full takeoff power from all engines was available. With normal takeoff power, the airplane should easily reach a height of 150 feet over the end of the runway, and the pilot has the full length of the runway to stop the airplane if an air turnback is required.

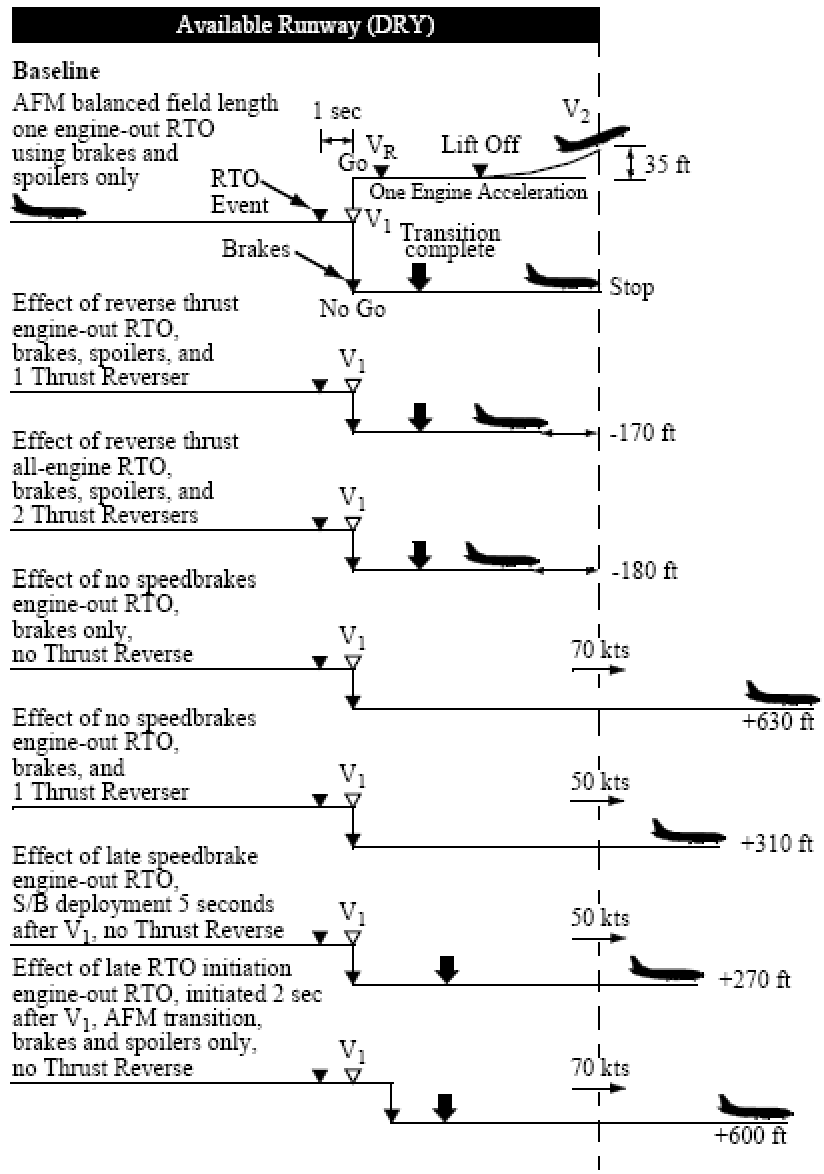
Making the Go/Stop decision starts long before V1. Early detection, good crew coordination and quick reaction are the keys to a successful takeoff or stop.

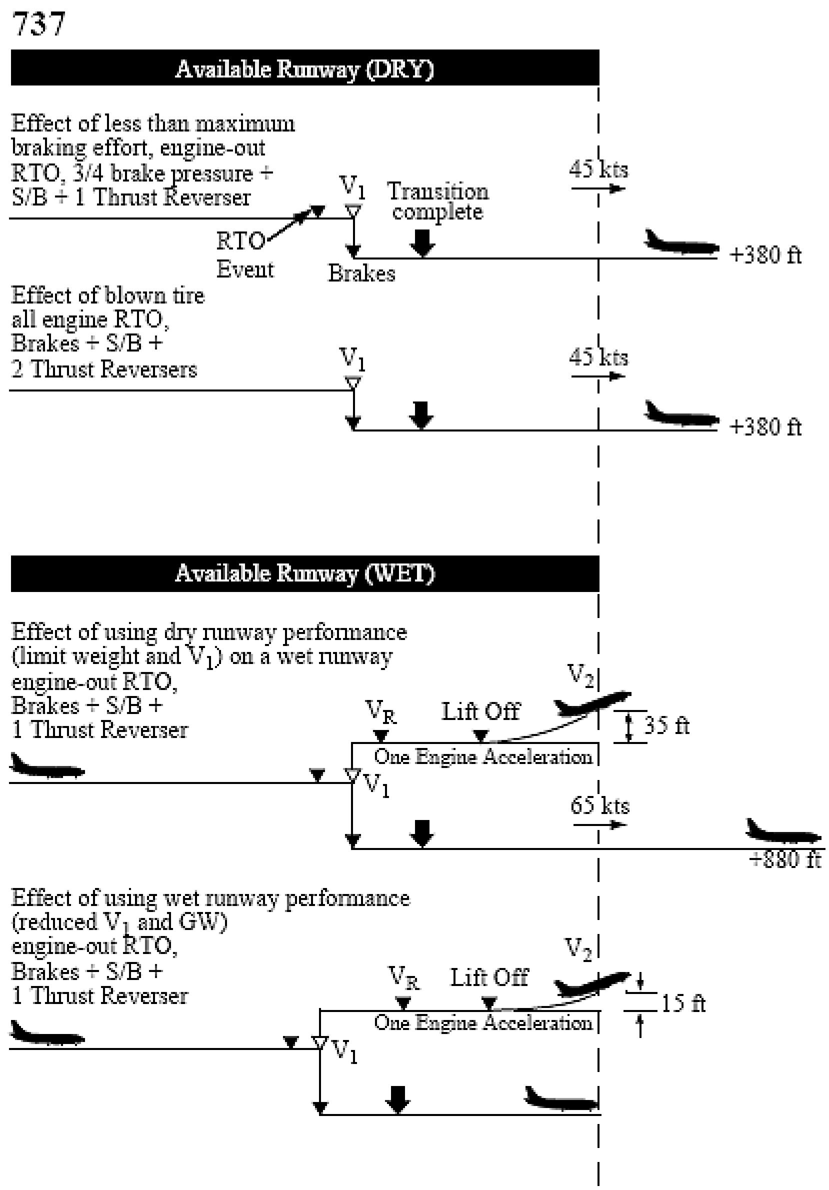
RTO EXECUTION OPERATIONAL MARGINS

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

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

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




737
Available Runway (DRY)
Effect of less than maximum braking effort, engine-out RTO, 3/4 brake pressure + S/B + 1 Thrust Reverser
V1
Transition complete
45 kts
RTO Event
Brakes
+380 ft
Effect of blown tire all engine RTO, Brakes + S/B + 2 Thrust Reversers
V1
45 kts
+380 ft
Available Runway (WET)
Effect of using dry runway performance (limit weight and V1) on a wet runway engine-out RTO, Brakes + S/B + 1 Thrust Reverser
V2
VR
Lift Off
35 ft
One Engine Acceleration
V1
65 kts
+880 ft
Effect of using wet runway performance (reduced V1 and GW) engine-out RTO, Brakes + S/B + 1 Thrust Reverser
V2
VR
Lift Off
15 ft
One Engine Acceleration
V1

INITIAL CLIMB - ALL ENGINES

For airplanes equipped with the SP-77 autopilot, use indicated airspeed and attitude as the primary pitch references crosschecking other flight instruments as needed. Adjust pitch to maintain a target airspeed of V2 + 20 knots.

V2 + 20 is the optimum climb speed with takeoff flaps. It results in the maximum altitude gain in the shortest distance from takeoff. Acceleration to higher speeds reduces the altitude gain. If airspeed exceeds V2 + 20 during the initial climb, stop the acceleration but do not attempt to reduce airspeed to V2 + 20. Any speed between V2 + 15 and V2 + 25 knots results in approximately the same takeoff profile. Crosscheck indicated airspeed for proper initial climb speed.

Retract the landing gear after a positive rate of climb is indicated on the altimeter. Do not apply brakes after becoming airborne. Braking is automatically applied when the landing gear lever is placed in the up position. After gear and flaps are retracted, the PM should verify the gear and flaps indications are normal.

MINIMUM FUEL OPERATION – TAKEOFF

The minimum fuel recommended for takeoff is trip fuel plus reserves. On very short flights this fuel quantity may not be enough to prevent forward fuel pump low pressure lights from illuminating after takeoff.
If any main tank fuel pump indicates low pressure do not turn off fuel pump switches. Avoid rapid acceleration of the airplane, reduce nose-up body attitude and maintain minimum nose-up body angle required for a safe climb gradient.

IMMEDIATE TURN AFTER TAKEOFF - ALL ENGINES

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

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

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

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

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

AUTOPILOT ENGAGEMENT

The autopilot is FAA certified to allow engagement at or above 1,000 feet AGL after takeoff. Other regulations or airline operating directives may specify a different minimum altitude. The airplane should be in trim, and the flight director commands should be satisfied prior to autopilot engagement. This prevents unwanted changes from the desired flight path during autopilot engagement.

FLAP RETRACTION SCHEDULE

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

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

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

With airspeed increasing, subsequent flap retractions should be initiated when airspeed reaches the fixed maneuvering speed for the existing flap position. For flaps up maneuvering, maintain at least flaps up maneuvering speed. With flaps up and above 3,000 feet AGL, set the desired climb speed.

TAKEOFF FLAP RETRACTION SPEED SCHEDULE

T/O Flaps	Select Flaps	At & Below 117,000 Lb (53,070 Kg)	Above 117,000 Lb (53,070 Kg)
25	15 5 1 UP	V2 + 15 150 170 190	V2 + 15 160 180 200
15	5 1 UP	V2 + 15 170 190	V2 + 15 180 200
5	1 UP	V2 + 15 190	V2 + 15 200
1	UP	190	200

Note: Limit bank angle to 15 degrees until reaching V2 + 15.

NOISE ABATEMENT TAKEOFF

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

CLIMB, CRUISE, DESCENT AND HOLDING

PREFACE

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

CLIMB

CLIMB CONSTRAINTS

All hard altitude climb restrictions, including "at or below" constraints, should be set in the altitude alert controller. The next altitude may be set when the restriction has been satisfied or further clearance has been received. This procedure provides altitude deviation alerts and ensures compliance with altitude clearance limits.

LOW ALTITUDE LEVEL OFF

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

TRANSITION TO CLIMB

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

ENGINE ICING DURING CLIMB

Engine icing may form when not expected and may occur when there is no evidence of icing on the windshield or other parts of the airplane. Once ice starts to form, accumulation can build very rapidly. Although one bank of clouds may not cause icing, another bank, which is similar, may cause icing.
Note: The engine anti-icing system should be turned on whenever icing conditions exist or are anticipated. Failure to follow the recommended anti-ice procedures can result in engine stall, overtemperature or engine damage.

ECONOMY CLIMB SCHEDULE - PDCS DATA UNAVAILABLE

- 250 knots - Below 10,000 feet
- 280 knots/0.74M - Above 10,000 feet

MAXIMUM RATE CLIMB

The PDCS provides a maximum rate climb for both high climb rates and minimum time to cruise altitude.
Maximum Rate Climb Schedule - PDCS Data Unavailable

- flaps up maneuvering speed + 50 knots until intercepting 0.70M

MAXIMUM ANGLE CLIMB

The PDCS does not provide maximum angle climb speeds, but maximum angle climb speed can be approximated by manually entering flaps up maneuvering speed. Maximum angle climb speed is normally used for obstacle clearance, minimum crossing altitude or to reach a specified altitude in a minimum distance.

CRUISE

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

MAXIMUM ALTITUDE

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

- maximum certified altitude (structural) - determined during certification and is usually set by the pressurization load limits on the fuselage.
- thrust limited altitude - the altitude at which sufficient thrust is available to provide a specific minimum rate of climb. (Reference the Long Range Cruise Maximum Operating Altitude table in the PI chapter of the QRH). Depending on the thrust rating of the engines, the thrust limited altitude may be above or below the maneuver limited altitude capability.
- buffet or maneuver limited altitude - the altitude at which a specific maneuver margin exists prior to buffet onset. This altitude provides at least a 0.2g margin (33° bank) for FAA operations or a 0.3g margin (40° bank) for CAA/JAA operations prior to buffet.

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

OPTIMUM ALTITUDE

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

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

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

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

The selected cruise altitude should normally be as close to optimum as possible. Optimum altitude is the altitude that gives the minimum trip cost for a given trip length, cost index, and gross weight. Optimum altitude does not account for winds. It provides approximately a 1.5 load factor (approximately 48° bank to buffet onset) or better buffet margin. As deviation from optimum cruise altitude increases, performance economy deteriorates.

Some loss of thrust limited maneuver margin can be expected above optimum altitude. Levels 2000 feet above optimum altitude normally allows approximately 45° bank prior to buffet onset. The higher the airplane flies above optimum altitude, the more the thrust margin is reduced. Before accepting an altitude above optimum, determine that it will continue to be acceptable as the flight progresses under projected conditions of temperature and turbulence.

On airplanes with higher thrust engines, the altitude selection is most likely limited by maneuver margin to initial buffet. Proj ected temperature and turbulence conditions along the route of flight should be reviewed when requesting/accepting initial cruise altitude as well as subsequent step climbs.

CRUISE SPEED DETERMINATION

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

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

LRC is a variable speed schedule providing fuel mileage 1% less than the maximum available. The PDCS applies wind corrections to LRC.

STEP CLIMB

Optimum step points are a function of the route length, flight conditions, speed mode, present aircraft altitude, STEP to altitude and the gross weight. The PDCS does not compute an optimum step point. Initiate a cruise climb to a predetermined altitude above optimum altitude when the airplane is at a predetermined altitude below the optimum altitude displayed on the PDCS. For example, when the airplane is 2,000 feet below the optimum altitude displayed on the PDCS, initiate a climb to a cruise altitude 2,000 feet above the optimum altitude. Maintain this new cruise altitude until the airplane is again 2,000 feet below the cruise altitude displayed on the PDCS, and repeat the process.

FUEL FOR ENROUTE CLIMB

The additional fuel required for a 4,000 foot enroute climb varies from 300 to 600 pounds (depending on the airplane gross weight). This additional fuel is offset by the savings in the descent. It is usually beneficial to climb to a higher altitude if recommended by the flight plan, provided the wind information used is reliable. Note: The fuel saved at higher altitude does not normally justify a step climb unless the cruise time of the higher altitude is approximately 20 minutes or longer.

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 include:
- ISA + 10° C: 1% increase in trip fuel
- 2,000 feet above/below optimum altitude: 1% to 2% increase in trip fuel
- 4,000 feet below optimum altitude: 3% to 5% increase in trip fuel
- 8,000 feet below optimum altitude: 8% to 14% increase in trip fuel
- cruise speed 0.01M above LRC: 1% to 2% increase in trip fuel. For cruise within 2,000 feet of optimum, long range cruise speed can be approximated by using 0.72M. Long range cruise also provides 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.

HIGH ALTITUDE HIGH SPEED FLIGHT

The airplane exhibits excellent stability throughout the high altitude/high Mach range. Mach buffet is not normally encountered at high Mach cruise. However, even in Mach buffet, control response is smooth and normal. The airplane does not have a Mach tuck tendency.

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

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

DESCENT

DESCENT SPEED DETERMINATION

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

DESCENT CONSTRAINTS

Set all mandatory altitude restrictions and "at or above" constraints in the altitude alert controller. The next altitude may be set when the restriction has been assured or further clearance has been received.

DESCENT PLANNING

Flight deck workload increases as the airplane descends into the terminal area. Distractions must be minimized and administrative and nonessential duties completed before descent or postponed until after landing. Perform essential duties early in the descent so more time is available during the critical approach and landing phases.

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

Proper descent planning is necessary to arrive at the desired altitude at the proper speed and configuration.

The distance required for the descent is approximately 3 NM/1000 feet altitude loss for no wind conditions using ECON speed. Rate of descent is dependent upon thrust, drag, airspeed schedule and gross weight.

DESCENT RATES

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

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

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

The speedbrake may be used to correct the descent profile if arriving too high or too fast. The Descent Procedure is normally initiated before the airplane descends below the cruise altitude for arrival at destination, and should be completed by 10,000 feet MSL. The Approach Procedure is normally started at transition level.

Plan the descent to arrive at traffic pattern altitude at flaps up maneuvering speed approximately 12 miles from the runway when proceeding straight-in or about 8 miles out when making an abeam approach. A good crosscheck is to be at 10,000 feet AGL, 30 miles from the airport, at 250 knots.

Losing airspeed can be difficult and may require a level flight segment. For planning purposes, it requires approximately 25 seconds and 2 NM to decelerate from 280 to 250 knots in level flight without speedbrakes. It requires an additional 35 seconds and 3 NM to decelerate to flaps up maneuvering speed at average gross weights. Using speedbrakes to aid in deceleration reduces these times and distances by approximately 50%.
Maintaining the desired descent profile and awareness of position will ensure 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

The use of speedbrakes with flaps extended should be avoided, if possible. With flaps greater than 15, the speedbrakes should be retracted. If circumstances dictate the use of speedbrakes with flaps extended, high sink rates during the approach should be avoided. Speedbrakes should be retracted before reaching 1,000 feet

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. 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 after level off is complete.

FLAPS AND LANDING GEAR

Normal descents are made in the clean configuration to pattern or instrument approach altitude. If greater descent rates are desired, extend the speedbrakes. When thrust requirements for anti-icing result in less than normal descent rates with speedbrakes extended, or if higher than normal descent rates are required by ATC clearance, the landing gear can be lowered to increase the rate of descent.

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

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

SPEED RESTRICTIONS

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

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

HOLDING

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

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

If holding speed is not available from the PDCS, refer to the PI section of the QRH. Recommended holding speeds can be approximated by using the following guidance until more accurate speeds are obtained from the QRH:

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

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 (210 knots Washington D. C. & New York FIRs)
14,001 feet MSL and above	265 knots

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

The initial outbound leg should be flown for 1 minute or 1 1/2 minutes as required by altitude. Timing for subsequent outbound legs should be adjusted as necessary to achieve proper inbound leg timing.

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

APPROACH AND MISSED APPROACH

PREFACE

This chapter outlines recommended operating practices and techniques for ILS, non-ILS, circling and visual approaches, and the Go-Around and Missed Approach maneuver. Flight profile illustrations represent the recommended basic configuration for normal and non-normal flight maneuvers and provide a basis for standardization and crew coordination.

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

APPROACH

INSTRUMENT APPROACHES

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

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

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

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

APPROACH BRIEFING

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

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

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

APPROACH CATEGORY

FAA Category	Speed
C	121 knots or more but less than 141 knots
D	141 knots or more but less than 166 knots
Speed - based upon a speed of VREF in the landing configuration at maximum certificated landing weight.	

ICAO Category	Range of Speeds at Threshold	Range of Speeds for Initial Approach	Range of Speeds for Final Approach	Max Speeds for Visual Maneuvering (Circling)	Max Speeds for Missed Approach	
					Intermediate	Final
C	121/140	160/240	115/160	180	160	240
D	141/165	185/250	130/185	205	185	265
Speeds at threshold - based upon a speed of VREF in the landing configuration at maximum certified landing weight.						

The designated approach category for an aircraft type is defined by landing reference speed (VREF) at maximum certified landing weight under both USA TERPS and ICAO PANS OPS.

• The 737 is classified as a Category "C" airplane for straight in approaches.

For circling approaches, the anticipated circling speed at the actual weight is used to determine the required approach minimums. This is because circling approach minimums for both USA TERPS and ICAO PANS OPS are based on obstruction clearance for approach maneuvering within a defined region of airspace. The region of airspace is determined as a function of actual aircraft speed. This region gets larger with increasing speed, which may result in higher approach minimums depending upon the terrain characteristics surrounding the airport. Similarly, approach minimums may decrease as speed is reduced for the same reason. However, the use of lower circling approach minimums based on actual approach speeds does not change the designated approach category of the airplane. Circling approach minimums are normally published as a function of maximum aircraft speeds for circling in lieu of aircraft approach categories on Jeppesen Approach Charts.

APPROACH CLEARANCE

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

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

PROCEDURE TURN

On most approaches the procedure turn must be completed within specified limits, such as within 10 NM of the procedure turn fix or beacon. Airplane configuration and ground speed outbound must be considered. If the procedure turn fix is crossed at an excessively high ground speed, the procedure turn protected airspace may be exceeded. Adjust time outbound for airspeed, wind effects, and location of the procedure turn fix. The procedure turn should be monitored using all navigation aids available to assure the airplane remains within protected airspace. The published procedure turn altitudes are normally minimum altitudes.

STABILIZED APPROACH REQUIREMENTS

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

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

Note: Do not attempt to land from an unstable approach. Recommended Elements of a Stabilized Approach
The following recommendations are consistent with criteria developed by the Flight Safety Foundation.

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

- the aircraft is on the correct flight path
- only small changes in heading/pitch are required to maintain the correct flight path
- the aircraft speed is not more than VREF + 20 knots indicated airspeed and not less than VREF
- the aircraft is in the correct landing configuration
- sink rate is no greater than 1,000 fpm; if an approach requires a sink rate greater than 1,000 fpm, a special briefing should be conducted
- power setting is appropriate for the aircraft configuration
- all briefings and checklists have been conducted.
- Specific types of approaches are stabilized if they also fulfill the following:
- ILS approaches should be flown within one dot of the glide slope and localizer, or within the expanded localizer scale (as installed)
- during a circling approach, wings should be level on final when the aircraft reaches 300 feet above airport elevation.

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

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

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

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

As the aircraft crosses the runway threshold it should be:

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

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

MANEUVERING (INCLUDING RUNWAY CHANGES AND CIRCLING)

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

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

MANDATORY MISSED APPROACH

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

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

LANDING MINIMA

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

Approach charts use the abbreviation DA(H) or MDA(H). DA(H) applies to Category I, II, and certain Category III operations. A decision altitude "DA" or minimum descent altitude "MDA" is referenced to MSL and the parenthetical height "(H)" is referenced to Touchdown Zone Elevation (TDZE) or threshold elevation. Example: A DA(H) of 1,440' (200') is a DA of 1,440' with a corresponding height above the touchdown zone of 200'.

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

RADIO ALTIMETER (RA)

A radio altimeter is normally used to determine DH when a DA(H) is specified for Category II or Category III approaches. Procedures at airports with irregular terrain use a barometric DH and/or a marker beacon to determine the missed approach point. The radio altimeter may also be used to cross check the primary altimeter over known terrain in the terminal area. However, unless specifically authorized, the radio altimeter is not used for determining MDA(H) on instrument approaches. It should also not be used for approaches where use of the radio altimeter is not authorized (RA NOT AUTHORIZED). However, if the radio altimeter is used as a safety backup, it should be discussed in the approach briefing.

MISSED APPROACH POINTS (MAP)

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

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

TIMING DURING APPROACHES

Some regulatory agencies may still require the use of timing for approaches. The timing table, when included, shows the distance from the final approach fix to the MAP.

INSTRUMENT LANDING SYSTEM (ILS)

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

LOCALIZER

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

OTHER NON-ILS APPROACHES

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

PRECISION APPROACH RADAR (PAR)

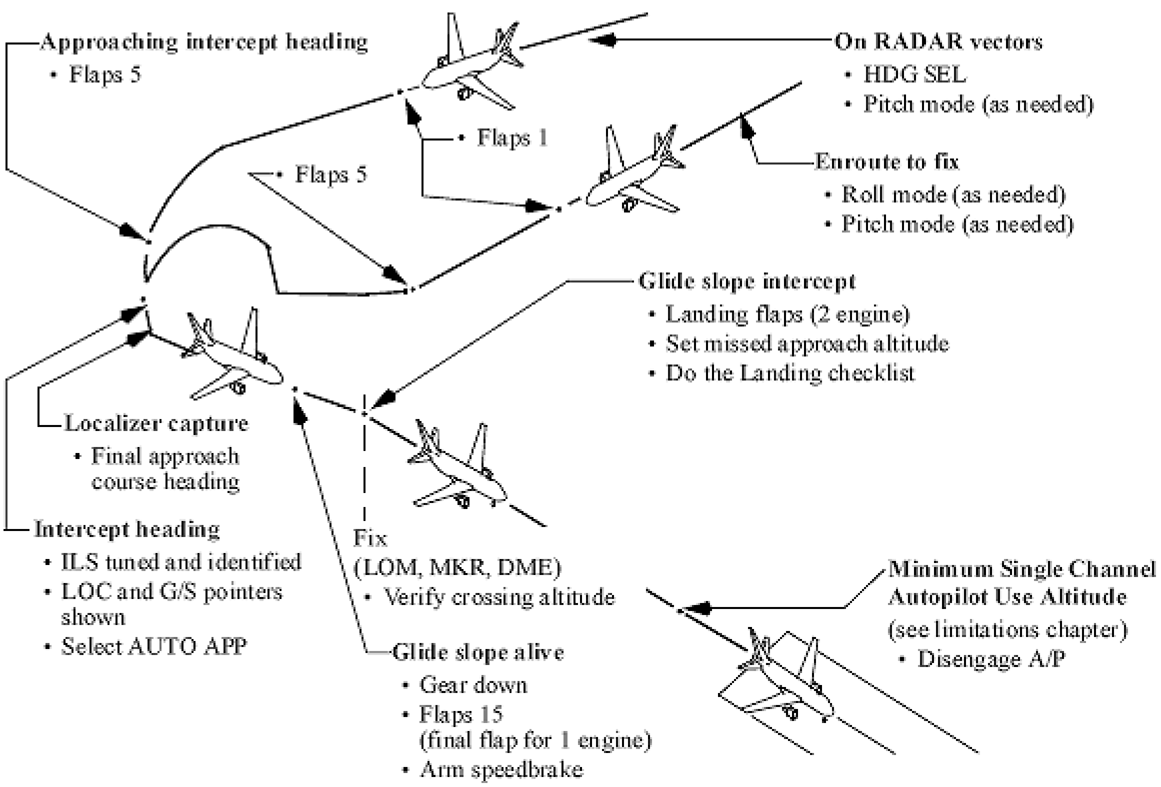
The MAP for a PAR is the geographic point where the glide path intersects the DA(H). Arrival at the MAP is determined by the pilot using the altimeter or as observed by the radar controller, whichever occurs first.

AIRPORT SURVEILLANCE RADAR (ASR)

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

ILS APPROACH

ILS APPROACH PROFILE



ILS APPROACH - GENERAL

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

DECISION ALTITUDE/HEIGHT - DA(H)

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

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

PROCEDURE TURN AND INITIAL APPROACH

Cross the procedure turn fix at flaps 5 maneuvering airspeed.

APPROACH AND FINAL APPROACH

Avoid the tendency for both pilots to be "heads-down" during the approach.

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

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

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

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

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

AUTO APP mode should not be selected until:

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

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

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

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

When on intercept heading, select the AUTO APP mode and observe the VOR/LOC and G/S arm annunciations on the approach progress display. AUTO APP mode should not be selected until both the localizer and glide slope pointers appear on the ADI and you have received clearance for the approach.
The pilots should monitor the quality of the approach, including speedbrake deployment and autobrake (as installed) application.

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

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

At glide slope capture, observe the approach progress display for correct modes. At this time, select landing flaps and VREF + wind correction (minimum VREF + 5), and complete the Landing checklist. The pilot monitoring should continue standard callouts during final approach and the pilot flying should acknowledge callouts.

When established on the glide slope, set the missed approach altitude in the altitude alert window. Extension of landing flaps at speeds in excess of flaps 15 speed may cause flap load relief activation (as installed) and large thrust changes.

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

There have been incidents where airplanes have captured false glide slope signals and maintained continuous on glide slope indications as a result of an ILS ground

transmitter erroneously left in the test mode. False glide slope signals can be detected by crosschecking the final approach fix crossing altitude and verifying a normal pitch attitude and descent rate is indicated on final approach after glide slope capture. Further, if a glide slope anomaly is suspected, an abnormal altitude range-distance relationship may exist. This can be identified by crosschecking distance to the runway with altitude. The altitude should be approximately 300 feet HAT per NM of distance to the runway for a 3° glide slope.

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

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

DELAYED FLAP APPROACH (NOISE ABATEMENT)

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

Intercept the glide slope with gear down and flaps 15 at flaps 15 speed. The thrust required to descend on the glide slope may be near idle. Approaching 1,000 feet AFE, select landing flaps, allow the speed to bleed off to the final approach speed, then adjust thrust to maintain it. Complete the Landing checklist.

DECISION ALTITUDE/HEIGHT - DA(H)

The pilot monitoring should expand the instrument scan to include outside visual cues when approaching DA(H). Do not continue the approach below DA(H) unless the airplane is in a position from which a normal approach to the runway of intended landing can be made and suitable visual reference can be maintained. Upon arrival at DA(H), or any time thereafter, any of the above requirements are not met, immediately execute the missed approach procedure. When visual contact with the runway is established, maintain the glide path to the flare. Do not descend below the glide path.

RAW DATA - (NO FLIGHT DIRECTOR)

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

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

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

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

Large bank angles will rarely be required while tracking inbound on the localizer. Use 5 to 10 degrees of bank angle.

When the glide slope pointer begins to move (glide slope alive), lower the landing gear, extend flaps 15 and decelerate to flaps 15 speed. This may be done in steps, pausing at intermediate settings so that large trim changes are not required at once. Intercepting the glide slope, extend landing flaps and establish the final approach speed. When established on the glide slope, preset the missed approach altitude in the altitude window of the MCP. On final approach maintain VREF + 5 knots or an appropriate correction for headwind component. Check altitude and time crossing the FAF. To stabilize on the final approach speed as early as possible, it is necessary to exercise good speed control during the glide slope intercept phase of the approach. The rate of descent will vary with the glide slope angle and groundspeed. Expeditious and smooth corrections should be made based on the ILS course and glide slope indications. Apply corrections at approximately the same rate and amount as the flight path deviations.

The missed approach procedure is the same as a normal missed approach. Flight Director guidance appears if GA (SP-77) is selected.

LOW VISIBILITY APPROACHES

A working knowledge of approach lighting systems and regulations as they apply to the required visual references is essential to safe and successful approaches. Touchdown RVR is normally controlling for Category I, II, and III approaches. For Category I and II approaches, mid and rollout RVR are normally advisory. For Category III operations mid and rollout RVR may be controlling. In some countries, visibility is used instead of RVR. Approval from the regulatory agency is required to use visibility rather than RVR.

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

A review of the approach and runway lighting systems available during the approach briefing is recommended as the pilot has only a few seconds to identify the lights required to continue the approach. For all low visibility approaches, a review of the airport diagram, expected runway exit, runway remaining lighting and expected taxi route during the approach briefing is recommended.

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

Autopilot or Flight Director System Configuration

Refer to the operator's Category II/IIIa Manual for specific airplane requirements that must be operative for Category II/IIIa operations.

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

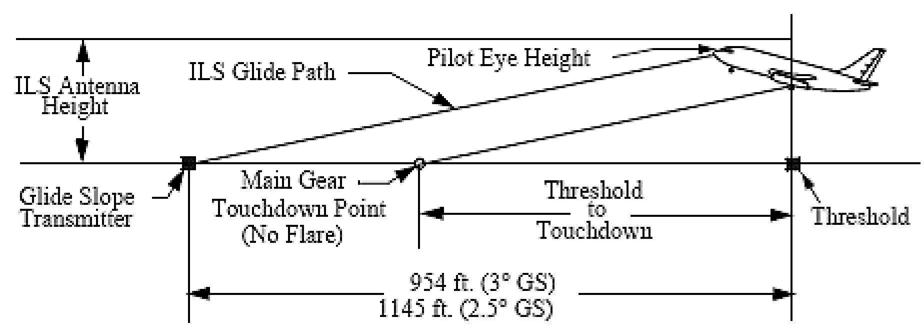
CAT II OPERATIONS

Category II approaches may be conducted using the autopilot, or flight director only, with two engines. For single autopilot operation, the autopilot must be disengaged no lower than the minimum altitude listed in the AFM. Autothrottles should be disconnected when the autopilot is disengaged.

ILS APPROACH/LANDING GEOMETRY

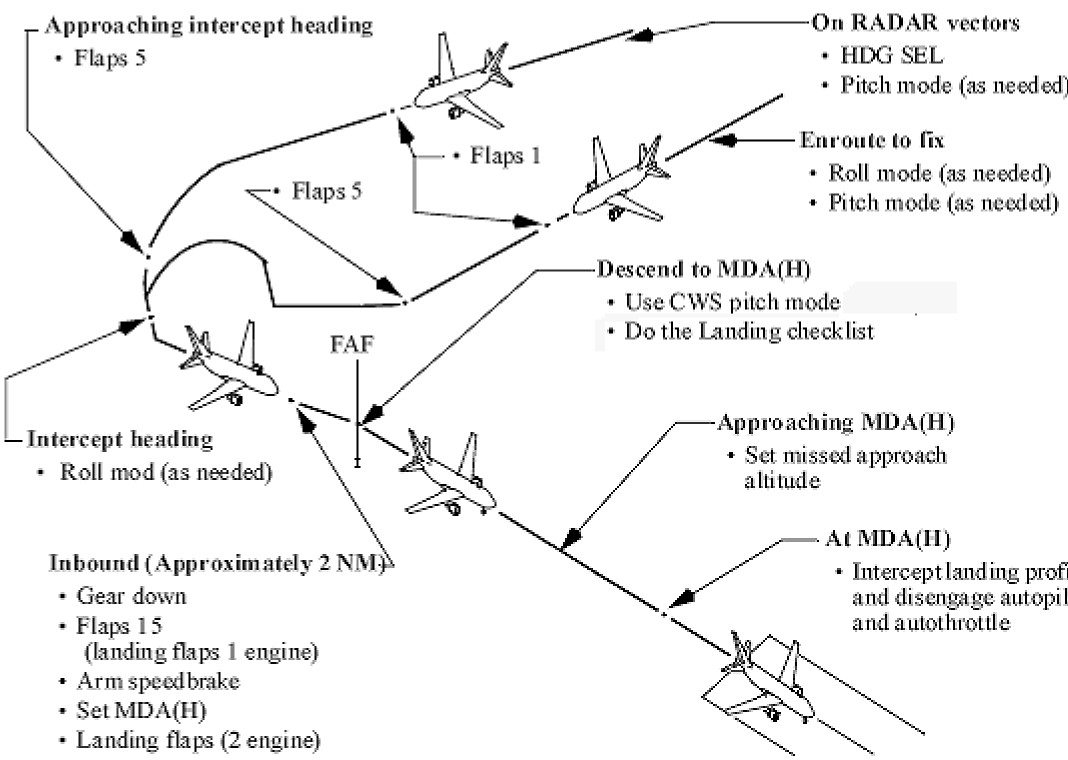
The following diagrams use these conditions:

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



Model	Glide Path (deg)	Airplane Body Attitude (deg)	Main Gear (feet)	Pilot Eye Height (feet)	Threshold to Main Gear Touchdown Point - No Flare (feet)
737 - 200	2.5	5.4	30.9	48.9	708.5
	3.0	4.9	30.9	48.5	590.1
737 - 200 Adv	2.5	4.4	31.8	48.9	727.7
	3.0	3.9	31.8	48.5	606.1

NON - ILS INSTRUMENT APPROACHES



NON - ILS INSTRUMENT APPROACHES - GENERAL

Non-ILS approaches are defined as:

- VOR approach
- NDB approach

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

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

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

A typical Non-ILS Instrument Approach as illustrated, assumes all preparations for the approach have been completed. Navaids are tuned and identified; final approach course is set (VOR or Localizer); RMIs are displaying appropriate course or bearing information; minimum descent altitude is set, and the approach briefing is complete. The procedure illustrated focuses generally on crew actions and avionics systems information. The flight pattern may be modified to suit local traffic and air traffic requirements.

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

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-IL S approaches, autopilot use allows better course and vertical path tracking accuracy, reduces the probability of inadvertent deviations below path, and is therefore recommended until suitable visual reference is established on final approach.

Manually flying non-ILS approaches in IMC conditions increases workload and does not take advantage of the significant increase in efficiency and protection provided by the automatic systems. However, to maintain flight crew proficiency, pilots may elect to use the flight director without the autopilot when in VMC conditions.

Note: The autopilot should remain engaged until suitable visual reference has been established.

RAW DATA MONITORING REQUIREMENTS

Raw data monitoring is required for all instrument approaches. Non - ILS Approach - One Engine Inoperative
Maneuvering prior to and after the final approach fix with one engine inoperative is the same as for an all engine non-ILS approach.

APPROACH PREPARATIONS

Non-ILS approaches are normally flown using the CWS pitch mode.
Non-ILS approach recommended roll modes are:

- VOR or Localizer: VOR LOC
- NDB or ASR: HDG SEL

Use MDA(H) for the approach minimum altitude. Set the barometric minimums at MDA + 50 feet to ensure that, if a missed approach is initiated, descent below the MDA(H) does not occur during the missed approach.

PROCEDURE TURN AND INITIAL APPROACH

Approaching intercept heading, select flaps 5 and select appropriate roll mode. Cross the procedure turn fix at flaps 5 and flaps 5 maneuvering airspeed. Approaching the FAF (approximately 2 NM), select gear down and flaps 15 and adjust speed. Set the altitude alert controller to the first intermediate altitude constraint, or MDA + 50 feet if no altitude constraint exists.

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

Just before the FAF, select landing flaps, reduce to final approach speed and complete the Landing checklist. If the charted FAF is too close to the runway to permit a stabilized approach, consider establishing final approach pitch mode and configuring for approach and landing earlier than specified in the FCOM procedure.

FINAL APPROACH

At or after the FAF, use CWS pitch mode and descend at appropriate vertical speed to arrive at the MDA(H) at a distance from the runway (VDP) to allow a normal landing profile. Establish an appropriate vertical speed considering the recommended vertical speeds that are published on the approach chart, if available. These recommended vertical speeds vary with the airplane's ground speed on final approach. If no recommended vertical speeds are available, set approximately 700 to 800 fpm.

A technique that may be used to achieve a constant angle path that arrives at MDA(H) at or near the VDP is to use 300 feet per mile for a 3° path. Determine the desired HAA which corresponds to the distance in NM from the runway end using the following table. The PM can then call out recommended altitudes as the distance to the runway changes (Example: 900 feet - 3 NM, 600 feet - 2NM, etc.). The descent rate should be adjusted in small increments for significant deviations from the nominal path. There should be no level flight segment at minimums.

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

Be prepared to land or go-around from the MDA(H) at the VDP. Note that a normal landing cannot be completed from the published missed approach point on many instrument approaches.

For airplanes equipped with the SP-77 autopilot, approximately 300 feet above the MDA(H), select the missed approach altitude. Leaving the MDA(H), disengage the autopilot and turn both F/Ds OFF. Complete the landing.

MINIMUM DESCENT ALTITUDE/HEIGHT (MDA(H))

The pilot monitoring should expand the instrument scan to include outside visual cues when approaching MDA(H). Do not continue the approach below MDA(H) unless the airplane is in a position from which a normal approach to the runway of intended landing can be made and suitable visual reference can be maintained. Upon arrival at MDA(H) or any time thereafter, if any of the above requirements are not met, immediately execute the missed approach procedure.

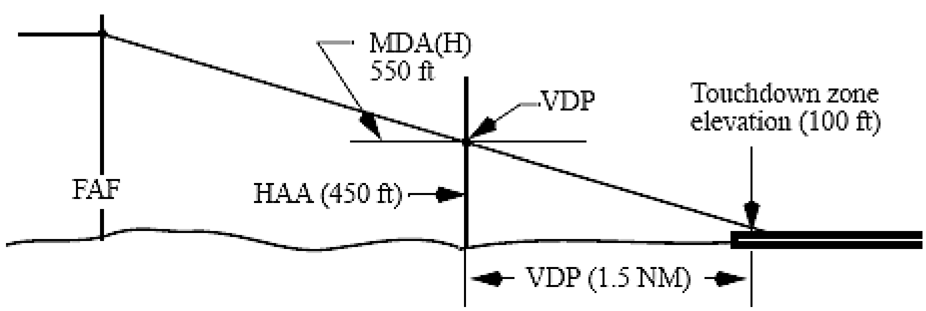
When suitable visual reference is established, maintain the descent path to the flare. Do not descend below the visual glide path.

VISUAL DESCENT POINT

For a non-IL S 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 XA NM distance from the runway.



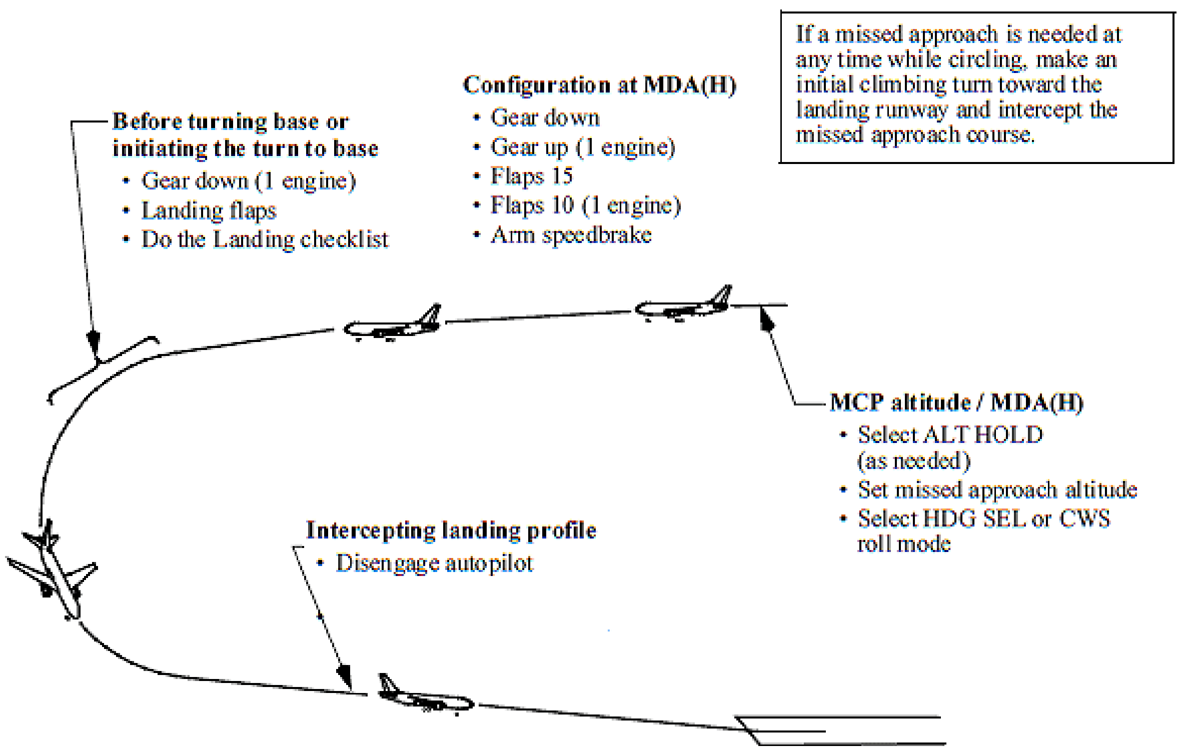
Most VDPs are between 1 and 2 NM from the runway. The following table provides more examples.

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

MISSED APPROACH - NON-ILS

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

CIRCLING APPROACH



CIRCLING APPROACH - GENERAL

The circling approach should be flown with landing gear down, flaps 15, and at flaps 15 maneuvering speed. Use the weather minima associated with the anticipated circling speed. Maintain MDA(H) using ALT HOLD mode and use HDG SEL or CWS roll mode for the maneuvering portion of the circling approach. If circling from an ILS approach, fly the ILS in VOR/LOC and CWS.

Note: If the MDA does not end in "00", set the altitude alert controller to the nearest 100 feet above the MDA and circle at MCP altitude.

Use of the Auto Approach mode for descent to a circling approach is not recommended for several reasons:

- the autopilot does not level off at the altitude set in the altitude alert controller
- exiting the Auto Approach mode requires initiating a go-around or disconnecting the autopilot and turning off the flight directors.

When in altitude hold at MDA and prior to commencing the circling maneuver, set the missed approach altitude.

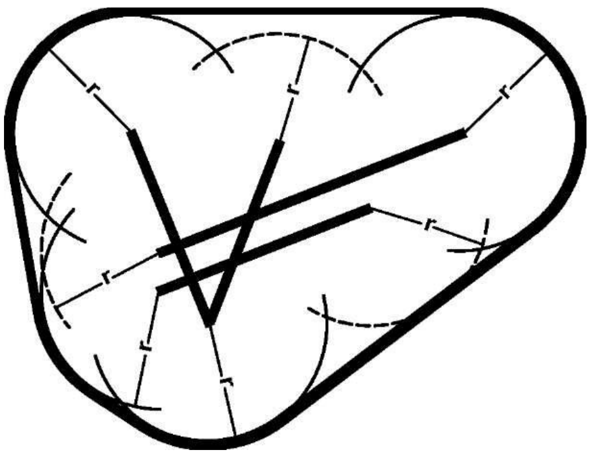
Before turning base or when initiating the turn to base leg, select landing flaps and and begin decelerating to the approach speed plus wind correction. To avoid overshooting final approach course, adjust the turn to final to initially aim at the inside edge of the runway threshold. Timely speed reduction also reduces turning radius to the runway. Complete the landing checklist. Do not descend below MDA until intercepting the visual profile to the landing runway.

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

After intercepting the visual profile, cycle both F/D to OFF, and select the PNF F/D to ON. This eliminates unwanted commands and allows F/D guidance in the event of a go-around. Complete the landing.

OBSTRUCTION CLEARANCE

Obstruction clearance areas during the circling approach are depicted in the following figure. Distances are determined by aircraft approach category. Adjust airplane heading and timing so that the airplane ground track does not exceed the obstruction clearance distance from the runway at any time during the circling approach.



Radius (r), defining size of areas, varies with airplane category.

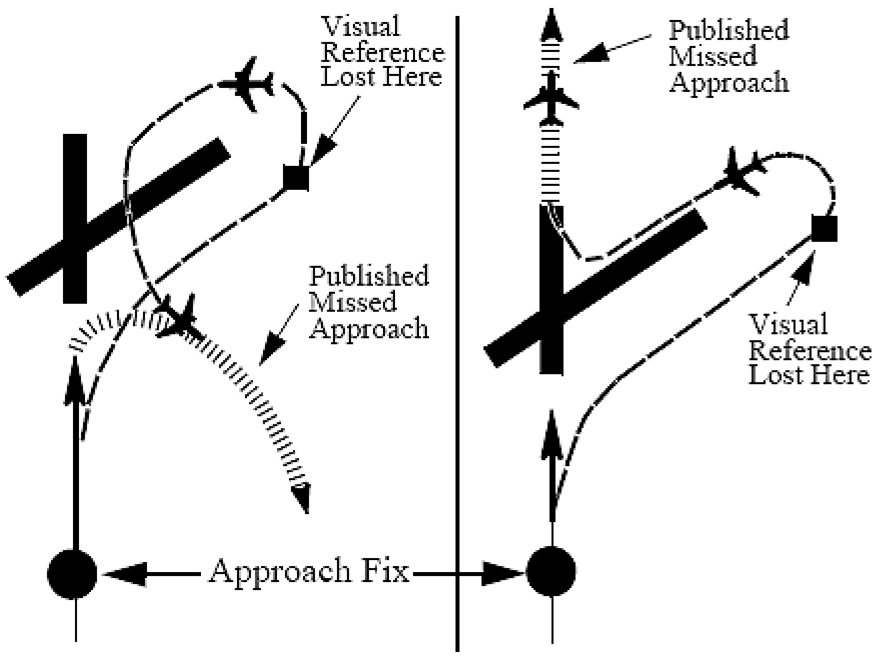
Aircraft Category	FAA Obstruction Clearance Radius (r)	ICAO Obstruction Clearance Radius (r)
C	1.7 NM	4.2 NM
D	2.3 NM	5.28 NM

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.

VISUAL REFERENCE

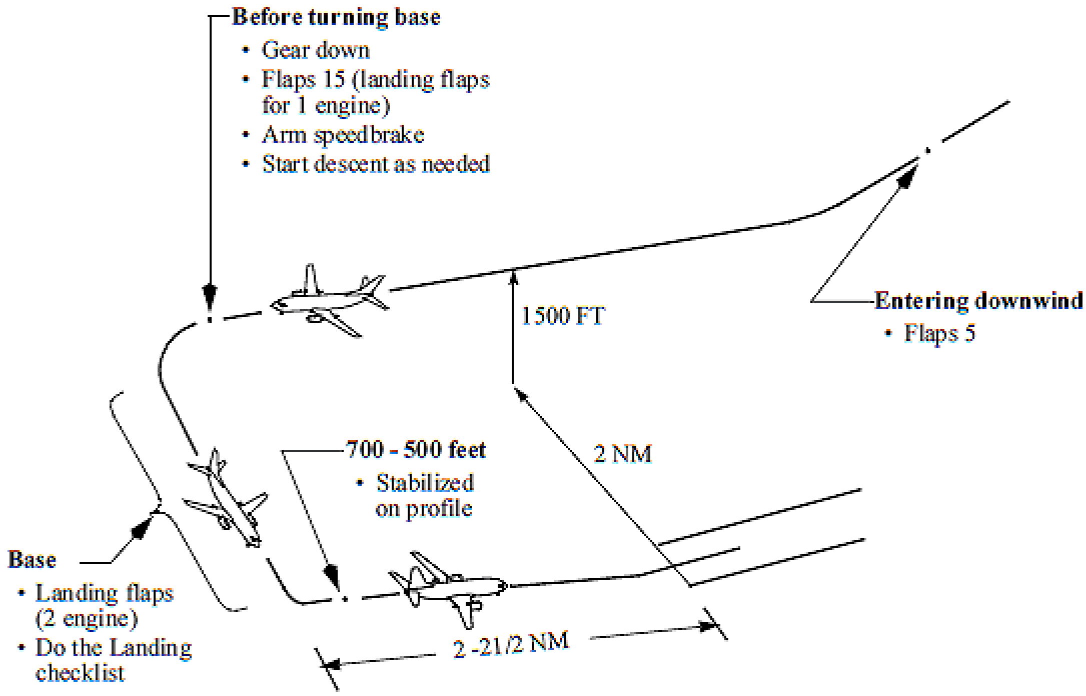
Different patterns may be required to become established on the prescribed missed approach course. This depends on airplane position at the time the missed approach is started. The following figure illustrates the maneuvering that may be required. This ensures the airplane remains within the circling and missed approach obstruction clearance areas.



In the event that a missed approach must be accomplished from below the MDA(H), consideration should be given to selecting a flight path which assures safe obstacle clearance until reaching an appropriate altitude on the specified missed approach path.

Refer to Missed Approach/Go-Around - All Approaches.

VISUAL TRAFFIC PATTERN



VISUAL APPROACH - GENERAL

The recommended landing approach path is approximately 2 1/2° to 3°. Once the final approach is established, the airplane configuration remains fixed and only small adjustments to the glide path, approach speed, and trim are necessary. This results in the same approach profile under all conditions.

THRUST

Engine thrust and elevators are the primary means to control attitude and rate of descent. Adjust thrust slowly using small increments. Sudden large thrust changes make airplane control more difficult and are indicative of an unstable approach. No large changes should be necessary except when performing a go-around. Large thrust changes are not required when extending landing gear or flaps on downwind and base leg. A thrust increase may be required when stabilizing on speed on final approach.

DOWNWIND AND BASE LEG

Fly at an altitude of 1500 feet above the runway elevation and enter downwind with flaps 5 at flaps 5 maneuvering speed. Maintain a track parallel to the landing runway approximately 2 NM abeam.

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

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

FINAL APPROACH

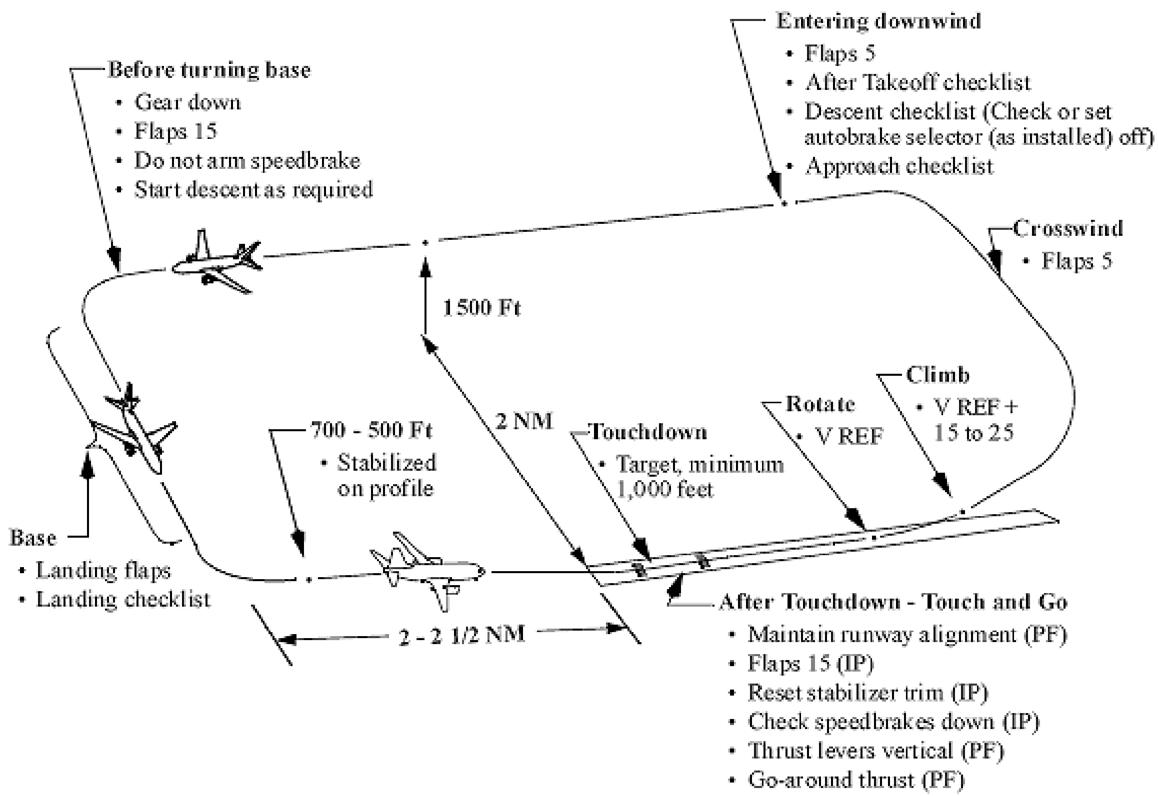
Roll out of the turn to final on the extended runway centerline and maintain the appropriate approach speed. An altitude of approximately 300 feet above airport elevation for each mile from the runway provides a normal approach profile. Attempt to keep thrust changes small to avoid large trim changes. With the airplane in trim and at target airspeed, pitch attitude should be approximately the normal approach body attitude. At speeds above approach speed, pitch attitude is less. At speeds below approach speed, pitch attitude is higher. Slower speed reduces aft body clearance at touchdown. Stabilize the airplane on the selected approach airspeed with an approximate rate of descent between 700 and 900 feet per minute on the desired glide path, in trim. Stabilize on the profile by 500 feet above touchdown.

Note: Descent rates greater than 1,000 fpm should be avoided.

With one engine inoperative, the rudder trim may be centered 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.

TOUCH AND GO LANDINGS



TOUCH AND GO LANDING – GENERAL

The primary objective of touch and go landings is approach and landing practice. It is not intended for landing roll and takeoff procedure training.

APPROACH

Accomplish the pattern and approach procedures as illustrated.The landing gear may remain extended throughout the maneuver for brake cooling, but be prepared to retract the landing gear if an actual engine failure occurs during go-around. Do not arm the speedbrakes. Select the autobrakes (as installed) OFF.

LANDING

The trainee should accomplish a normal final approach and landing. After touchdown, the instructor selects flaps 15, sets stabilizer trim, ensures speedbrakes are down, and at the appropriate time instructs the trainee to move the thrust levers to approximately the vertical position (so engines stabilize before applying go-around thrust). When the engines are stabilized, the instructor instructs the trainee to set thrust.

Note: Flaps 15 is recommended after touchdown to minimize the possibility of a tailstrike during the takeoff.
WARNING: After reverse thrust is initiated, a full stop landing must be made.

At VREF, the instructor calls "ROTATE" and the trainee rotates smoothly to approximately 15 ° pitch and climb at VREF + 15 to 25 knots. The takeoff warning horn may sound momentarily if the flaps have not retracted to flaps 15 and the thrust levers are advanced to approximately the vertical position.

STOP AND GO LANDINGS

The objective of stop and go landings is to include landing roll, braking, and takeoff procedure practice in the training profile.

Note: At high altitude airports, or on extremely hot days, stop and go landings are not recommended.

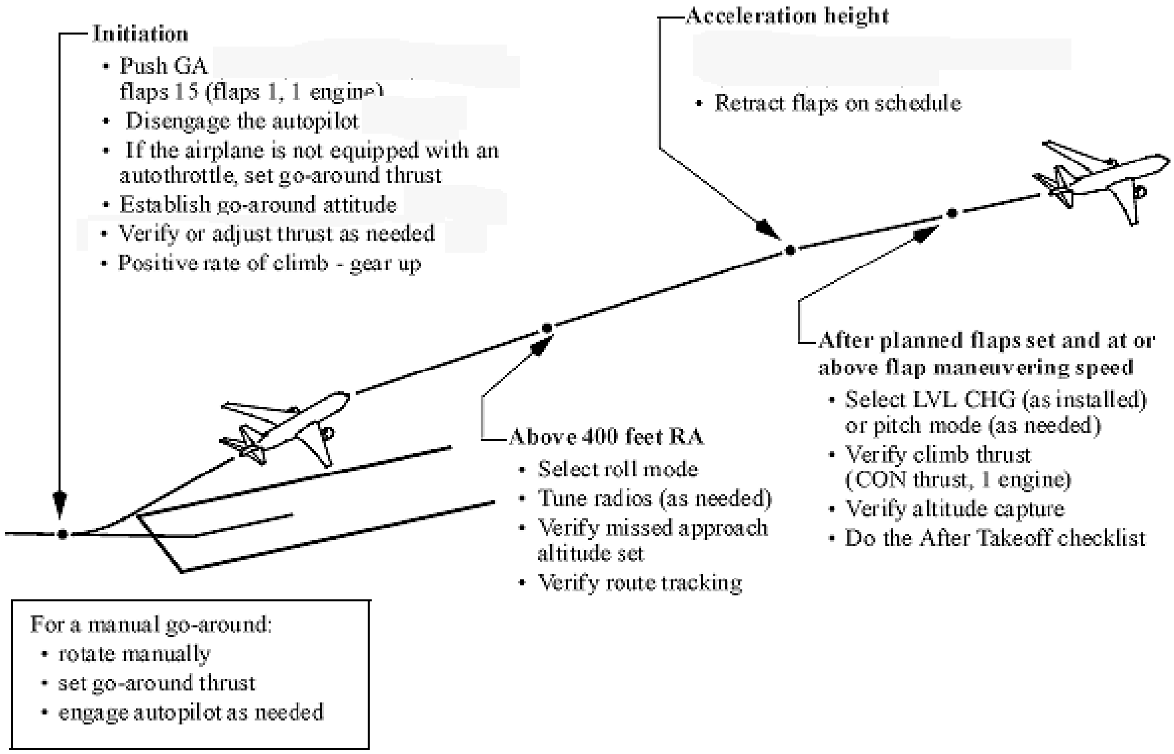
After performing a normal full-stop landing, a straight ahead takeoff may be performed if adequate runway is available (FAR field length must be available). After stopping, and before initiating the takeoff, accomplish the following:

- set takeoff flaps
- trim the stabilizer for takeoff
- place speedbrake lever in the down detent
- check the rudder trim
- set airspeed bugs for the flap setting to be used. Perform a normal takeoff.

Do not make repeated full stop landings without allowing time for brake cooling. Brake heating is cumulative and brake energy limits may be exceeded. Flat tires may result.

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

GO-AROUND AND MISSED APPROACH - ALL APPROACHES



GO-AROUND AND MISSED APPROACH - ALL ENGINES OPERATING

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

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

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

At typical landing weights, actual thrust required for a normal go-around is usually considerably less than maximum go-around thrust. This provides a thrust margin for windshear or other situations requiring maximum thrust.

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

The minimum altitude for flap retraction during a normal takeoff is not normally applicable to a missed approach procedure. However, obstacles in the missed approach flight path must be taken into consideration. During training, use 1,000 feet AGL to initiate flap retraction, as during the takeoff procedure.

If initial maneuvering is required during the missed approach, accomplish the missed approach procedure through gear up before initiating the turn. Delay further flap retraction until initial maneuvering is complete and a safe altitude and appropriate speed are attained.

LANDING

PREFACE

This chapter outlines recommended operating practices and techniques for landing, rejected landings and landing roll. Techniques are provided to help the pilot effectively utilize approach lighting, control the airplane during crosswind landings and maintain directional control after landing. Additionally, information on factors affecting landing distance and landing geometry is provided.

LANDING CONFIGURATIONS AND SPEEDS

Flaps 15, 30 (for noise abatement) and 40 are normal landing flap positions. Flaps 15 is normally limited to airports where approach climb performance is a factor. Runway length and condition must be taken into account when selecting a landing flap position.

MANEUVER MARGIN

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

Full maneuver margin exists for all normal landing procedures whenever speed is at or above the maneuver speed for the current flap setting. Full maneuver margin exists with flaps 15 at VREF 30 + 5 or VREF 40 + 5 during a go-around at go-around thrust.

Airspeeds recommended for non-normal flight profiles are intended to restore near normal maneuvering margins and/or aerodynamic control response.

The configuration changes are based on maintaining full maneuvering and/or maximum performance unless specified differently in individual procedures. It is necessary to apply wind correction to the VREF speeds. See the Command Speed section in chapter 1 for an explanation of wind corrections.

NON-NORMAL LANDING CONFIGURATIONS AND SPEEDS

The Non-Normal Configuration Landing Distance table in the Performance Inflight chapter of the QRH shows speeds and landing distances for various non-normal landing configurations and runway conditions. The target speed for the approach is the appropriate approach VREF plus the wind and gust additives.

NON-NORMAL LANDING DISTANCE

Because of higher approach speeds associated with the non-normal landing condition the actual landing distance is increased. The flight crew should review the non-normal configuration landing distance information in the Performance Inflight section of the QRH.

VISUAL APPROACH SLOPE INDICATOR (VASI/T - VASI)

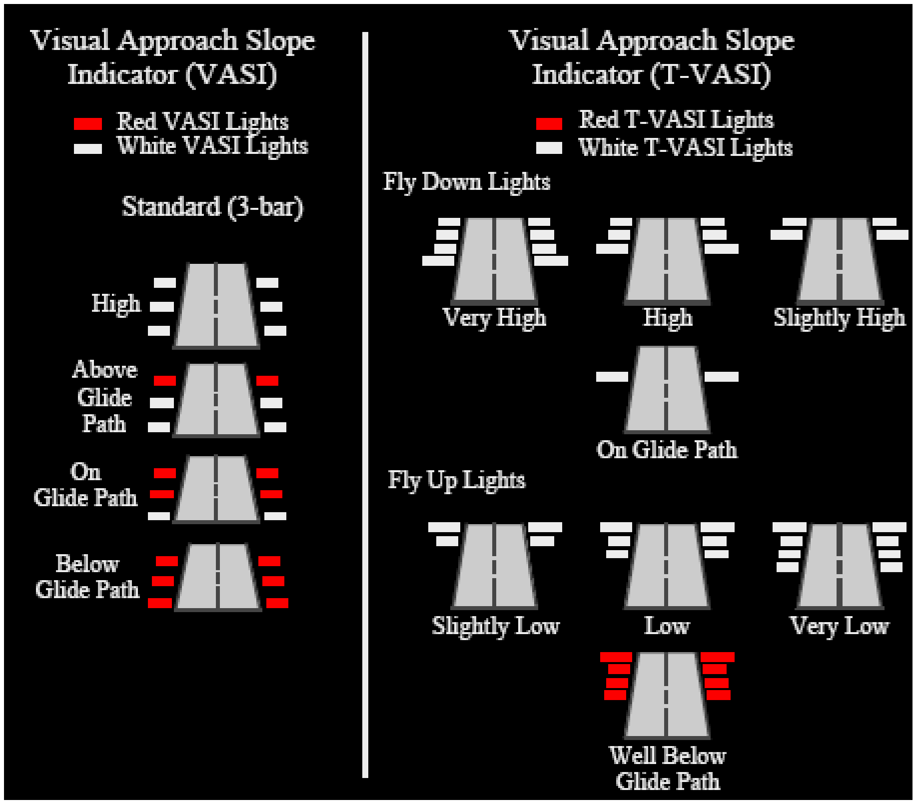
The VASI is a system of lights arranged to provide visual descent guidance information during the approach. All VASI systems are visual projections of the approach path normally aligned to intersect the runway at a point 1,000 or 1,800 feet beyond the threshold. Flying the VASI glide slope to touchdown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

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

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

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

THREE BAR VASI/T – VASI



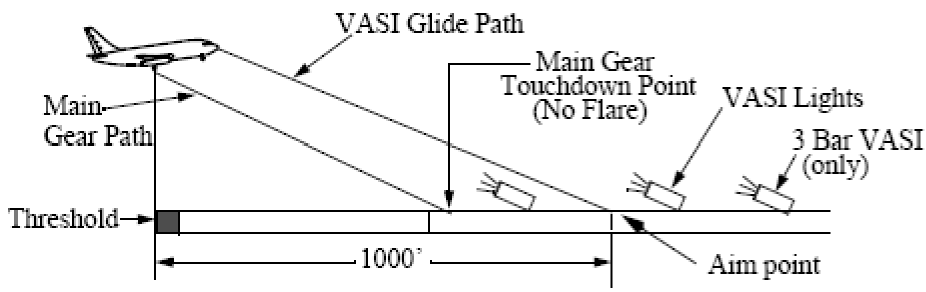
VASI LANDING GEOMETRY

Two-bar VASI installations provide one visual glide path which is normally set at 3°. Three-bar VASI installations provide two visual glide paths. The lower glide path is provided by the near and middle bars and is normally set at 3° while the upper glide path, provided by the middle and far bars, is normally 1/4° higher (3.25°). This higher glide path is intended for use only by high cockpit (long wheelbase) airplanes to provide a sufficient threshold crossing height.

TWO BAR/THREE BAR VASI LANDING GEOMETRY

The following diagrams use these conditions:

- data is based upon typical landing weight
- airplane body attitudes are based on Flaps 30 and Flaps 40, VREF (for the flap setting used) + 5 and should be reduced by 1° for each 5 knots above this speed.
- eye height is calculated at the moment the main gear is over the threshold.



Flaps 40			AIM Point at 1,000 Feet		
737 Model	Visual Glide Path (degrees)	Airplane Body Attitude (degrees)	Threshold Height		Main Gear Touchdown Point - no flare (feet)
			Pilot Eye Height (feet)	Main Gear Height (feet)	
-200	3.0	4.9	50.4	34.6	660
-200 Adv	3.0	3.9	50.4	35.3	673

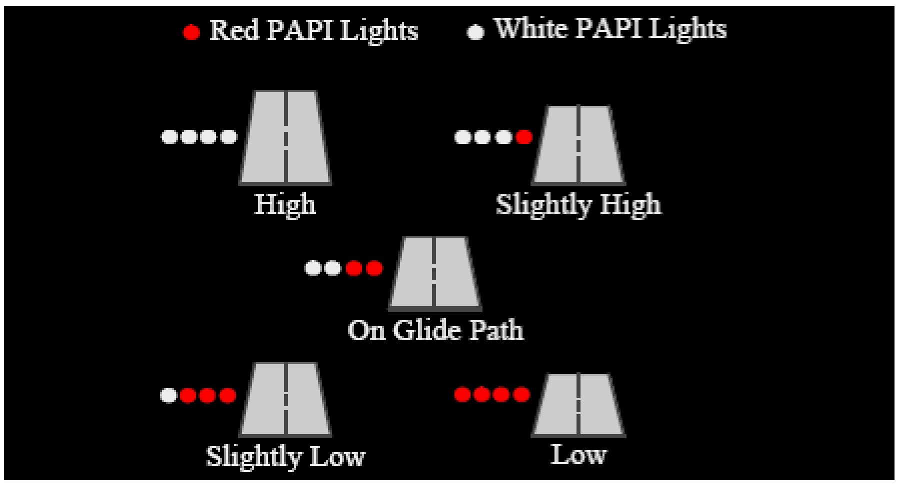
Flaps 40			AIM Point at 1,000 Feet		
737 Model	Visual Glide Path (degrees)	Airplane Body Attitude (degrees)	Threshold Height		Main Gear Touchdown Point - no flare (feet)
			Pilot Eye Height (feet)	Main Gear Height (feet)	
-200	3.0	2.3	50.4	36.3	693
-200 Adv	3.0	1.7	50.4	36.7	700

PRECISION APPROACH PATH INDICATOR (PAPI)

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

When the airplane is on a normal 3° glide path, the pilot sees two white lights on the left and two red lights on the right. The PAPI may be safely used with respect to threshold height, but may result in landing further down the runway. The PAPI is normally aligned to intersect the runway 1,000 to 1,500 feet down the runway.

PAPI LANDING GEOMETRY



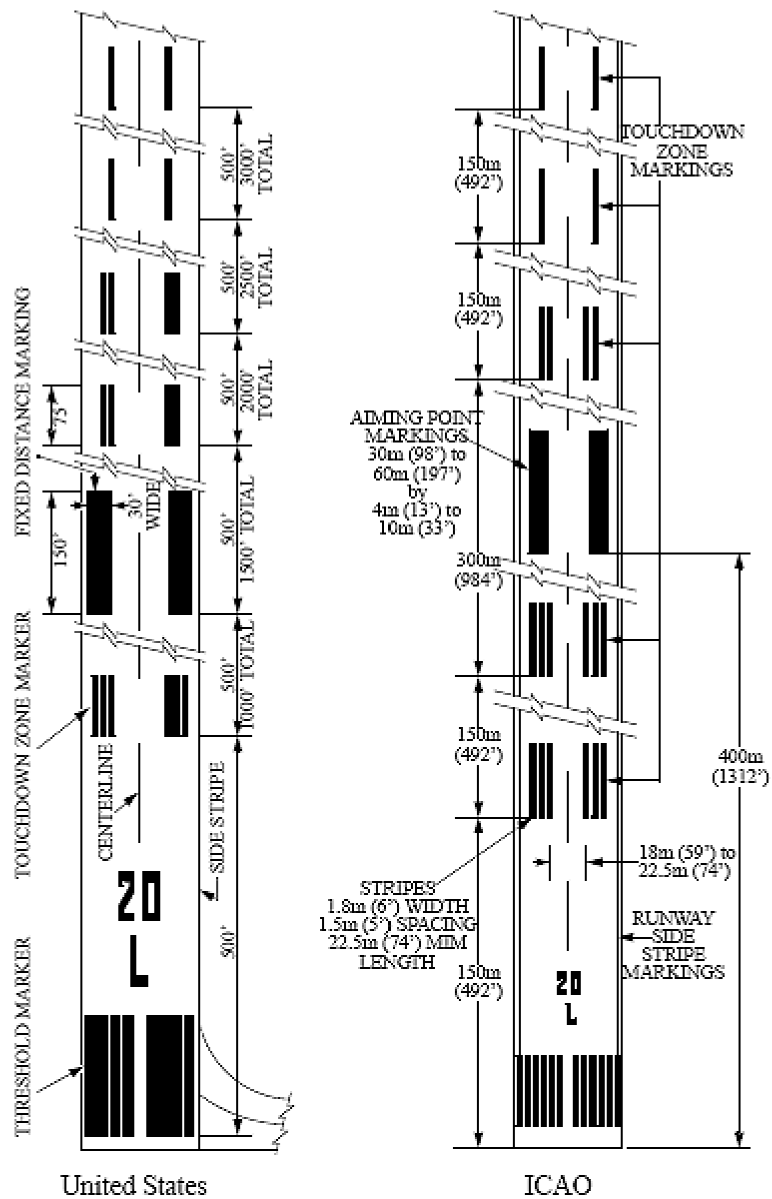
LANDING GEOMETRY VISUAL AIM POINT

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

Visual aim points versus gear touchdown point differences increase as glide path angle decreases as in a flat approach. For a particular visual approach, the difference between gear path and eye level path must be accounted for by the pilot.

LANDING RUNWAY MARKINGS (TYPICAL)

The following runway markings are for runways served by a precision approach.



THRESHOLD HEIGHT

Threshold height is a function of glide path angle and landing gear touchdown target. Threshold height for main gear and pilot eye level is shown in the Two Bar/Three Bar VASI Landing Geometry tables on a previous page. Special attention must be given to establishing a final approach that assures safe threshold clearance and gear touchdown at least 1,000 feet down the runway. The radio altimeter should be used to assist the pilot in judging terrain clearance, threshold height and flare initiation height

FLARE AND TOUCHDOWN

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

When the threshold passes under the airplane nose and out of sight, shift the visual sighting point to approximately 3/4 the runway length. 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 15 feet above the runway by increasing pitch attitude approximately 2° - 3°. This slows the rate of descent.

After the flare is initiated, smoothly retard the thrust levers to idle, and make small pitch attitude adjustments to maintain the desired descent rate to the runway. Ideally, main gear touchdown should occur simultaneously with thrust levers reaching idle. A smooth power reduction to idle also assists in controlling the natural nose-down pitch change associated with thrust reduction. Hold sufficient back pressure on the control column to keep the pitch attitude constant. A touchdown attitude as depicted in the figure below is normal with an airspeed of approximately VREF plus any gust correction.

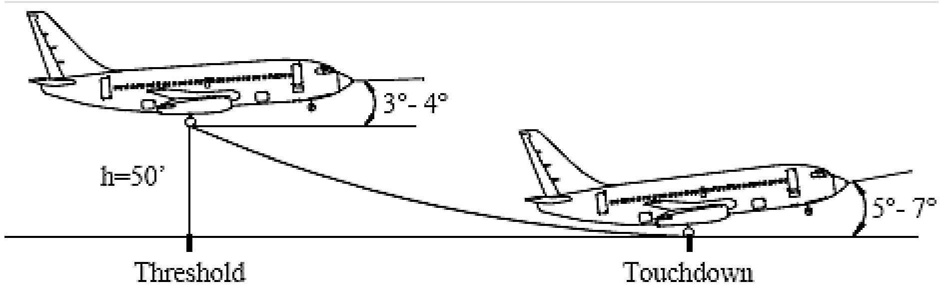
Note: Do not trim during flare or after touchdown.Trimming in the flare increases the possibility of a tailstrike.

LANDING FLARE PROFILE

The following diagram uses these conditions:

- 3° approach glide path
- flare distance is approximately 1,000 to 2,000 feet beyond the threshold
- typical landing flare times range from 4 to 8 seconds and are a function of the approach speed

- airplane body attitudes are based upon typical landing weights, flaps 30, VREF 30 + 5 (approach) and VREF 30 + 0 (landing), and should be reduced by 1° for each 5 knots above this speed.



Typically, the pitch attitude increases slightly during the actual landing, but avoid over-rotating. Do not increase the pitch attitude after touchdown; this could lead to a tail strike.

Shifting the visual sighting point down the runway assists in controlling the pitch attitude during the flare. A smooth power reduction to idle also assists in controlling the natural nose down pitch change associated with thrust reduction. Hold sufficient back pressure on the control column to keep the pitch attitude constant.

Avoid rapid control column movements during the flare. Do not use pitch trim during flare or after touchdown. Such actions are likely to cause the pitch attitude to increase at touchdown and increase the potential for a tailstrike. Do not allow the airplane to float; fly the airplane onto the runway. Do not attempt to extend the flare by increasing pitch attitude in an attempt to achieve a perfectly smooth touchdown. Do not attempt to hold the nose wheel off the runway.

BOUNCED LANDING RECOVERY

If the airplane should bounce, hold or re-establish a normal landing attitude and add thrust as necessary to control the rate of descent. Thrust need not be added for a shallow bounce or skip. When a high, hard bounce occurs, initiate a go-around. Apply go-around thrust and use normal go-around procedures. Do not retract the landing gear until a positive rate of climb is established because a second touchdown may occur during the go-around.

Bounced landings can occur because higher than idle power is maintained through initial touchdown, disabling the automatic speedbrake deployment even when the speedbrakes are armed. During the resultant bounce, if the thrust levers are then retarded to idle, automatic speedbrake deployment can occur resulting in a loss of lift and nose up pitching moment which can result in a tail strike or hard landing on a subsequent touchdown.

GO-AROUND AFTER TOUCHDOWN

If a go-around is initiated prior to 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 prior to thrust reverser selection, auto speedbrakes retract and autobrakes disarm as thrust levers are advanced. The F/D go-around mode will not be available until go-around is selected after becoming airborne.

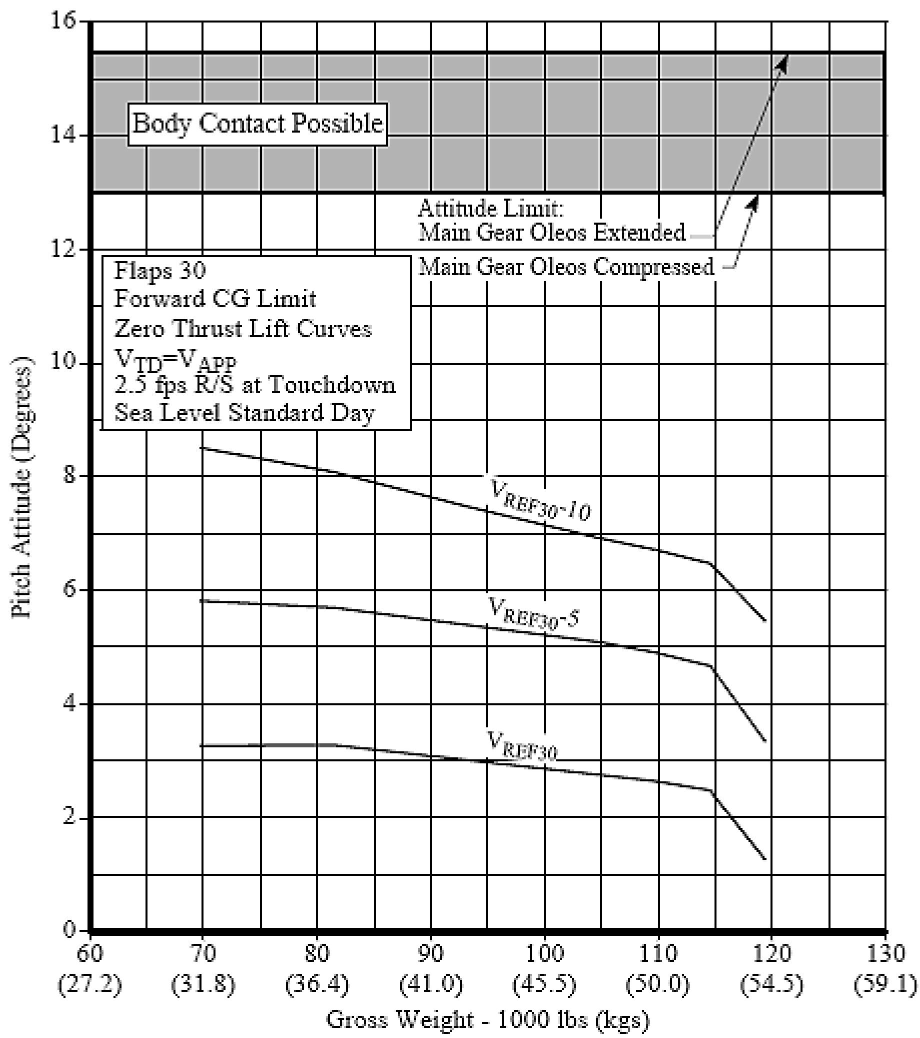
Once reverse thrust is initiated following touchdown, a full stop landing must be made. Factors dictating this are:

- five seconds are required for a reverser to transition to the forward thrust position
- a possibility exists that a reverser may not stow in the forward thrust position.

NORMAL TOUCHDOWN ATTITUDE

If flare control and thrust are excessive near touchdown, the airplane tends to float in ground effect.

With proper airspeed control and thrust management, touchdown occurs at no less than VREF - 5.



PITCH AND ROLL LIMIT CONDITIONS

The Ground Contact Angles - Normal Landing figure illustrates body roll angle/pitch angles at which the airplane structure contacts the runway. Prolonged flare increases the body pitch attitude 2° to 3°. When prolonged flare is coupled with a misjudged height above the runway aft body contact is possible.
Fly the airplane onto the runway at the desired touchdown point and at the desired airspeed. Do not hold it off and risk the possibility of a tailstrike.

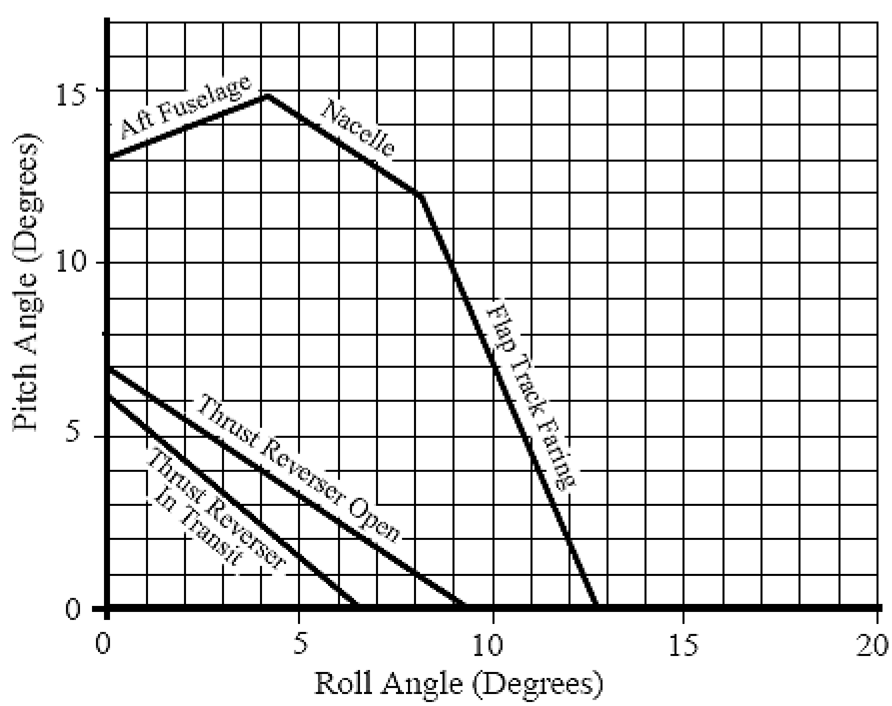
Note: A smooth touchdown is not the criterion for a safe landing.

GROUND CONTACT ANGLES - NORMAL LANDING

Conditions

- Pitch about gear centerline
- Slats fully extended

1. • Aileron full down
2. Roll about outer tire centerline
3. Stabilizer full nose up
4. Elevator full down
5. Struts compressed
6. Flaps 40



AFTER TOUCHDOWN AND LANDING ROLL

Avoid touching down with thrust above idle since this may establish an airplane nose up pitch tendency and increases landing roll.

After main gear touchdown, initiate the landing roll procedure. If the speedbrakes do not extend automatically move the speedbrake lever to the UP position without delay. Fly the nosewheel onto the runway smoothly by relaxing aft control column pressure. Control column movement forward of neutral should not be required. Do not attempt to hold the nosewheel off the runway. Holding the nose up after touchdown for aerodynamic braking is not an effective braking technique.

To avoid the risk of possible airplane structural damage, do not make large nose down control column movements prior to nose wheel touchdown.

To avoid the risk of tailstrike, do not allow the pitch attitude to increase after touchdown. However, applying excessive nose down elevator during landing can result in substantial forward fuselage damage. Do not use full down elevator. Use an appropriate autobrake setting or manually apply wheel brakes smoothly with steadily increasing pedal pressure as required for runway condition and runway length available. Maintain deceleration rate with constant or increasing brake pressure as required until stopped or desired taxi speed is reached.

SPEEDBRAKES

The speedbrake system is controlled with the SPEEDBRAKE lever (which is moved UP and DOWN). The speedbrake system consists of individual spoiler panels which the pilot can extend and retract by moving the SPEEDBRAKE lever.

The speedbrakes can be fully raised after touchdown while the nose wheel is lowered to the runway, with no adverse pitch effects. The speedbrakes spoil the lift from the wings, which places the airplane weight on the main landing gear, providing excellent brake effectiveness.

Unless speedbrakes are raised after touchdown, braking effectiveness may be reduced initially as much as 60%, since very little weight is on the wheels and brake application may cause rapid anti-skid modulation.

Normally, speedbrakes are armed to extend automatically. Both pilots should monitor speedbrake extension after touchdown. In the event auto extension fails, the speedbrake should be manually extended immediately.

Pilot awareness of the position of the speedbrake lever during the landing phase is important in the prevention of over-run. The position of the speedbrakes should be announced during the landing phase by the PM. This improves the crew's situational awareness of the position of the spoilers during landing and builds good habit patterns which can prevent failure to observe a malfunctioned or disarmed spoiler system.

DIRECTIONAL CONTROL AND BRAKING AFTER TOUCHDOWN

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

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

FACTORS AFFECTING LANDING DISTANCE

Advisory information for normal and non-normal configuration landing distances is contained in the PI section of the QRH. Actual stopping distances for a maximum effort stop are approximately 60% of the dry runway field length requirement. Factors that affect stopping distance include: height and speed over the threshold, glide slope angle, landing flare, lowering the nose to the runway, use of reverse thrust, speedbrakes, wheel brakes and surface conditions of the runway.

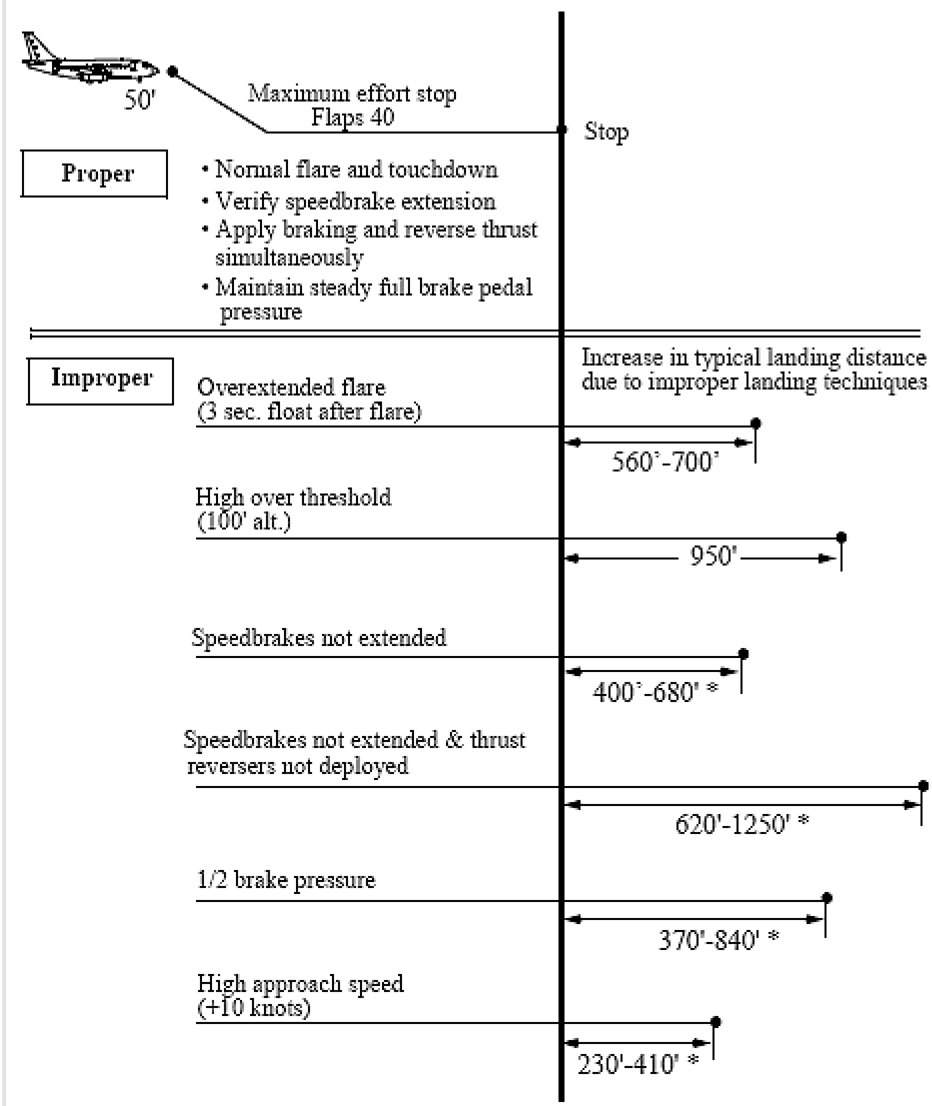
Note: Reverse thrust and speedbrake drag are most effective during the high speed portion of the landing. Deploy the speedbrake lever and activate reverse thrust with as little time delay as possible.

Note: Speedbrakes fully deployed, in conjunction with maximum reverse thrust and maximum manual anti-skid braking provides the minimum stopping distance.

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

Height of the airplane over the runway threshold also has a significant effect on total landing distance. For example, on a 3° glide path, passing over the runway threshold at 100 feet altitude rather than 50 feet could increase the total landing distance by approximately 950 feet. This is due to the length of runway used up before the airplane actually touches down.

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.



* Landing distance varies with runway condition, wet or dry. Data excludes contaminated runway considerations.

WHEEL BRAKES

Braking force is proportional to the force of the tires on the runway and the coefficient of friction between the tires and the runway. The contact area normally changes little during the braking cycle. The perpendicular force comes from airplane weight and any downward aerodynamic force such as speedbrakes. The coefficient of friction depends on the tire condition and runway surface, e.g., concrete, asphalt, dry, wet or icy.

AUTOMATIC BRAKES (AS INSTALLED)

Boeing recommends that whenever runway limited, using higher than normal approach speeds, landing on slippery runways or landing in a crosswind, the autobrake system be used.

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

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

Flight crew/airline experience with airplane characteristics relative to the various runway conditions routinely encountered provide initial guidance as to the desirable level of deceleration selected.

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

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

The use of minimum reverse thrust almost doubles the brake energy requirements and can result in brake temperatures much higher than normal.

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

If stopping distance is not assured with autobrakes engaged, the PF should immediately apply manual braking sufficient to assure deceleration to a safe taxi speed within the remaining runway.
A table in the PI section of the QRH shows the relative stopping capabilities of the available autobrake selections.

TRANSITION TO MANUAL BRAKING

The speed at which the transition from autobrakes to manual braking is made depends upon airplane deceleration rate, runway conditions and stopping requirements. When transitioning to manual braking, keep the speedbrakes deployed and use reverse thrust as required until taxi speed. This is especially important when nearing the end of the runway where rubber deposits affect stopping ability.

- When transitioning from the autobrake system to manual braking, the PF should notify the PM. Techniques for release of autobrakes can affect passenger comfort and stopping distance. These techniques are:
- stow the speed brake handle. When stopping distance within the remaining runway is assured, this method provides a smooth transition to manual braking, is effective before or after thrust reversers are stowed, and is less dependent on manual braking technique
- smoothly apply brake pedal force as in a normal stop, until the autobrake system disarms. Following disarming of the autobrakes, smoothly release brake pedal pressure. Disarming the autobrakes before coming out of reverse thrust provides a smooth transition to manual braking
- manually position the autobrake selector off (normally done by the PM at the direction of the PF).

MANUAL BRAKING

The following technique for manual braking provides optimum braking for all runway conditions:

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

Immediately after main gear touchdown, smoothly apply a constant brake pedal pressure for the desired braking. For short or slippery runways, use full brake pedal pressure.

- do not attempt to modulate, pump or improve the braking by any other special techniques
- do not release the brake pedal pressure until the airplane speed has been reduced to a safe taxi speed
- the antiskid system stops the airplane for all runway conditions in a shorter distance than is possible with either antiskid off or brake pedal modulation.

The antiskid system adapts pilot applied brake pressure to runway conditions by sensing an impending skid condition and adjusting the brake pressure to each individual wheel for maximum braking effort. When brakes are applied on a slippery runway, several skid cycles occur before the antiskid system establishes the right amount of brake pressure for the most effective braking.

If the pilot modulates the brake pedals, the antiskid system is forced to readjust the brake pressure to establish optimum braking. During this readjustment time, braking efficiency is lost.

Low available braking coefficient of friction on extremely slippery runways at high speeds may be interpreted as a total antiskid failure. Pumping the brakes or turning off the antiskid degrades braking effectiveness. Maintain steadily increasing brake pressure, allowing the antiskid system to function at its optimum.

Although immediate braking is desired, manual braking techniques normally involve a four to five second delay between main gear touchdown and brake pedal application even when actual conditions reflect the need for a more rapid initiation of braking. This delayed braking can result in the loss of 800 to 1,000 feet of runway. Directional control requirements for crosswind conditions and low visibility may further increase the delays. Distractions arising from a malfunctioning reverser system can also result in delayed manual braking application.

BRAKE COOLING

A series of taxi-back or stop and go landings without additional in-flight brake cooling can cause excessive brake temperatures. The energy absorbed by the brakes from each landing is cumulative.

Extending the gear a few minutes early in the approach normally provides sufficient cooling for a landing. Total in-flight cooling time can be determined from the Performance Inflight section of the QRH.

Note: Brake energy data provided in the QRH should be used to identify potential overheat situations.
To minimize brake temperature build-up:

- For airplanes without operative brake temperature monitoring systems:
- If the last ground time plus present flight time is less than 90 minutes, extend the landing gear 5 minutes early or 7 minutes prior to landing
- For airplanes with operating brake temperature monitoring systems: Extend the landing gear approximately one minute early for each unit of brake temperature above normal.

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

REVERSE THRUST OPERATION

Awareness of the position of the forward and reverse thrust levers must be maintained during the landing phase. Improper seat position as well as long sleeved apparel may cause inadvertent advancement of the forward thrust levers, preventing movement of the reverse thrust levers.

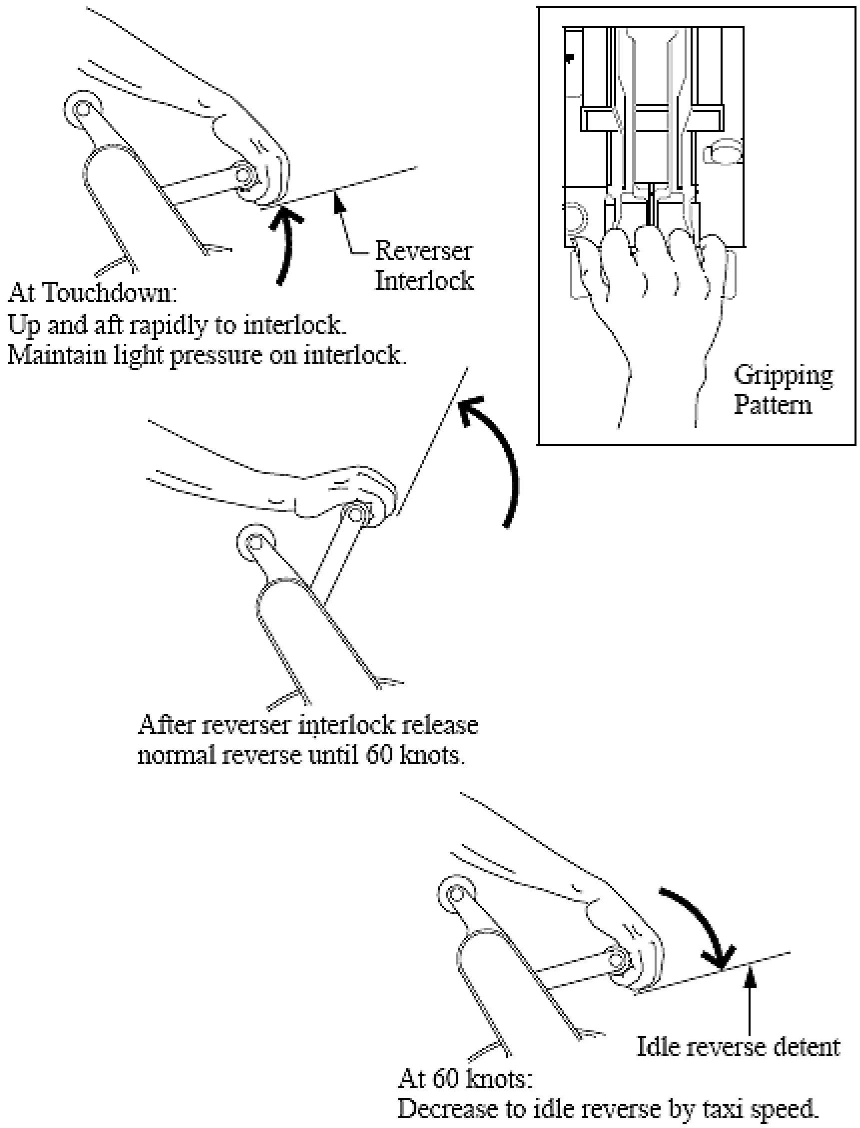
The position of the hand should be comfortable, permit easy access to the autothrottle disconnect switch, and allow control of all thrust levers, forward and reverse, through full range of motion.

Note: Reverse thrust always reduces the "brake only" stopping distance, brake and tire wear. Reverse thrust is most effective at high speeds.

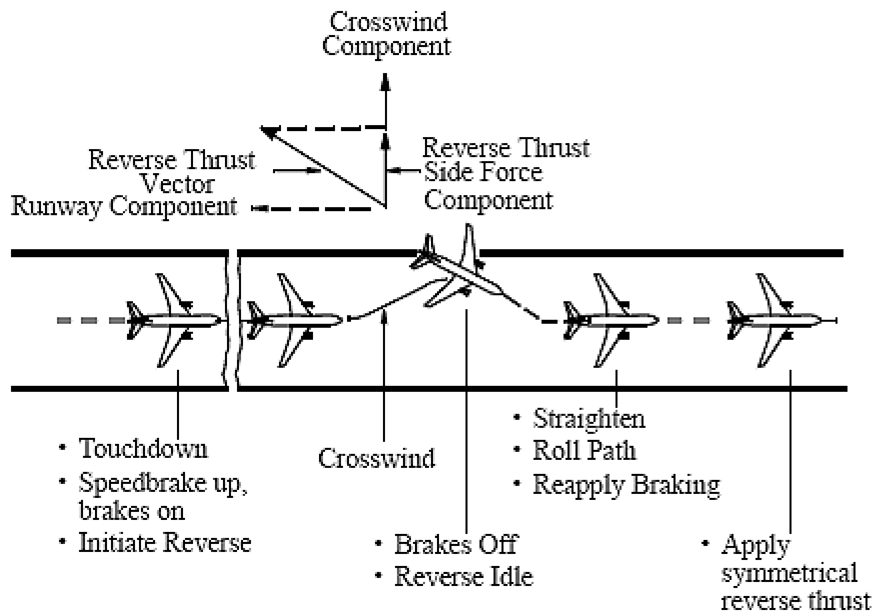
After touchdown, with the thrust levers at idle, rapidly raise the reverse thrust levers up and aft to the interlock position, then to the number 2 reverse thrust detent. Conditions permitting, limit reverse thrust to the number 2 detent. The PM should monitor engine operating limits and call out any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

Maintain reverse thrust as required, up to maximum, until the airspeed approaches 60 knots. At this point start reducing the reverse thrust so that the reverse thrust levers are moving down at a rate commensurate with the deceleration rate of the airplane. The thrust levers should be positioned to reverse idle by taxi speed, then to full down after the engines have decelerated to idle. 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. If an engine surges during reverse thrust operation, quickly select reverse idle on all engines.

REVERSE THRUST OPERATIONS



REVERSE THRUST AND CROSSWIND (ALL ENGINES)



This figure shows a directional control problem during a landing rollout on a slippery runway with a crosswind. As the airplane starts to weathervane into the wind, the reverse thrust side force component adds to the crosswind component and drifts the airplane to the downwind side of the runway. Main gear tire cornering forces available to counteract this drift are at a minimum when the antiskid system is operating at maximum braking effectiveness for the existing conditions.

To correct back to the centerline, reduce reverse thrust to reverse idle and release the brakes. This minimizes the reverse thrust side force component without the requirement to go through a full reverser actuation cycle, and improve tire cornering forces for realignment with the runway centerline. Use rudder pedal steering and differential braking as required, to prevent over correcting past the runway centerline. When re-established near the runway centerline, apply maximum braking and symmetrical reverse thrust to stop the airplane.

CROSSWIND LANDINGS

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

LANDING CROSSWIND GUIDELINES

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

On slippery runways, crosswind guidelines are a function of runway surface condition, airplane loading, and assume proper pilot technique.

Runway Condition	Crosswind - Knots *
Dry	40 ***
Wet	40 ***
Standing Water/Slush	20
Snow - No Melting	35 ***
Ice - No Melting **	17

Note: Reduce crosswind guidelines by 5 knots on wet or contaminated runways whenever asymmetric reverse thrust is used.

* Winds measured at 33 feet (10 m) tower height and apply for runways 148 feet (45m) or greater in width.
** Landing on untreated ice or snow should only be attempted when no melting is present.
*** Sideslip only (zero crab) landings are not recommended with crosswinds in excess of 13 knots at flaps 15, 16 knots at flaps 30, or 18 knots at flaps 40. This recommendation ensures adequate ground clearance and is based on maintaining adequate control margin.

CROSSWIND LANDING TECHNIQUES

Three methods of performing crosswind landings are presented. They are the touchdown in a crab, the de-crab technique (with removal of crab in flare), and the sideslip technique. Whenever a crab is maintained during a crosswind approach, offset the flight deck on the upwind side of centerline so that the main gear touches down in the center of the runway.

As rudder is applied, the upwind wing sweeps forward developing roll. Hold wings level with simultaneous application of aileron control into the wind. The touchdown is made with cross controls and both gear touching down simultaneously. Throughout the touchdown phase upwind aileron application is utilized to keep the wings level.

TOUCHDOWN IN CRAB

The airplane can land using crab only (zero side slip) up to the landing crosswind guideline speeds. (See the landing crosswind guidelines table, this chapter).

On dry runways, upon touchdown the airplane tracks toward the upwind edge of the runway while de-crabbing to align with the runway. Immediate upwind aileron is needed to ensure the wings remain level while rudder is needed to track the runway centerline. The greater the amount of crab at touchdown, the larger the lateral deviation from the point of touchdown. For this reason, touchdown in a crab only condition is not recommended when landing on a dry runway in strong crosswinds.

On very slippery runways, landing the airplane using crab only reduces drift toward the downwind side at touchdown, permits rapid operation of spoilers and autobrakes because all main gears touchdown simultaneously, and may reduce pilot workload since the aircraft does not have to be de-crabbed before touchdown. However, proper rudder and upwind aileron must be applied after touchdown to ensure directional control is maintained.

SIDESLIP (WING LOW)

The sideslip crosswind technique aligns the aircraft with the extended runway centerline so that main gear touchdown occurs on the runway centerline.

The initial phase of the approach to landing is flown using the crab method to correct for drift. Prior to the flare the airplane centerline is aligned on or parallel to the runway centerline. Downwind rudder is used to align the longitudinal axis to the desired track as aileron is used to lower the wing into the wind to prevent drift. A steady sideslip is established with opposite rudder and low wing into the wind to hold the desired course.

Touchdown is accomplished with the upwind wheels touching just before the downwind wheels. Overcontrolling the roll axis must be avoided because overbanking could cause the engine nacelle or outboard wing flap to contact the runway. (See Ground Clearance Angles - Normal Landing charts, this chapter.)

Properly coordinated, this maneuver results in nearly fixed rudder and aileron control positions during the final phase of the approach, touchdown, and beginning of the landing roll. However, since turbulence is often associated with crosswinds, it is often difficult to maintain the cross control coordination through the final phase of the approach to touchdown.

If the crew elects to fly the sideslip to touchdown, it may be necessary to add a crab during strong crosswinds. (See the landing crosswind guidelines table, this chapter). Main gear touchdown is made with the upwind wing low and crab angle applied. As the upwind gear touches first, a slight increase in downwind rudder is applied to align the airplane with the runway centerline. At touchdown, increased application of upwind aileron should be applied to maintain wings level.

OVERWEIGHT LANDING

Overweight landings may be safely accomplished by using normal landing procedures and techniques. There are no adverse handling characteristics associated with overweight landings. Landing distance is normally less than takeoff distance for flaps 30 or 40 landings at all gross weights. However, wet or slippery runway field length requirements should be verified from the landing distance charts in the Performance Inflight chapter of the Operations Manual. Brake energy limits will not be exceeded for flaps 30 or 40 landings at all gross weights.

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

If stopping distance is a concern, reduce the landing weight as much as possible. At the captain's discretion, reduce weight by holding at low altitude with a high drag configuration (gear down) to achieve maximum fuel burn-off.

Analysis has determined that, when landing at high gross weights at speeds associated with non-normal procedures requiring flaps set at 15 or less, maximum effort stops may exceed the brake energy limits. The gross weights where this condition can occur are well above maximum landing weights. For these non-normal landings, maximize use of the available runway for stopping.

Observe flap placard speeds during flap extension and on final approach. In the holding and approach patterns, maneuvers should be flown at the normal maneuver speeds. During flap extension, airspeed can be reduced by as much as 20 knots below normal maneuver speeds before extending to the next flap position. These lower speeds result in larger margins to the flap placards, while still providing normal bank angle maneuvering capability, but do not allow for a 15° overshoot margin in all cases.

Use the longest available runway, and consider wind and slope effects. Where possible avoid landing in tailwinds, on runways with negative slope, or on runways with less than normal braking conditions. Do not carry excess airspeed on final. This is especially important when landing during an engine inoperative or other non-normal condition. At weights above the maximum landing weight, the final approach maximum wind correction may be limited by the flap placards and load relief system.

Fly a normal profile. Ensure that a higher than normal rate of descent does not develop. Do not hold the airplane off waiting for a smooth landing. Fly the airplane onto the runway at the normal touchdown point. If a long landing is likely to occur, go-around. After touchdown, immediately apply maximum reverse thrust using all of the available runway for stopping to minimize brake temperatures. Do not attempt to make an early runway turnoff.

Autobrake stopping distance guidance is contained in the Performance Inflight section of the QRH. If adequate stopping distance is available based upon approach speed, runway conditions, and runway length, the recommended autobrake setting should be used.

MANEUVERS

PREFACE

This chapter provides a quick reference summary of operating procedures and training maneuvers. The discussion portion of each illustration highlights important information. The flight profile illustrations represent the Boeing recommended basic configuration during the accomplishment of the flight maneuvers, and provides a basis for standardization and crew coordination.

The procedures recommended are based on minimizing crew workload, crew coordination and operational safety and provide a basis for standardization.

ACCELERATION TO AND DECELERATION FROM VMO

Acceleration to and deceleration from VMO demonstrates performance capabilities and response to speed, thrust, and configuration changes throughout the medium altitude speed range of the airplane. This maneuver is performed in the full flight simulator and is for demonstration purposes only. It is normally performed at 10,000 to 15,000 feet, simulating slowdown to 250 knots due to speed restrictions.

VMO is a structural limitation and is the maximum operating indicated airspeed. It is a constant airspeed from sea level to the altitude where VMO and MMO coincide. MMO is the structural limitation above this altitude. Sufficient thrust is available to exceed VMO in level flight at lower altitudes. Failure to reduce to cruise thrust in level flight can result in excessive airspeed.

Begin the maneuver at existing cruise speed with the autothrottle connected and the autopilot disconnected.

Set command speed to VMO. As speed increases observe:

- nose down trim required to keep airplane in trim and maintain level flight
- handling qualities during acceleration
- autothrottle protection at VMO.

At a stabilized speed just below VMO execute turns at high speed while maintaining altitude. Next, accelerate above VMO by disconnecting the autothrottle and increasing thrust.

When the overspeed warning occurs reduce thrust levers to idle, set command speed to 250 knots, and decelerate to command speed. Since the airplane is aerodynamically clean, any residual thrust results in a longer deceleration time. As airspeed decreases observe that nose up trim is required to keep airplane in trim and maintain level flight. During deceleration note the distance traveled from the time the overspeed warning stops until reaching 250 knots.

Once stabilized at 250 knots, set command speed to flaps up maneuvering speed and decelerate to command speed, again noting the distance traveled during deceleration. Observe the handling qualities of the airplane during deceleration.

This maneuver may be repeated using speedbrakes to compare deceleration times and distances.

ENGINE OUT FAMILIARIZATION

The exercises shown in the following table are performed to develop proficiency in handling the airplane with an engine inoperative and gain familiarization with rudder control requirements.

<table>
<tr><th></th><th>Condition One</th><th>Condition Two</th></tr>
<tr><td>Airspeed</td><td>flaps up maneuvering speed</td><td>V2</td></tr>
<tr><td>Landing Gear</td><td>Up</td><td>Down</td></tr>
<tr><td>Flaps</td><td>Up</td><td>15</td></tr>
<tr><td>Thrust</td><td>As Required</td><td>MCT</td></tr>
<tr><td colspan="3">When In Trim - Retard one thrust lever to idle
Controls - Apply to maintain heading, wings level
Rudder - Apply to center control wheel
Airspeed - Maintain with thrust (Condition One) Pitch (Condition Two)

Trim - As required to relieve control forces</td></tr>
</table>

Engine out controllability is excellent during takeoff roll and after lift-off. Minimum control speeds in the air (VMCAs) are below VR and VREF.

RUDDER AND LATERAL CONTROL

This familiarization is performed to develop proficiency in handling the airplane with an engine inoperative. It also helps to gain insight into rudder control requirements.

Under instrument conditions the instrument scan is centered around the attitude indicator. Roll is usually the first indication of an asymmetric condition. Roll control (ailerons) should be used to hold the wings level or maintain the desired bank angle. Stop the yaw by smoothly applying rudder at the same rate that thrust changes. When the rudder input is correct, very little control wheel displacement is necessary. Refine the rudder input as required and trim the rudder so the control wheel remains approximately level.

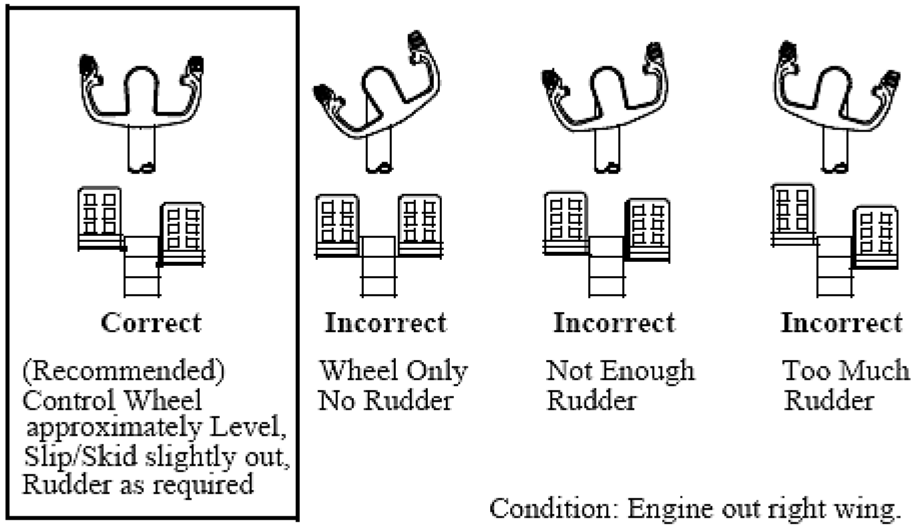
When the rudder is trimmed to level the control wheel, the airplane maintains heading. A small amount of bank toward the operating engine may be noticeable on the bank indicator. The slip/skid indicator is displaced slightly toward the operating engine.

If the airplane is trimmed with too much control wheel displacement, full lateral control is not available and spoilers on one wing may be raised, increasing drag.

Make turns at a constant airspeed and hold the rudder displacement constant. Do not attempt to coordinate rudder and lateral control in turns. Rudder pedal inputs produce roll due to yaw and induce the pilot to counter rudder oscillations with opposite control wheel.

The following figure shows correct and incorrect use of the rudder.

If an engine failure occurs with the autopilot engaged, manually position the rudder to approximately center the control wheel and add thrust. Trim the rudder to relieve rudder pedal pressure.



THRUST AND AIRSPEED

If not thrust limited, apply additional thrust, if required, to control the airspeed. The total two engine fuel flow existing at the time of engine failure may be used initially to establish a thrust setting at low altitude. If performance limited (high altitude), adjust airplane attitude to maintain airspeed while setting maximum continuous thrust.

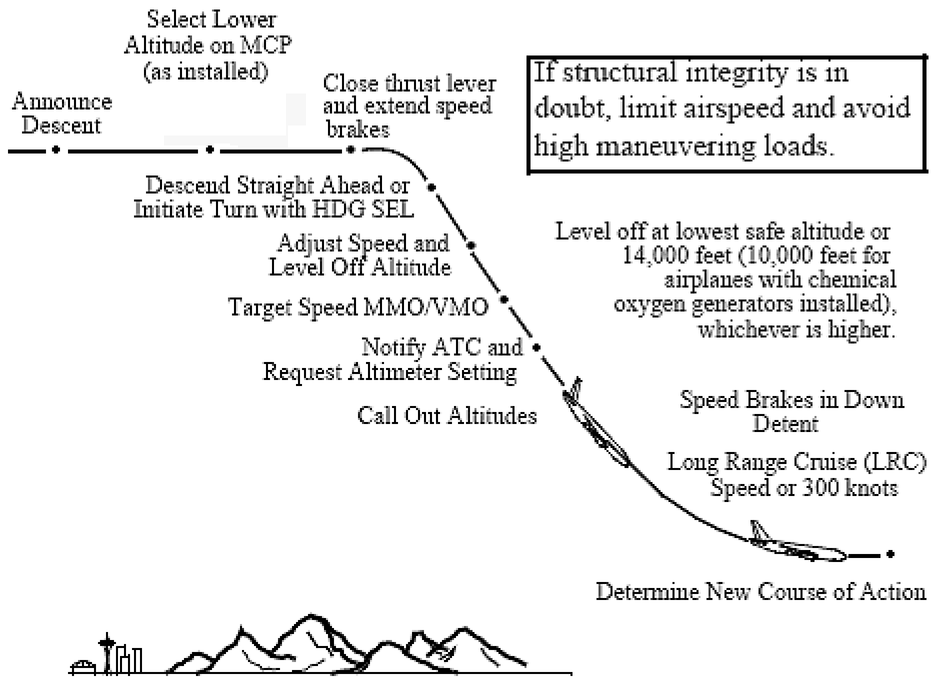
HIGH ALTITUDE MANEUVERING, "G" BUFFET

Airplane buffet reached as a result of aircraft maneuvering is commonly referred to as "g" buffet. During turbulent flight conditions, it is possible to experience high altitude "g" buffet at speeds less than MMO. In training, buffet is induced to demonstrate the airplane's response to control inputs during flight in buffet. Establish an airspeed of 0.80M. Induce "g" buffet by smoothly increasing the bank angle until the buffet is noticeable. Increase the rate of descent while increasing the bank angle to maintain airspeed. Do not exceed 45° of bank. If buffet does not occur by 45° of bank, increase control column back pressure until buffet occurs. When buffet is felt, relax back pressure and smoothly roll out to straight and level. Notice that the controls are fully effective at all times.

RAPID DESCENT

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 in CWS pitch mode is recommended on airplanes equipped with the (SP-77) autopilot.



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 IAS or less. Avoid high maneuvering loads.

Perform the procedure deliberately and methodically. Do not be distracted from flying the airplane. If icing conditions are entered, use engine anti-ice and thrust as required.

Note: Rapid descent is 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 recall items have been accomplished and call out any items not completed. The PM calls out 2,000 feet and 1,000 feet above the level off altitude.

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

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

MANUAL ENTRY AND LEVEL OFF

The entry may be accomplished on heading or a turn may be made to clear the airway or controlled track. However, since extending the speedbrakes initially reduces the maneuver margin, it is recommended that turns not be initiated until the airplane is established in the descent.

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

About 10 knots before reaching target speed, slowly raise the pitch attitude to maintain target speed. Keep the airplane in trim at all times. If MMO/VMO is inadvertently exceeded, change pitch smoothly to decrease speed.

Approaching level off altitude, smoothly adjust pitch attitude to reduce rate of descent. The speedbrake lever should be returned to the down detent when approaching the desired level off altitude. After reaching level flight add thrust to maintain long range cruise or 300 knots.

AFTER LEVEL OFF

Recheck the pressurization system and evaluate the situation. Do not remove the crew oxygen masks if cabin altitude remains above 10,000 feet. Determine the new course of action based on weather, oxygen, fuel remaining, medical condition of crew and passengers, and available airports. Obtain a new ATC clearance
.

STALL RECOVERY

The objective of the approach to stall recovery maneuver is to familiarize the pilot with the stall warning and correct recovery techniques. Recovery from a fully developed stall is discussed later in this section.

APPROACH TO STALL RECOVERY

The following discussion and maneuvers are for an approach to a stall as opposed to a fully developed stall. An approach to a stall is a controlled flight maneuver; a stall is an out-of-control, but recoverable, condition.

Initial Conditions | **Approach** | **Recovery**

Flaps	Gear	Bank	Target% N1*
Up	Up	0°	50 - 55%
15	Dn	25°	55 - 60%
30	Dn	0°	70 - 75%

*Approximate power settings to achieve a 1 kt/sec deceleration

If ground contact is not a factor

At buffet or stick shaker:

- Apply maximum thrust
- Smoothly decrease pitch attitude to approximately 5° above the horizon
- Level wings
- Accelerate to maneuvering speed for flap position
- Stop descent and return to target altitude
- At altitudes above 20,000 feet, pitch attitudes less than 5° may be necessary to achieve acceptable acceleration.

Maintain airplane in trim until stick shaker or buffet

Note pitch attitude at trim speed

Maneuver complete

If ground contact is a factor

At buffet or stick shaker:

- Apply maximum thrust
- Smoothly adjust attitude as necessary to avoid terrain
- Level wings
- Accelerate to maneuvering speed for flap position
- Level off at target altitude.

COMMAND SPEED

As the airplane is decelerated to the desired initial condition for the approach to stall, set command speed to the maneuver speed for each selected flap setting. For the approach to stall in the landing configuration, set command speed to VREF 30 + 5 knots.

INITIAL BUFFET-STALL WARNING-STALL BUFFET

Approach to stalls are entered with thrust set appropriate for an airspeed decrease of 1 knot per second.
During the initial stages of a stall, local airflow separation results in initial buffet giving natural warning of an approach to stall. A stall warning is considered to be any warning readily identifiable by the pilot, either artificial (stick shaker) or initial buffet. Recovery from an approach to stall is initiated at the earliest recognizable stall warning, initial buffet or stick shaker.

LATERAL AND DIRECTIONAL CONTROL

Lateral control is maintained with ailerons. Rudder control should not be used because it causes yaw and the resultant roll is undesirable.

EFFECT OF FLAPS

Flaps are used to increase low speed performance capability. The leading edge devices ensure that the inboard wing stalls prior to the outboard wing. This causes the nose of the airplane to pitch down at the onset of the stall.

EFFECT OF SPEEDBRAKES

For any airspeed, the angle of attack is higher with speedbrakes up. This increases initial buffet speed and stick shaker speed but has a lesser effect on actual stall speed.

ENTRY

To save time, thrust levers may be closed to allow a more rapid deceleration. Target thrust for the configuration should be set approaching selected speed.

Some thrust is used during entry to provide positive engine acceleration for the recovery. The airplane is maintained in trim while decelerating. Level flight or a slight rate of climb is desired.

LANDING GEAR

If the entry has been made with the landing gear extended, do not retract it until after the recovery.

FLAPS

Do not retract flaps during the recovery. Retracting the flaps from the landing position, especially when near the ground, causes an altitude loss during the recovery.

RECOVERY

Recover from approach to a stall with one of the following recommended recovery techniques.

GROUND CONTACT NOT A FACTOR

At the first indication of stall (buffet or stick shaker) smoothly apply maximum thrust, smoothly decrease the pitch attitude to approximately 5 degrees above the horizon and level the wings. As the engines accelerate, counteract the nose up pitch tendency with positive forward control column pressure and nose down trim. (At altitudes above 20,000 feet, pitch attitudes of less than 5 degrees may be necessary to achieve acceptable acceleration.)

Accelerate to maneuvering speed and stop the rate of descent. Correct back to the target altitude.

GROUND CONTACT A FACTOR

At the first indication of stall (buffet or stick-shaker) smoothly advance the thrust levers to maximum thrust and adjust the pitch attitude as necessary to avoid the ground. Simultaneously level the wings. Control pitch as smoothly as possible. As the engines accelerate the airplane nose pitches up. To assist in pitch control, add more nose down trim as the thrust increases. Avoid abrupt control inputs that

may induce a secondary stall. Use intermittent stick shaker as the upper limit for pitch attitude for recovery when ground is a factor.
When ground contact is no longer a factor, continue to adjust pitch as required to maintain level flight or a slight climb while accelerating to maneuvering speed for the existing flap position.

AUTOPILOT ENGAGED

If an approach to a stall is encountered with the autopilot engaged, apply limit thrust and allow the airplane to return to the normal speed. At high altitude, it may be necessary to initiate a descent to regain maneuvering speed. If autopilot response is not acceptable, it should be disengaged.

RECOVERY FROM A FULLY DEVELOPED STALL

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

An airplane stall is characterized by any one (or a combination) of the following conditions:

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

These conditions are usually accompanied by a continuous stall warning. A stall must not be confused with the stall warning that alerts the pilot to an approaching stall. Recovery from an approach to a stall is not the same as recovery from an actual stall. An approach to a stall is a controlled flight maneuver; a stall is an out-of-control, but recoverable, condition.

Note: Anytime the airplane enters a fully developed stall, the autopilot and autothrottle should be disconnected.

To recover from a stall, angle of attack must be reduced below the stalling angle. Nose down pitch control must be applied and maintained until the wings are unstalled. Application of forward control column (as much as full forward may be required) and the use of some nose-down stabilizer trim should provide sufficient elevator control to produce a nose-down pitch rate. It may be difficult to know how much stabilizer trim to use, and care must be taken to avoid using too much trim. Pilots should not fly the airplane using stabilizer trim, and should stop trimming nose down when they feel the g force on the airplane lessen or the required elevator force lessen.

Under certain conditions, on airplanes with underwing-mounted engines, it may be necessary to reduce thrust in order to prevent the angle of attack from continuing to increase. Once the wing is unstalled, upset recovery actions may be taken and thrust reapplied as necessary.

If normal pitch control inputs do not stop an increasing pitch rate in a nose high situation, rolling the airplane to a bank angle that starts the nose down may be effective. Bank angles of about 45°, up to a maximum of 60°, could be needed. Normal roll controls - up to full deflection of ailerons and spoilers - may be used. Unloading the wing by maintaining continuous nose-down elevator pressure keeps the wing angle of attack as low as possible, making the normal roll controls as effective as possible.

Finally, if normal pitch control then roll control is ineffective, careful rudder input in the direction of the desired roll may be required to initiate a rolling maneuver recovery.

WARNING: Only a small amount of rudder is needed. Too much rudder applied too quickly or held too long may result in loss of lateral and directional control.

STEEP TURNS

The objective of the steep turn maneuver is to familiarize the pilot with airplane handling characteristics and improve the instrument cross check.

During training, 45° of bank is used. It is not intended that the pilot should bank greater than 25° to 30° for normal, or non-normal procedures. If so equipped, the GPWS gives momentary bank angle alerts when exceeding bank angles of 40°.

Note: Stabilizer trim is not recommended during the steep turn maneuver because of increased workload during roll out.

ENTRY

Stabilize airspeed at 250 knots on heading and altitude. Use a normal turn entry. An increase in pitch is required as the bank angle is increased to maintain constant altitude. An increase in thrust is required to maintain constant airspeed.

DURING TURN

Pitch and thrust control are the same as for a normal turn; however, larger pitch adjustments are required for a given altitude deviation. Trimming during the maneuver is not recommended. Varying the angle of bank while turning makes pitch control more difficult. If altitude loss becomes excessive, reduce the angle of bank as necessary to regain positive pitch control.

Smooth and positive control is required. A rapid instrument scan is required to detect deviations early enough to be corrected by small adjustments.

ATTITUDE DIRECTOR INDICATOR (ADI)

The ADI has cyclical precession in pitch during steep turns. Although the actual airplane pitch attitude remains constant in a perfect steep turn, the instrument indication of pitch attitude slowly varies throughout the turn. Do not rely upon it for pitch attitude other than for small corrections based on short period observations.

VERTICAL SPEED INDICATOR

The vertical speed indicator interprets a change of acceleration as a change to vertical speed. Rapid increase in "g" forces as a steep turn is entered causes a transient display of approximately 200 FPM climb, even though the airplane is maintaining altitude perfectly. A 200 FPM descent appears because of the reduction in "g" force during a fast rollout. The VSI gives correct indications only during periods of steady "g" force.

ALTIMETER

Crosscheck the direction and rate of change, and make smooth minor adjustments to the pitch attitude for corrections.

AIRSPEED

Airspeed changes very slowly because of small changes in thrust and drag. Anticipate thrust changes and apply them at the first indication of change on the airspeed indicator. An increase in thrust is required as bank angle increases.

Note: If the airspeed cursor is set to 250 knots on the airspeed indicator, the airspeed fast/slow indicator (as installed) on the ADI indicates thrust change required.

ROLLOUT

Roll out at the same rate as used with normal turns. Normally rollout should begin 15° to 20° prior to the desired heading. An decrease in pitch is required as the bank angle is decreased to maintain constant altitude. An decrease in thrust is required to maintain constant airspeed.

TERRAIN AVOIDANCE

The Ground Proximity Warning System (GPWS) PULL UP Warning occurs for an unsafe closure rate with the terrain. 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.

UPSET RECOVERY

An upset can generally be defined as unintentionally exceeding the following conditions:

- pitch attitude greater than 25 degrees nose up, or
- pitch attitude greater than 10 degrees nose down, or
- bank angle greater than 45 degrees, or
- within above parameters but flying at airspeeds inappropriate for the conditions.

GENERAL

Though flight crews in line operation rarely, if ever, encounter an upset situation, understanding how to apply aerodynamic fundamentals in such a situation helps them control the airplane. Several techniques are available for recovering from an upset. In most situations, if a technique is effective, it is not recommended that pilots use additional techniques. Several of these techniques are discussed in the example scenarios below:

- stall recovery
- nose high, wings level
- nose low, wings level
- high bank angles
- nose high, high bank angles
- nose low, high bank angles

STALL RECOVERY

In all upset situations, it is necessary to recover from a stall before applying any other recovery actions. A stall may exist at any attitude and may be recognized by continuous stick shaker activation accompanied by one or more of the following:

- buffeting which could be heavy at times
- lack of pitch authority and/or roll control
- inability to arrest descent rate.

If the airplane is stalled, recovery from the stall must be accomplished first by applying and maintaining nose down elevator until stall recovery is complete and stick shaker activation ceases. Under certain conditions, it may be necessary to reduce some thrust in order to prevent the angle of attack from continuing to increase. Once stall recovery is complete, upset recovery actions may be taken and thrust reapplied as needed.

NOSE HIGH, WINGS LEVEL

In a situation where the airplane pitch attitude is unintentionally more than 25 degrees nose high and increasing, the airspeed is decreasing rapidly. As airspeed decreases, the pilot's ability to maneuver the airplane also decreases. If the stabilizer trim setting is nose up, as for slow-speed flight, it partially reduces the nose-down authority of the elevator. Further complicating this situation, as the airspeed decreases, the pilot could intuitively make a large thrust increase. This causes an additional pitch up. At full thrust settings and very low airspeeds, the elevator, working in opposition to the stabilizer, has limited control to reduce the pitch attitude.

In this situation the pilot should trade altitude for airspeed, and maneuver the airplane's flight path back toward the horizon. This is accomplished by the input of up to full nose-down elevator and the use of some nose-down stabilizer trim. These actions should provide sufficient elevator control power to produce a nose-down pitch rate. It may be difficult to know how much stabilizer trim to use, and care must be taken to avoid using too much trim. Pilots should not fly the airplane using stabilizer trim, and should stop trimming nose down when they feel the g force on the airplane lessen or the required elevator force lessen. This use of stabilizer trim may correct an out-of-trim airplane and solve a less-critical problem before the pilot must apply further recovery measures. Because a large nose-down pitch rate results in a condition of less than 1 g, at this point the pitch rate should be controlled by modifying control inputs to maintain between 0 to 1 g. If altitude permits, flight tests have determined that an effective way to achieve a nose-down pitch rate is to reduce some thrust.

If normal pitch control inputs do not stop an increasing pitch rate, rolling the airplane to a bank angle that starts the nose down should work. Bank angles of about 45 degrees, up to a maximum of 60 degrees, could be needed. Unloading the wing by maintaining continuous nose-down elevator pressure keeps the wing angle of attack as low as possible, making the normal roll controls as effective as possible. With airspeed as low as stick shaker onset, normal roll controls - up to full deflection of ailerons and spoilers - may be used. The rolling maneuver changes the pitch rate into a turning maneuver, allowing the pitch to decrease. Finally, if normal pitch control then roll control is ineffective, careful rudder input in the direction of the desired roll may be required to induce a rolling maneuver for recovery.

Only a small amount of rudder is needed. Too much rudder applied too quickly or held too long may result in loss of lateral and directional control. Because of the low energy condition, pilots should exercise caution when applying rudder.

The reduced pitch attitude allows airspeed to increase, thereby improving elevator and aileron control effectiveness. After the pitch attitude and airspeed return to a desired range the pilot can reduce angle of bank with normal lateral flight controls and return the airplane to normal flight.

NOSE LOW, WINGS LEVEL

In a situation where the airplane pitch attitude is unintentionally more than 10 degrees nose low and going lower, the airspeed is increasing rapidly. A pilot would likely reduce thrust and extend the speedbrakes. Thrust reduction causes an additional nose-down pitching moment. Speedbrake extension causes a nose-up pitching moment, an increase in drag, and a decrease in lift for the same angle of attack. At airspeeds well above VMO/MMO, the ability to command a nose-up pitch rate with elevator may be reduced because of the extreme aerodynamic loads on the elevator.

Again, it is necessary to maneuver the airplane's flight path back toward the horizon. At moderate pitch attitudes, applying nose-up elevator, reducing thrust, and extending speedbrakes, if necessary, changes the pitch attitude to a desired range. At extremely low pitch attitudes and high airspeeds (well above VMO/MMO), nose-up elevator and nose-up trim may be required to establish a nose-up pitch rate.

HIGH BANK ANGLES

A high bank angle is one beyond that necessary for normal flight. Though the bank angle for an upset has been defined as unintentionally more than 45 degrees, it is possible to experience bank angles greater than 90 degrees.

Any time the airplane is not in "zero-angle-of-bank" flight, lift created by the wings is not being fully applied against gravity, and more than 1 g is required for level flight. At bank angles greater than 67 degrees, level flight cannot be maintained within flight manual limits for a 2.5 g load factor. In high bank angle increasing airspeed situations, the primary objective is to maneuver the lift of the airplane to directly oppose the force of gravity by rolling (in the shortest direction) to wings level. Applying nose-up elevator at bank angles above 60 degrees causes no appreciable change in pitch attitude and may exceed normal structure load limits as well as the wing angle of attack for stall. The closer the lift vector is to vertical (wings level), the more effective the applied g is in recovering the airplane.

A smooth application of up to full lateral control should provide enough roll control power to establish a very positive recovery roll rate. If full roll control application is not satisfactory, it may even be necessary to apply some rudder in the direction of the desired roll.

Only a small amount of rudder is needed. Too much rudder applied too quickly or held too long may result in loss of lateral and directional control or structural failure.

NOSE HIGH, HIGH BANK ANGLES

A nose high, high angle of bank upset requires deliberate flight control inputs. A large bank angle is helpful in reducing excessively high pitch attitudes. The pilot must apply nose-down elevator and adjust the bank angle to achieve the desired rate of pitch reduction while considering energy management. Once the pitch attitude has been reduced to the desired level, it is necessary only to reduce the bank angle, ensure that sufficient airspeed has been achieved, and return the airplane to level flight.

NOSE LOW, HIGH BANK ANGLES

The nose low, high angle of bank upset requires prompt action by the pilot as altitude is rapidly being exchanged for airspeed. Even if the airplane is at a high enough altitude that ground impact is not an immediate concern, airspeed can rapidly increase beyond airplane design limits. Simultaneous application of roll and adjustment of thrust may be necessary. It may be necessary to apply nose-down elevator to limit the amount of lift, which will be acting toward the ground if the bank angle exceeds 90 degrees. This also reduces wing angle of attack to improve roll capability. Full aileron and spoiler input should be used if necessary to smoothly establish a recovery roll rate toward the nearest horizon. It is important to not increase g force or use nose-up elevator or stabilizer until approaching wings level. The pilot should also extend the speedbrakes as necessary.

UPSET RECOVERY TECHNIQUES

It is possible to consolidate and incorporate recovery techniques into two basic scenarios, nose high and nose low, and to acknowledge the potential for high bank angles in each scenario described above. Other crew actions such as recognizing the upset, reducing automation, and completing the recovery are

included in these techniques. The recommended techniques provide a logical progression for recovering an airplane.
If an upset situation is recognized, immediately accomplish the Upset Recovery maneuver found in the non-normal maneuvers section in the QRH.

WINDSHEAR

GENERAL

Improper or ineffective vertical flight path control has been one of the primary factors in many cases of flight into terrain. Low altitude windshear encounters are especially significant because windshear can place the crew in a situation which requires the maximum performance capability of the airplane. Windshear encounters near the ground are the most threatening because there is very little time or altitude to respond to and recover from an encounter.

AIRPLANE PERFORMANCE IN WINDSHEAR

Knowledge of how windshear affects airplane performance can be essential to the successful application of the proper vertical flight path control techniques during a windshear encounter.

The wind component is mostly horizontal at altitudes below 500 feet. Horizontal windshear may improve or degrade vertical flight path performance. Windshear that improves performance is first indicated in the flight deck by an increasing airspeed. This type of windshear may be a precursor of a shear that decreases airspeed and degrades vertical flight path performance.

Airspeed decreases if the tailwind increases, or headwind decreases, faster than the airplane is accelerating. As the airspeed decreases, the airplane normally tends to pitch down to maintain or regain the in-trim speed. The magnitude of pitch change is a function of the encountered airspeed change. If the pilot attempts to regain lost airspeed by lowering the nose, the combination of decreasing airspeed and decreasing pitch attitude produces a high rate of descent. Unless this is countered by the pilot, a critical flight path control situation may develop very rapidly. As little as 5 seconds may be available to recognize and react to a degrading vertical flight path.

In critical low altitude situations, trade airspeed for altitude, if possible. An increase in pitch attitude, even though the airspeed may be decreasing, increases the lifting force and improves the flight path angle. Proper pitch control, combined with maximum available thrust, utilizes the total airplane performance capability.

The crew must be aware of the normal values of airspeed, altitude, rate of climb, pitch attitude and control column forces. Unusual control column force may be required to maintain or increase pitch attitude when airspeed is below the in-trim speed. If significant changes in airspeed occur and unusual control forces are required, the crew should be alerted to a possible windshear encounter and be prepared to take action.

AVOIDANCE, PRECAUTIONS AND RECOVERY

Crew actions are divided into three areas: Avoidance, Precautions and Recovery. For more information on avoidance and precautions, see the Windshear Supplementary Procedure in Volume 1 of the FCOM. For specific crew actions for recovery, see the non-normal maneuvers section in the QRH.

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