Takeoff and Initial Climb — Chapter 3

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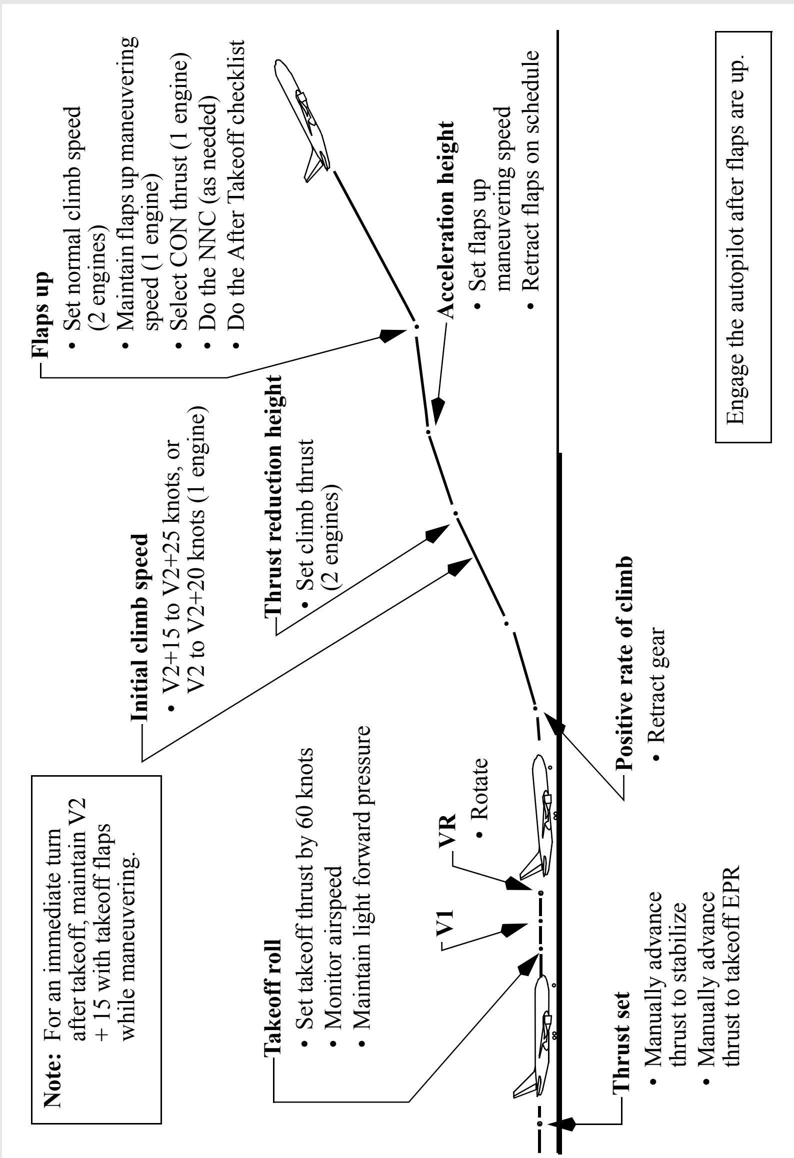
Preface

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

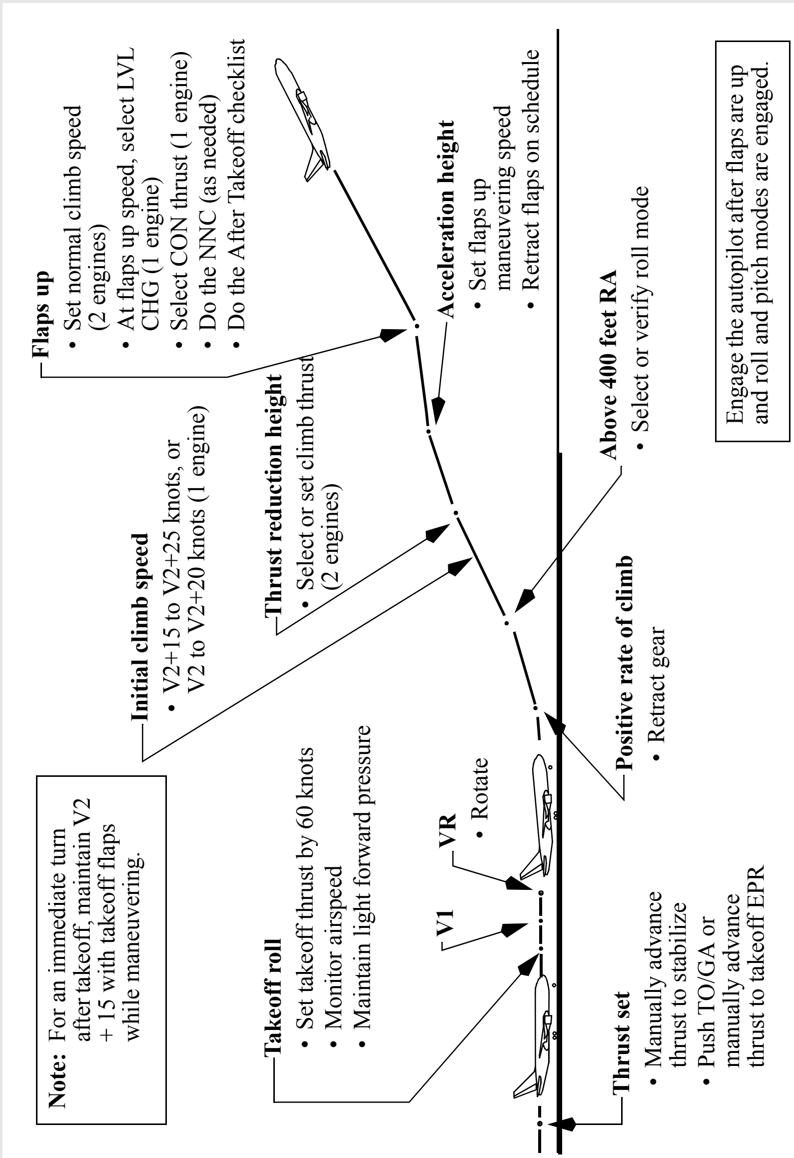
The flight profile illustrations represent the recommended basic configuration during the accomplishment of the flight maneuvers, and provides a basis for standardization and crew coordination.

Takeoff

Takeoff Profile - SP-77 Autopilot



Takeoff Profile - SP-177 Autopilot



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.

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

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

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.

For airplanes equipped with the SP-177 autopilot, autothrottle and flight director use is recommended for all takeoffs. However, do not follow flight director commands until after liftoff.

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

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

Use of Autothrottle (SP-177)

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

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

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

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

Rotation and Liftoff - All Engines

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

For airplanes equipped with the SP-177 autopilot, after liftoff use the flight director as the primary pitch reference, cross checking indicated airspeed and other flight instruments.

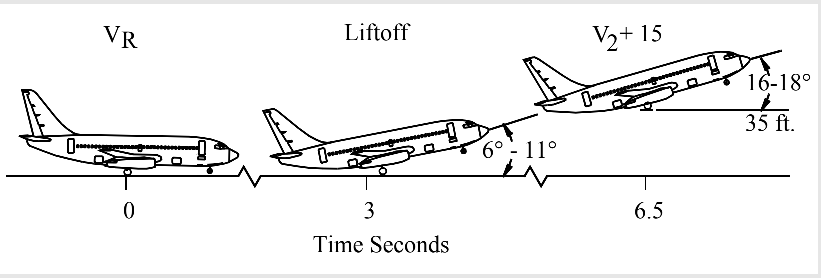
737-200
Using the technique above, liftoff attitude is achieved in approximately 3 to 6 seconds. Rotate smoothly at an average pitch rate of 3 degrees/second.

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

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.

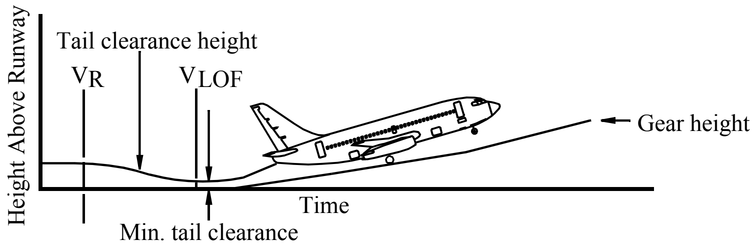


Retract the landing gear after a positive rate of climb is indicated on the altimeter.

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.



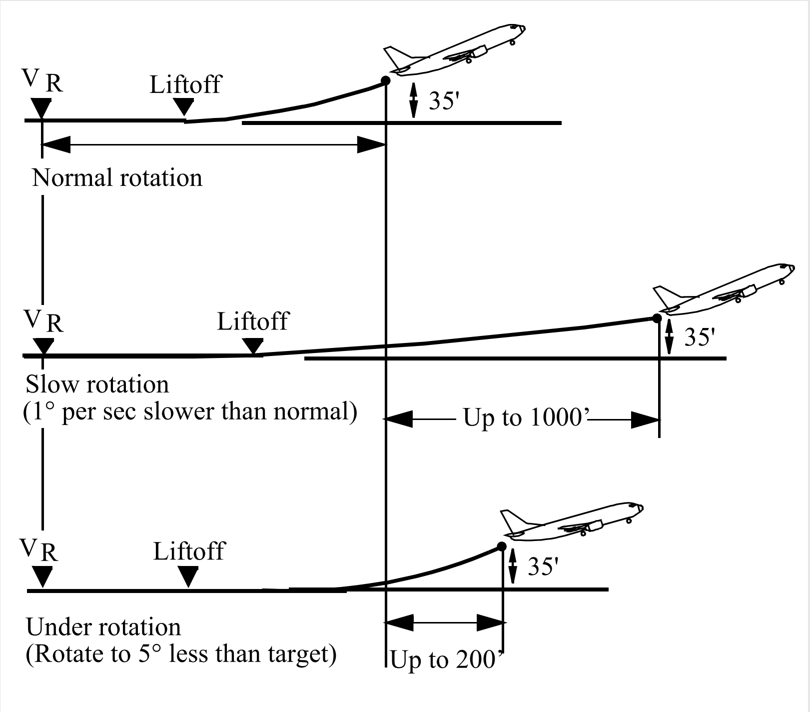
Model	Flap	Liftoff Attitude (degrees)	Minimum Tail Clearance inches (cm)	Tail Strike Pitch Attitude (degrees)
200	1 5 15 25	10.2 8.5 5.8 6.2	30 (77) 37 (95) 47 (119) 46 (116)	15.5
200A	1 2 5 15 25	10.9 10.0 9.6 8.9 8.8	27 (69) 31 (79) 33 (84) 36 (92) 36 (92)	15.5

Effect of Rotation Speed and Pitch Rate on Liftoff

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

For airplanes equipped with the SP-177 autopilot, an improper rotation can have an effect on the command speed after liftoff. If the rotation is delayed beyond V2 + 20, the speed commanded by the flight director is rotation speed up to a maximum of V2 + 25. An earlier liftoff does not affect the commanded initial climb speed, however, either case degrades overall takeoff performance.

Slow or Under Rotation (Typical)



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

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

Crosswind Takeoff

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

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

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

Directional Control

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

Note: During wet 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.

Reduced Thrust Takeoff

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

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

Assumed Temperature Method (ATM)

This method achieves a takeoff thrust less than the full rated takeoff thrust by using an assumed temperature that is higher than the actual temperature. The maximum thrust reduction authorized by most regulatory agencies is 25% below any certified rating.

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

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

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

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.

Effect of Deicing/Anti-Icing Fluids on Takeoff

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

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

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

Federal Aviation Regulation (FAR) Takeoff Field Length

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

- The distance required to accelerate with all engines, experience an engine failure 1 second prior to V1, continue the takeoff and reach a point 35 feet above the runway at V2 speed. (Accelerate-Go Distance).
- The distance required to accelerate with all engines, experience an event 1 second prior to V1, recognize the event, initiate the stopping maneuver and stop within the confines of the runway (Accelerate-Stop Distance).
- 1.15 times the all engine takeoff distance required to reach a point 35 feet above the runway.

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

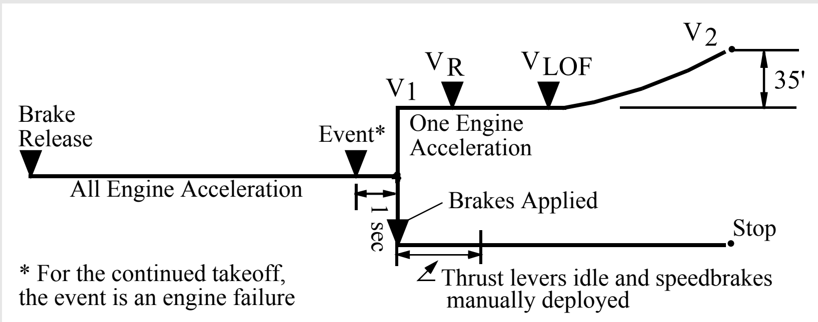
During certification, maximum manual braking and speedbrakes are used. Thrust reversers are not used. Although reverse thrust is not used in determining the FAR accelerate-stop distance, thrust reversers should be used during any operational rejected takeoff.

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

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

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

FAR Takeoff



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.

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

For airplanes equipped with the SP-177 autopilot, if the takeoff is rejected prior to the THR HOLD annunciation, the autothrottle should be disengaged as the thrust levers are moved to idle. If the autothrottle is not disengaged, the thrust levers advance to the selected takeoff thrust position when released. After THR HOLD is annunciated, the thrust levers, when retarded, remain in idle. For procedural consistency, disengage the autothrottles for all rejected takeoffs.

If rejecting due to fire, in windy conditions consider positioning the 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.

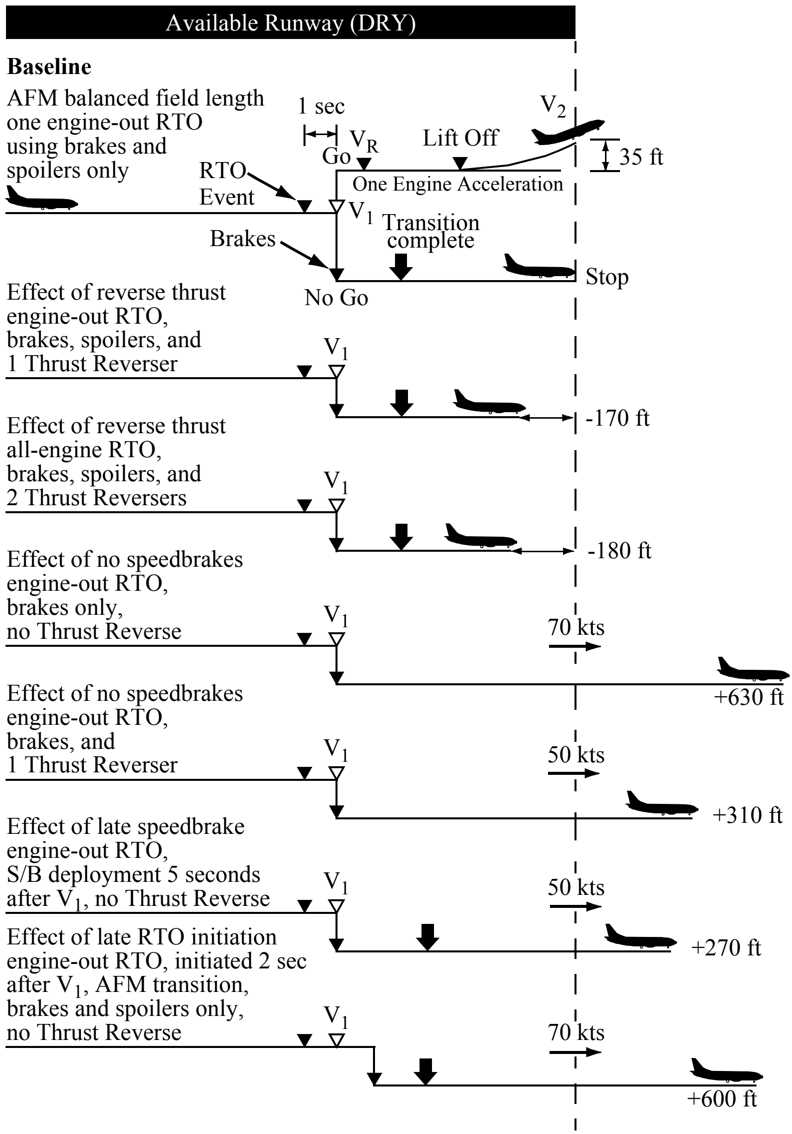
RTO Execution Operational Margins

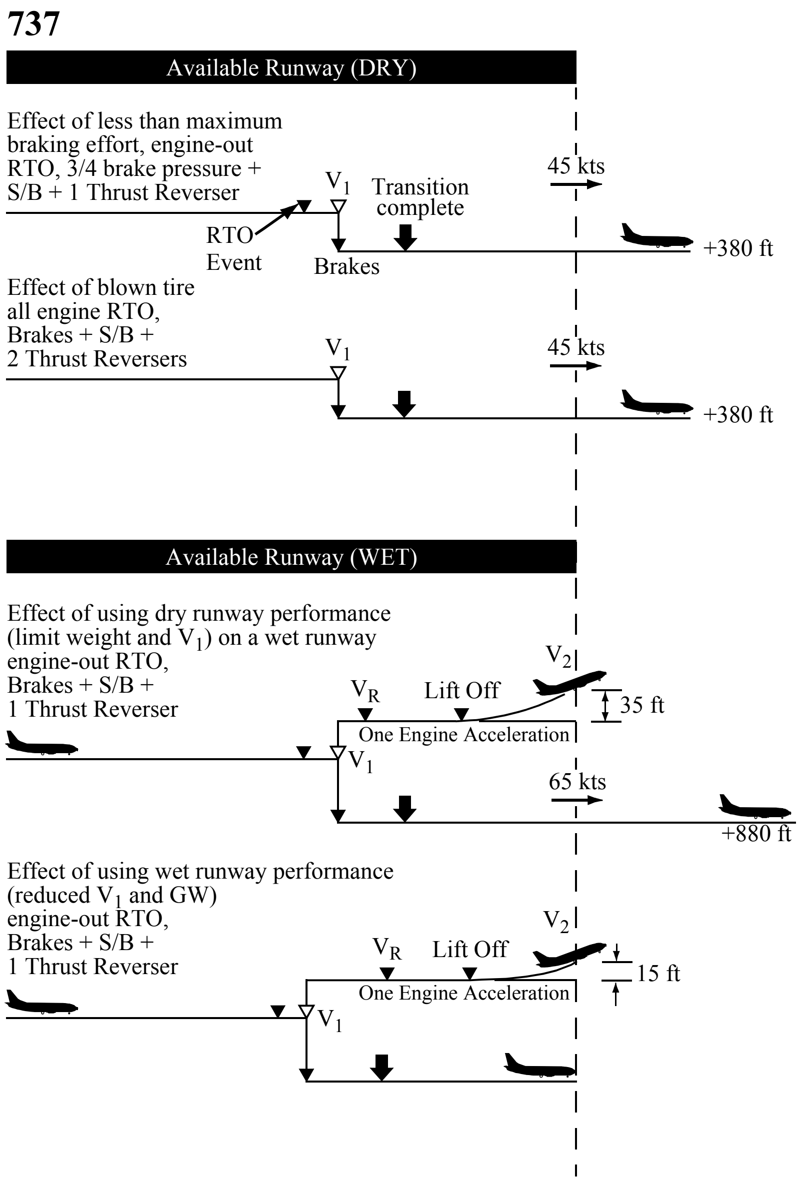
A successful rejected takeoff at or near V1 is dependent upon the captain making timely decisions and using the proper procedures.

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


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.

For airplanes equipped with the SP-177 autopilot, use the flight director after liftoff as the primary pitch reference, cross checking indicated airspeed and other flight instruments. After liftoff, the flight director commands pitch to maintain a target airspeed of V2 + 20 knots until another flap setting is selected after liftoff. The pilot is then responsible for updating the MCP window to the desired target speeds. If the flight director is not used, indicated airspeed and attitude become the primary pitch references.

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

Retract the landing gear after a positive rate of climb is indicated on the altimeter. Do not apply brakes after becoming airborne. 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.

Roll Modes (SP-177)

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

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

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.

Noise Abatement - One Engine Inoperative

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

Takeoff - Engine Failure

General

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

Engine Failure Recognition

An engine failure at or after V1 initially affects yaw much like a crosswind effect. Vibration and noise from the affected engine may be apparent and the onset of the yaw may be rapid.

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

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Approach and Missed Approach — Chapter 5

Preface

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

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

Approach

Instrument Approaches

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

Complete the approach preparations before arrival in the terminal area. Set decision altitude/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
- management of AFDS.

Approach Category

FAA Category	Speed
C	121 knots or more but less than 141 knots
D	141 knots or more but less than 166 knots
Speed - based upon a 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	
					Inter-mediate	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)

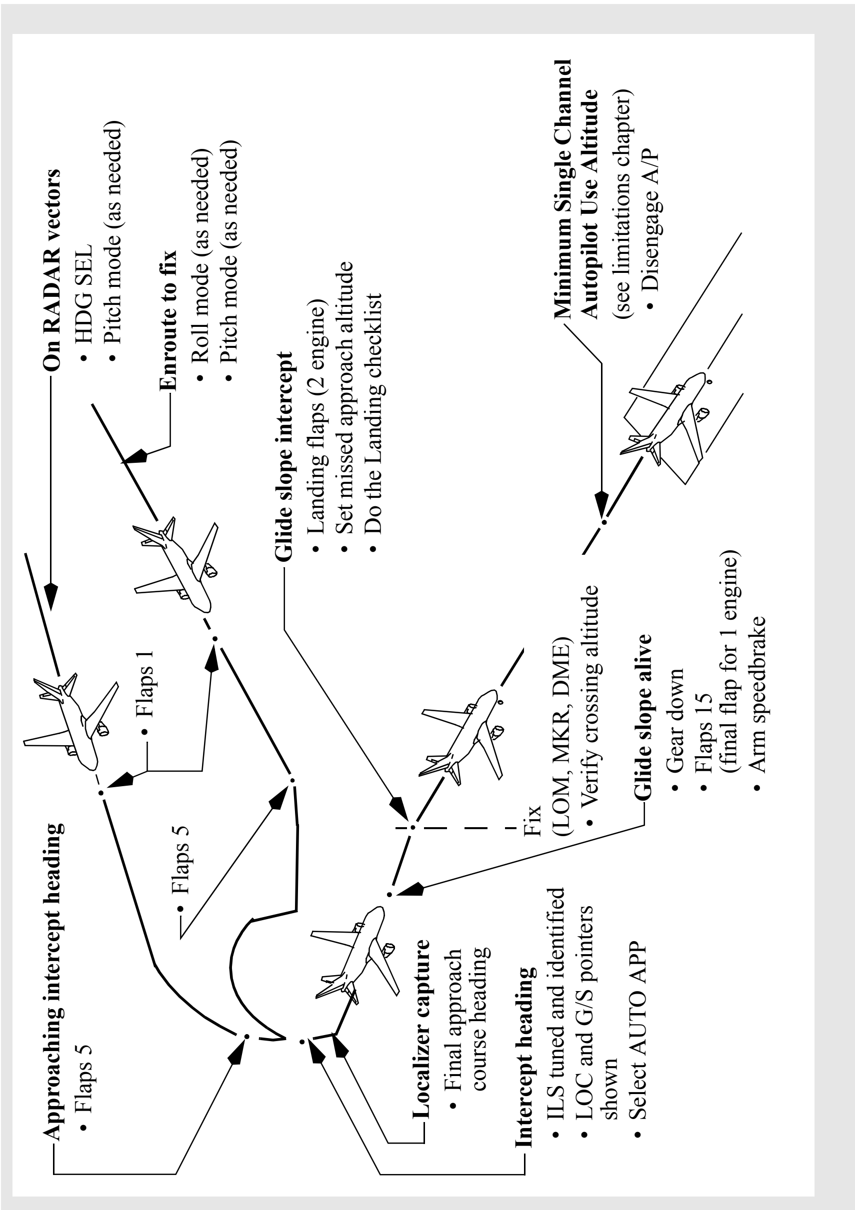
The MAP for a PAR is the geographic point where the glide path intersects the DA(H). Arrival at the MAP is determined by the pilot using the altimeter or as observed by the radar controller, whichever occurs first.

Airport Surveillance Radar (ASR)

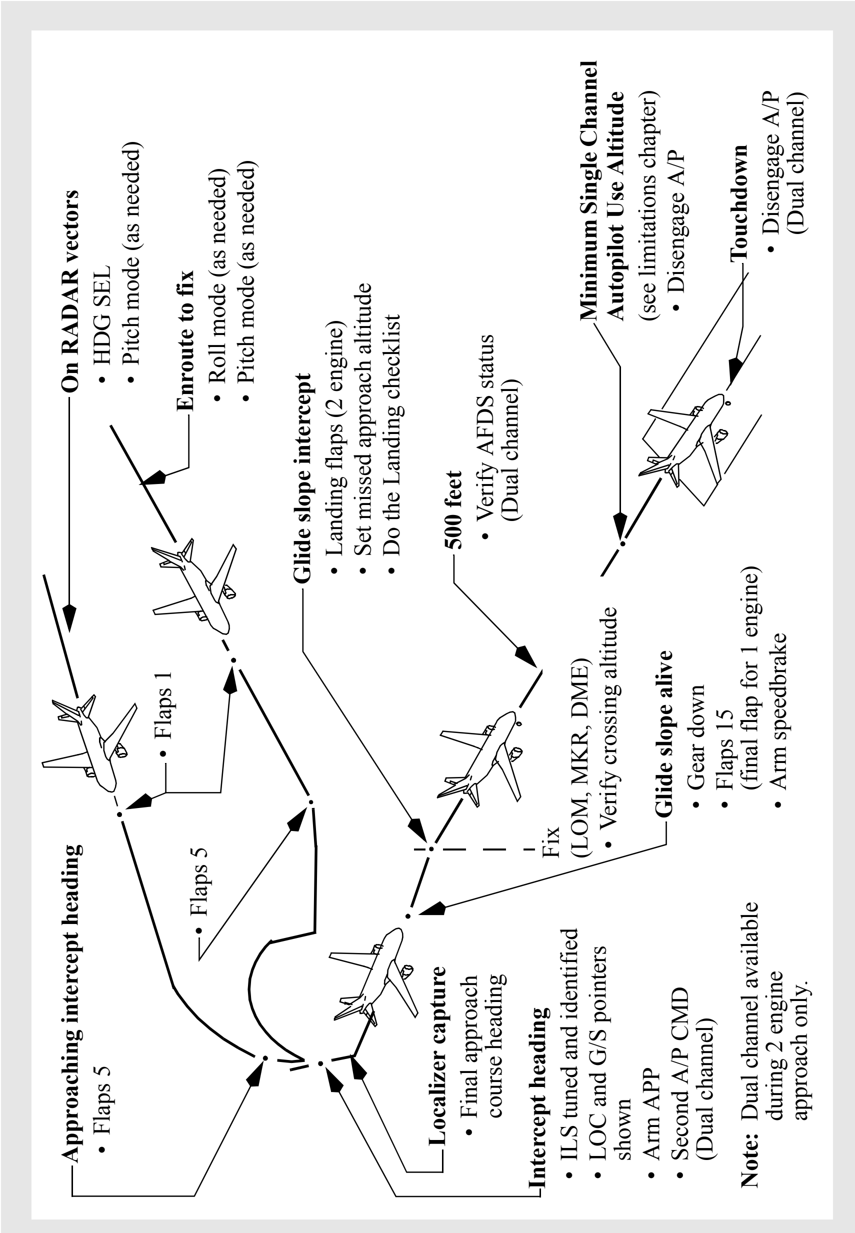
The radar controller is required to discontinue approach guidance when the airplane is at the MAP or one mile from the runway, whichever is greater. Perform the missed approach when instructed by the controller.

ILS Approach

ILS Approach Profile (SP-77 Autopilot)



ILS Approach Profile (SP-177 Autopilot)



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) or TO/GA (SP-177) is selected. Refer to Go–Around and Missed Approach - All Approaches, this chapter.

AFDS Autoland Capabilities (SP-177 Autopilot)

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

Note: For autoland use flaps 30 or 40.

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

Autoland ILS Performance

Most ILS installations are subject to signal interference by either surface vehicles or aircraft. To prevent this interference, ILS critical areas are established near each localizer and glide slope antenna. In the United States, vehicle and aircraft operation are restricted in these critical areas any time the weather is reported less than 800 foot ceiling and/or visibility is less than 2 miles.

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

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

Flight inspections of ILS facilities do not necessarily include ILS beam performance inside the runway threshold or along the runway unless the ILS is used for Category II or III approaches. For this reason, the ILS beam quality may vary and autolands performed from a Category I approach at these facilities should be closely monitored.

Flight crews must remember that the ILS critical areas are usually not protected when the weather is above 800 foot ceiling and/or 2 mile visibility. As a result, ILS beam bends may occur because of vehicle or aircraft interference. Sudden and unexpected flight control movements may occur at a very low altitude or during the landing when the autopilot attempts to follow the beam bends. At ILS facilities where critical areas are not protected, flight crews should be alert for this possibility and guard the flight controls (control wheel, rudder pedals and thrust levers) throughout automatic approaches and landings. Be prepared to disengage the autopilot and manually land or go-around.

Low Visibility Approaches

A working knowledge of approach lighting systems and regulations as they apply to the required visual references is essential to safe and successful approaches. Touchdown RVR is normally controlling for Category I, 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.

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

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

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

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. Airplanes equipped the SP-177 may also use dual autopilots. For single autopilot operation, the autopilot must be disengaged no lower than the minimum altitude listed in the AFM. Autothrottles should be disconnected when the autopilot is disengaged.

CAT IIIa Operations (SP-177)

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

Autopilot or Flight Director Faults

Faults can occur at any point during an ILS approach. Many non-normal situations or scenarios are possible. The flight deck is designed so that a quick analysis and decision can be made for virtually all non-normal or fault situations using the Autopilot/Autothrottle indicators, Approach Progress Display or Flight Mode Annunciations (as installed) and master caution system.

Reference the operator's Category II/III Manuals for specific responses to autopilot or flight director faults during Category II/III approaches.

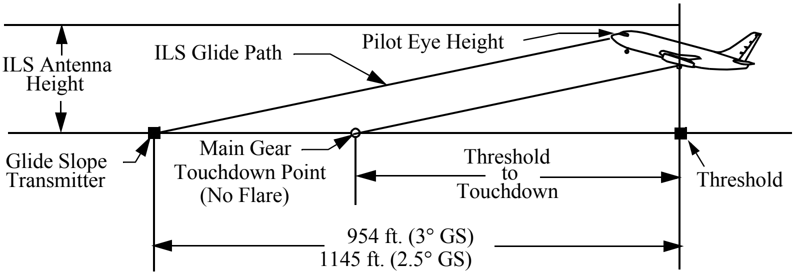
Dual Channel Approach and Go-Around Warnings (SP-177)

WARNING	When	Cause	Pilot Response
Steady red A/P disengage warning light	Below 800’ RA during approach	Stabilizer out of trim	Disengage A/P and execute manual landing (see note) or manual go-around
	During GA	Elevator position not suitable for single autopilot operation	Disengage A/P and execute manual level off OR Select higher go-around altitude
No FLARE arm annunciation	500’ above field elevation during approach	Pitch and roll monitors may not be enabled, or only first A/P up is engaged	Disengage A/P and execute manual landing (see note) or manual go-around
Flashing red A/P disengage warning light and wailer	Below 800’ RA during approach	A/P disengagement	Execute manual landing or manual go-around
Flashing red A/T disengage warning light	Anytime	A/T disengagement	Cancel A/T disengage warning and control thrust levers manually
Flashing red Autoland Warning light (as installed)	Below 500’ -------or------- Below 200’	A/P disengages or stab trim warning occurs ------------------ ILS deviation warning occurs	Disengage autopilot and execute manual landing (see note) or manual go-around.
Note: Execute manual landing only if suitable visual reference is established or if alternate landing minima can be used.			

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-Normal Operations - ILS

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

One Engine Inoperative

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

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

Autopilot Preflight

Self-test switches .... OFF

[Any self-test switch left on in the electronic equipment compartment illuminates the AUTOPILOT disengage lights.]

Engaging:

Control wheel and column .... Center

Autopilot mode selector .... MAN

Autopilot aileron and elevator engage switches .... Engage

Manual Mode Test:

Control wheel steering:

Autopilot mode selector .... MAN

Control column and wheel .... Exert force in pitch and roll

[A force above low detent level will activate the flight controls and cause movement of the control column of control wheel.]

Altitude hold:

Autopilot mode selector .... MAN

Autopilot pitch mode selector .... ALT HOLD

Control column .... Exert force in pitch

[A force in excess of the high detent level will trip the autopilot pitch mode selector to OFF. Subsequent pitch inputs to the autopilot are by low detent CWS.]

Heading select:

Autopilot heading switch .... HDG SEL

Heading selector ....Rotate left and right through airplane heading

[The control wheel will follow the movement of the heading selector.]

Control wheel ....Exert force in roll

[A force in excess of the high detent level will trip the autopilot heading switch to the center position. Subsequent roll inputs to the autopilot are by low detent CWS.]

VOR/LOC Mode Test

VHF navigation radio ....Usable VOR frequency

Autopilot mode selector ....VOR/LOC

Check that the autopilot VOR/LOC annunciator illuminates amber. The control wheel remains centered. Roll inputs to the autopilot are by low detent CWS.

Course selector .... Rotate slowly to center the course deviation bar

Check that the autopilot VOR/LOC annunciator illuminates green at approximately 1/2 dot deviation. This simulates capture of the VOR. The control wheels rotate to complete capture. Subsequent roll inputs to the autopilot are from the VHF NAV radio.

Auto Approach Mode Test

VHF navigation radio .... Usable ILS frequency

Autopilot mode selector ....AUTO APP

Check that the autopilot VOR/LOC and GLIDE SLOPE annunciators illuminate amber. The control column remains centered. Subsequent pitch inputs to the autopilot are by low detent CWS.

Manual G/S Mode Test

Autopilot mode selector ....MAN G/S

Check that the autopilot GLIDE SLOPE annunciator illuminates green. The control column pitches forward. Pitch inputs to the autopilot are longer from CWS.

Control column ....Exert force in pitch

A force in excess of high detent level will trip the mode selector to MAN. Subsequent pitch inputs to the autopilot are by low detent CWS.

Disengage Test

Autopilot aileron and elevator engage switches ....Engage

Autopilot disengage switch ....Push

Note: The autopilot disengage light flashes when the autopilot is disengaged automatically.

Stabilizer Out of Trim Light Test

Autopilot ....Engage

Control column ....Pull back and hold

STAB OUT OF TRIM light .... Illuminated

Control column .... Release

STAB OUT OF TRIM light ....Extinguished

Flight Control Switches Test

To check system B:

Autopilot system select switch .... B

Autopilot ....Engage

Yaw damper switch ....ON

Flight control switch B .... OFF

Autopilot .... Disengages

Yaw damper .... Disengages

Flight control switch B ....ON

Yaw damper switch ....ON

Autopilot Operation

Manual Mode:

Yaw damper switch .... ON

Autopilot elevator and aileron engage switches .... Engaged

If bank angle is less than 5 degrees, the airplane will roll wings level and maintain heading. If bank angle is greater than 5 degrees, the airplane will maintain bank angle.

The airplane will maintain the pitch attitude at the time of engagement.

To maneuver in pitch and roll:

Use CWS at a force greater than LOW detent level. When CWS pitch force is relaxed below low detent level, the airplane maintains the existing pitch attitude. When CWS roll force is relaxed below low detent level, if the bank angle is less than 5 degrees, the airplane rolls wings level and maintains heading. If bank angle is greater than 5 degrees, the airplane maintains bank angle.

To maintain bank angle less than 5 degrees:

Autopilot heading switch .... HDG OFF

When CWS roll force is relaxed below low detent level, the airplane maintains the existing bank angle. Return the autopilot heading switch to remove this submode.

To maneuver in roll and hold altitude:

Pitch mode selector ....ALT HOLD

Use CWS to induce roll at low detent level force. Altitude is maintained by input from the air data computer at the time the pitch mode selector is positioned to ALT HOLD. CWS pitch input greater than high detent level trips the pitch mode selector to OFF.

To maneuver in pitch and hold heading:

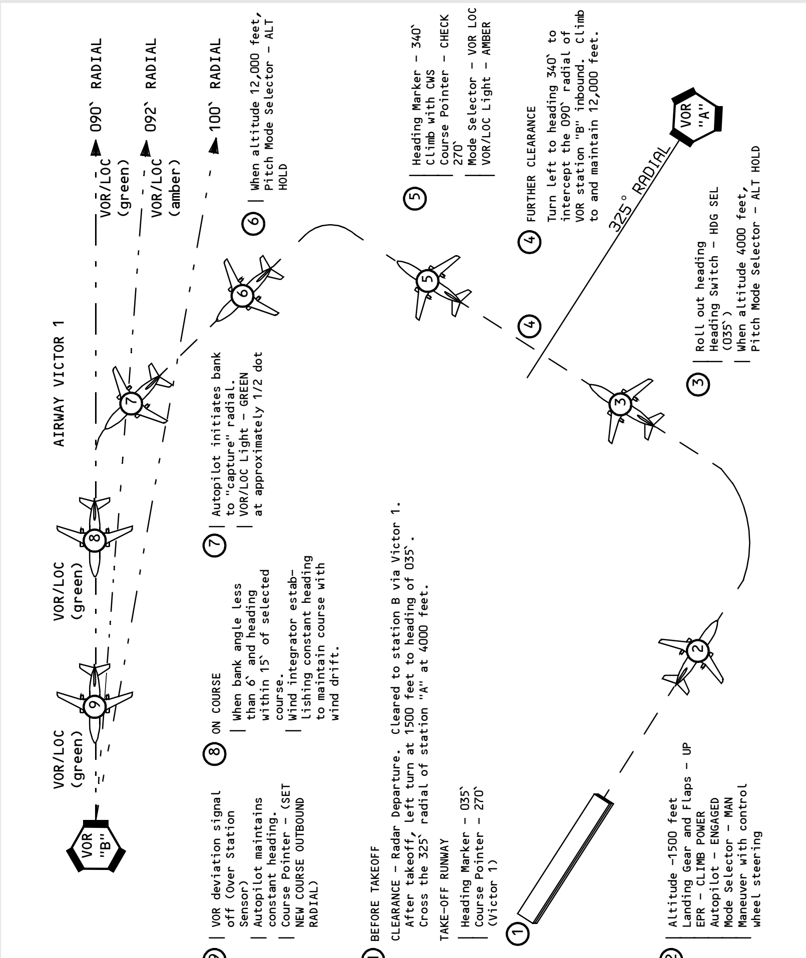
Autopilot heading switch .... HDG SEL

Use CWS to control pitch attitude at low detent level. The airplane turns to and maintains the heading selected on the HSI with the autopilot heading switch in HDG SEL. CWS roll input greater than high detent level trips the autopilot heading switch to the center position.

To maneuver in turbulence:

Pitch mode selector .... TURB

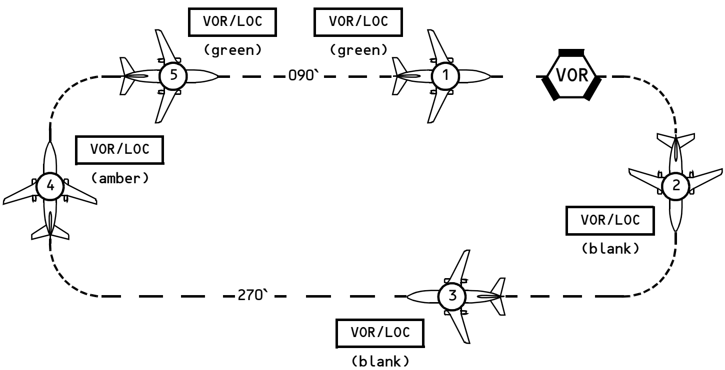
Use CWS at low detent level to control pitch and roll. Pitch signals are damped and roll is limited to 8 degrees bank.



AUTOPILOT OPERATION
(DEPARTURE)

5 On course inbound to station

1
Mode Selector - VOR/LOC
Course Pointer - 90°
Pitch Mode Selector - ALT HOLD
Heading Marker - APPROXIMATELY 225°
Over VOR:
Mode Selector - MAN
Heading Select Switch - HDG SEL



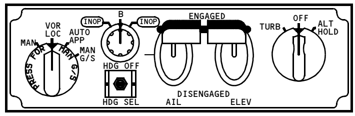
4
Heading Marker - ROTATE RIGHT TO HEADING OF 045°
Mode Selector - VOR/LOC
Will capture VOR when HSI indicates approximately 1/2 dot deviation.

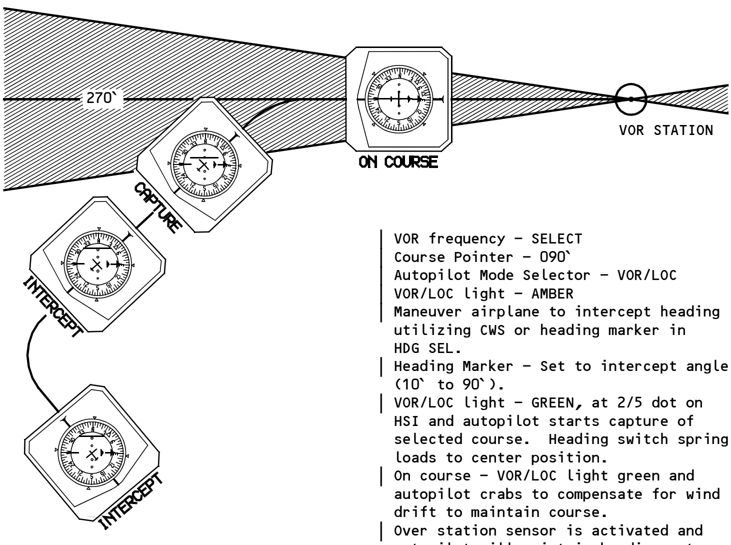
3 Roll out on a heading of approximately 270°. The heading marker may be reset to compensate for wind drift.

2 Heading Marker - 270°

AUTOPILOT OPERATION
(HOLDING-VOR)

A/P
VOR/LOC
APPROACH
PROGRESS
DISPLAY



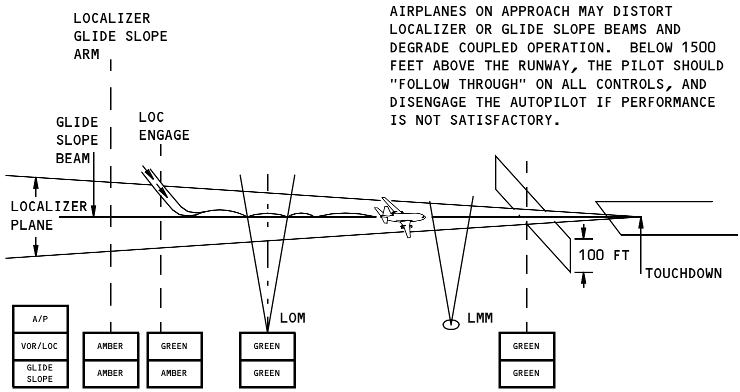


VOR frequency - SELECT
Course Pointer - 090˚
Autopilot Mode Selector - VOR/LOC
VOR/LOC light - AMBER
Maneuver airplane to intercept heading utilizing CWS or heading marker in HDG SEL.
Heading Marker - Set to intercept angle (10˚ to 90˚).
VOR/LOC light - GREEN, at 2/5 dot on HSI and autopilot starts capture of selected course. Heading switch spring loads to center position.
On course - VOR/LOC light green and autopilot crabs to compensate for wind drift to maintain course.
Over station sensor is activated and autopilot will maintain heading at cone of confusion.
Departing station - select new course with course pointer or select MAN mode and maneuver with CWS if course change is more than 15˚.
CWS at low detent level for pitch before and after capture and at high detent level for roll after capture.

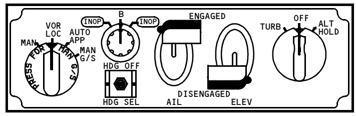
AUTOPILOT OPERATION
(NAVIGATION-VOR/LOC)

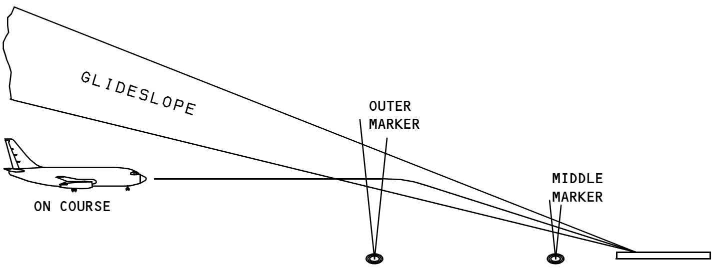
PRE-REQUISITES	VOR/LOC	GLIDE SLOPE	1500 FEET	DECISION HEIGHT	GO-AROUND
Autopilot engaged Localizer tuned Select "AUTO APP" Utilize CWS or HDG SEL for intercept	VOR LOC armed Engaged 2 dots from localizer beam	Glide slope armed Engaged at approx. 1/3 dot HSI fly up Airplane sets up descent approx. 700 fpm for 10 seconds and then follows the beam	Localizer and glide slope gain programming function of radio altimeter inputs	Disengage autopilot prior to landing	Disengage autopilot and fly manually. or Revert to CWS mode.

CAUTION: VEHICLES IN THE VICINITY OF THE ILS OR AIRPLANES ON APPROACH MAY DISTORT LOCALIZER OR GLIDE SLOPE BEAMS AND DEGRADE COUPLED OPERATION. BELOW 1500 FEET ABOVE THE RUNWAY, THE PILOT SHOULD "FOLLOW THROUGH" ON ALL CONTROLS, AND DISENGAGE THE AUTOPILOT IF PERFORMANCE IS NOT SATISFACTORY.



AUTOPILOT OPERATION
(ILS-AUTO APP)





SPLIT AXIS OPERATION (ROLL CHANNEL ONLY)

Autopilot control in roll axis only.

- VOR or localizer signal - SELECTED
- Autopilot Mode Selector - VOR LOC
- VOR/LOC Light - AMBER
- Autopilot Elevator Engage Switch - DISENGAGED

Intercept Localizer Course - VOR/LOC LIGHT GREEN

Localizer capture is identical to AUTO APP mode or VOR LOC mode as previously described. Heading select may be utilized until localizer on-course where the Heading Select Switch moves to the spring-loaded center position.

Outer Marker or Approximate Glide Slope Intercept Point.

Utilize control column for pitch inputs. Pitch Mode Selector does not hold in ALT HOLD or TURB with Autopilot Elevator Engage Switch in the DISENGAGED position.

NOTE: Roll channel may be used in MAN and VOR LOC modes with inoperative pitch channel and operates normally as previously described.

AUTOPILOT OPERATION
(SPLIT AXIS APPROACH)

Non-ILS Approach (VOR/LOC/LOC-BC/NDB/ASR/LDA/SDF)

Autopilot or flight director use is recommended until suitable visual reference is established. DME or other appropriate fix information is required to determine distance to the landing runway on final approach. The INS, Omega or equivalent navigation system (as installed) may be used to determine distance to the landing runway provided the flight crew verifies present position accuracy prior to commencing the approach.

This procedure assumes the following approach preparations are complete:

- Navaids tuned and identified
- Final approach course set (VOR, localizer, etc.)
- RDMI/RMIs (as installed) show the appropriate course or bearing information
- Minimum descent altitude is set on altimeter reference marker (as installed)
- Approach briefing is complete
- For a straight-in approach, the landing configuration is established when on the final approach descent path
- For a circling approach, the circling configuration (gear down, flaps 15 or gear up, flaps 10) is established at or before the final approach descent point and landing configuration is established when intercepting the landing profile.

Recommended roll modes:

- VOR, localizer, LDA or SDF: VOR LOC
- LOC-BC, NDB or ASR: HDG SEL

When on an intercept heading to the final approach course:

Roll mode .... Select

At the final approach descent point (FAF or other appropriate fix):

Vertical Speed ....Select/Establish

Select or establish an appropriate vertical speed resulting in a constant angle approach (constant descent final approach) Initially, use a vertical speed corresponding to the airplane ground speed (shown on the approach chart). Once established on the final approach descent path, use distance and recommended height information on the approach chart (if available) to determine relative height to recommended vertical path. Make small and frequent adjustments to the vertical speed to maintain proper path and to comply with minimum altitudes on final approach. The MDA(H) will be reached at approximately the same position as the Visual Descent Point (VDP) shown on some approach charts.

If recommended height information is not available, use a path that approximates 3 degrees. To maintain a 3 degree constant angle approach path, make small but frequent adjustments to the vertical speed to comply with the following recommended heights above touchdown (HAT) and comply with the minimum altitudes on final approach:

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

For a straight-in approach:

At approximately 50 feet above MDA (H) and suitable visual reference established:

Autopilot .... Disengage

If suitable visual reference is not established:

Execute a missed approach.

For a circling approach:

Approaching MDA (H) and suitable visual reference is established:

Altitude Hold .... Engage

Maintain level flight and suitable visual reference while circling.

Use HDG SEL to maneuver.

Intercepting the landing profile:

Autopilot .... Disengage

If suitable visual reference not established or is lost:

Execute a missed approach. If a missed approach is started while circling, make a climbing turn in the shortest direction toward the landing runway and comply with the published missed approach procedure.

Intentionally
Blank