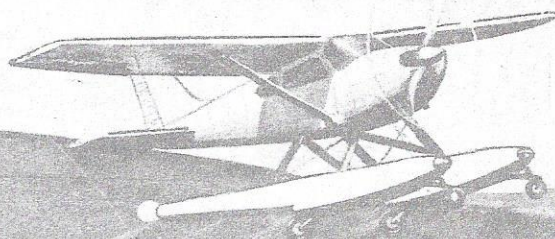
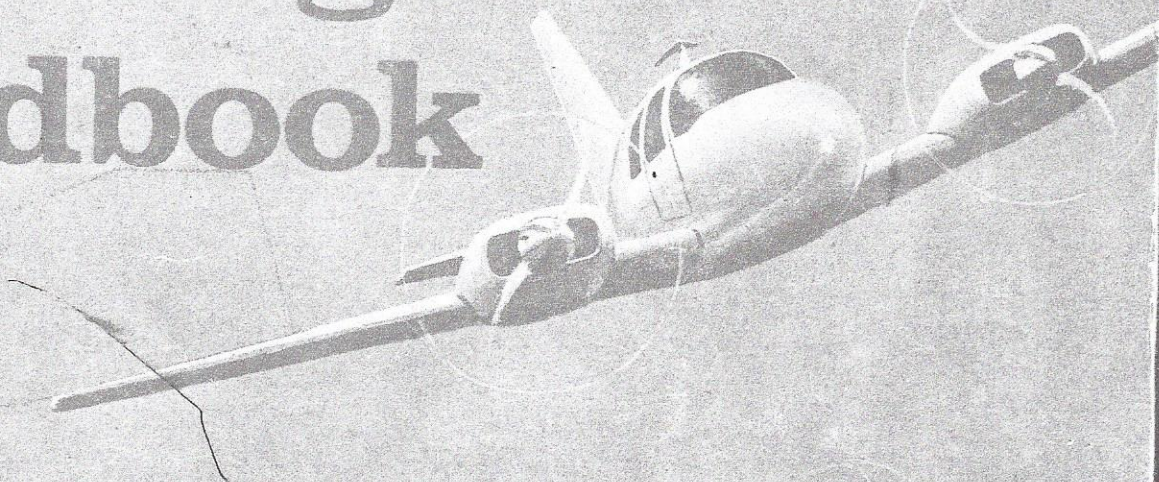


Flight Training Handbook



REVISED 1980

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

FLIGHT STANDARDS SERVICE



Go-around procedures vary with different airplanes, depending on their weight, flight characteristics, flap and retractable gear systems, and flight performance. Specific procedures must be learned by the transitioning pilot from the Pilot's Operating Handbook, which should always be available in the cockpit.

There are several general go-around procedures which apply to most airplanes, and are worth pointing out:

a. When the decision to go around is reached, takeoff power should be applied immediately and the descent stopped by adjusting the pitch attitude to avoid further loss of altitude.

b. The flaps should be retracted only in accordance with the procedure prescribed in the airplane's operating manual. Usually this will require the flaps to be positioned as for takeoff.

c. After a positive rate of climb is established the landing gear should be retracted, best rate-of-climb airspeed obtained and maintained, and the airplane trimmed for this climb. The procedure for a normal takeoff climb should then be followed.

The basic requirements of a successful go-around, then, are the prompt arrest of the descent, and the attainment and maintenance of the best rate-of-climb airspeed.

At any time the airspeed is faster than the flaps-up stalling speed, the flaps may be retracted completely without losing altitude if simultaneously the angle of attack is increased sufficiently. At critically slow airspeeds, however, retracting the flaps prematurely or suddenly can cause a stall or an unanticipated loss of altitude. Rapid or premature retraction of the flaps should be avoided on go-arounds, especially when close to the ground, because of the careful attention and exercise of precise pilot technique necessary to prevent a sudden loss of altitude. It generally will be found that retracting the flaps only halfway or to the specified approach setting decreases the drag a relatively greater amount than it decreases the lift.

The FAA approved Airplane Flight Manual or Pilot's Operating Handbook should be consulted regarding landing gear and flap retraction procedures because in some installations simultaneous retraction of the gear and flaps

may increase the flap retraction time, and full flaps create more drag than the extended landing gear.

Light-Twin Performance Characteristics

From the transitioning pilot's point of view, the basic difference between a light-twin and single-engine airplane is the potential problem involving engine failure. The information that follows is confined to that one basic difference.

The term "light-twin" as used here pertains to the propeller driven airplane having a maximum certificated gross weight of less than 12,500 pounds, and which has two reciprocating engines mounted on the wings.

Before the subject of operating technique in light twin-engine airplanes can be thoroughly discussed, there are several terms that need to be reviewed. "V" speeds such as V_x , V_{xse} , V_y , V_{yse} , and V_{mc} are the main performance speeds the light-twin pilot needs to know in addition to the other performance speeds common to both twin-engine and single-engine airplanes. The airspeed indicator in twin-engine airplanes is marked (in addition to other normally marked speeds) with a red radial line at the minimum controllable airspeed with the critical engine inoperative, and a blue radial line at the best rate-of-climb airspeed with one engine inoperative (Fig. 16-5).

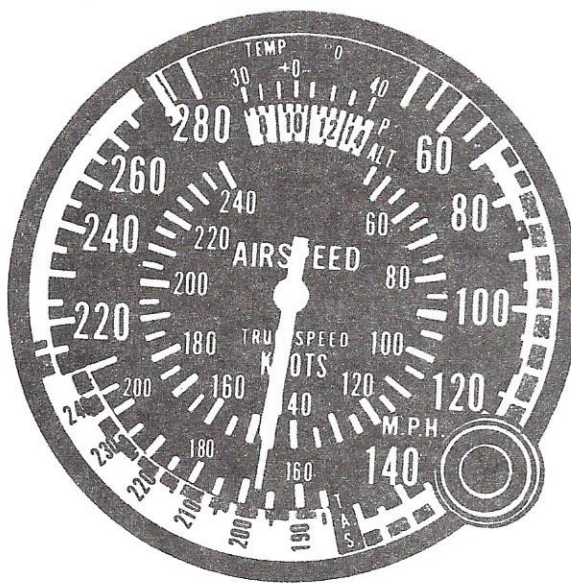


Figure 16-5 Airspeed Markings for Twin-Engine Airplane

V_x —The speed for best angle of climb. At this speed the airplane will gain the greatest height for a given distance of forward travel. This speed is used for obstacle clearance with all engines operating. However, this speed is different when one engine is inoperative, and in this handbook is referred to as V_{xse} (single-engine).

V_y —The speed for the best rate of climb. This speed will provide the maximum altitude gain for a given period of time with all engines operating. However, this speed too will be different when one engine is inoperative and in this handbook is referred to as V_{yse} (single-engine).

V_{mc} —The minimum control speed with the critical engine inoperative. The term V_{mc} can be defined as the minimum airspeed at which the airplane is controllable when the critical engine is suddenly made inoperative, and the remaining engine is producing takeoff power. The Federal Aviation Regulations under which the airplane was certificated, stipulate that at V_{mc} the certificating test pilot must be able to: (1) stop the turn which results when the critical engine is suddenly made inoperative within 20° of the original heading, using maximum rudder deflection and a maximum of 5° bank into the operative engine, and (2) after recovery, maintain the airplane in straight flight with not more than a 5° bank (wing lowered toward the operating engine). This does not mean that the airplane must be able to climb or even hold altitude. It only means that a heading can be maintained. The principle of V_{mc} is not at all mysterious. It is simply that at any airspeed less than V_{mc} , air flowing along the rudder is such that application of rudder forces cannot overcome the asymmetrical yawing forces caused by takeoff power on one engine and a powerless windmilling propeller on the other. The demonstration of V_{mc} is discussed in a later section of this handbook.

Many pilots erroneously believe that because a light-twin has two engines, it will continue to perform at least half as well with only one of those engines operating. There is nothing in FAR, Part 23, governing the certification of light-twins, which requires an airplane to maintain altitude while in the takeoff configuration and with one engine inoperative. In fact, many of the current light-twins are not required to do this with one engine inoperative in any configuration, even at sea level. This is of major significance in the operations of light-twins certificated under Part 23. With regard to performance (but not controllability) in the takeoff or landing configuration, the light twin-engine airplane is, in concept, merely a single-engine airplane with its power divided into two individual units. The following discussion should help the pilot to eliminate any misconceptions of single-engine operation of light-twin airplanes.

When one engine fails on a light-twin, performance is not really halved, but is actually reduced by 80 percent or more. The performance loss is greater than 50 percent because an airplane's climb performance is a function of the thrust horsepower which is in excess of that required for level flight. When power is increased in both engines in level flight and the airspeed is held constant, the airplane will start climbing—the rate of climb depending on the power added (which is power in excess of that required for straight-and-level flight). When one engine fails, however, it not only loses power but the drag increases considerably because of asymmetric thrust and the operating engine must then carry the full burden alone. To do this, it must produce 75 percent or more of its rated power. This leaves very little excess power for climb performance.

As an example, an airplane which has an all-engine rate of climb of 1,860 FPM and a single engine rate of climb of 190 FPM would lose almost 90 percent of its climb performance when one engine fails.

Nonetheless, the light-twin does offer obvious safety advantages over the single-engine airplane (especially in the enroute phase) but *only if* the pilot fully understands the real options offered by that second engine in the takeoff and approach phase of flight.

It is essential then that the light-twin pilot take proficiency training periodically from a competent flight instructor.

Engine-Out Emergencies

In general, the operating and flight characteristics of modern light-twins with one engine inoperative are excellent. These airplanes can be controlled and maneuvered safely as long as sufficient airspeed is maintained. However, to utilize the safety and performance characteristics effectively, the pilot must have a sound understanding of the single-engine performance and the limitations resulting from an unbalanced of power.

A pilot checking out for the first time in any multiengine airplane should practice and become thoroughly familiar with the control and performance problems which result from the failure of one engine during any flight condition. Practice in all the control operations and precautions is necessary and demonstration of these is required on multiengine rating flight tests. Practice should be continued as long as the pilot engages in flying a twin-engine airplane, so that corrective action will be instinctive and the ability to control airspeed, heading, and altitude will be retained.

The feathering of a propeller should be demonstrated and practiced in all airplanes equipped with propellers which can be feathered and unfeathered safely in flight. If the airplane used is not equipped with feathering propellers, or is equipped with propellers which cannot be feathered and unfeathered safely in flight, one engine should be secured (shut down) in accordance with the procedures in the FAA approved Airplane Flight Manual or the Pilot's Operating Handbook. The recommended propeller setting should be used, and the emergency setting of all ignition, electrical, hydraulic, and fire extinguisher systems should be demonstrated.

Propeller Feathering

When an engine fails in flight the movement of the airplane through the air tends to keep the propeller rotating, much like a windmill. Since the failed engine is no longer delivering power to the propeller to produce thrust but instead, may be absorbing energy to overcome

friction and compression of the engine, the drag of the windmilling propeller is significant and causes the airplane to yaw toward the failed engine (Fig. 16-6). Most multiengine airplanes are equipped with "full-feathering propellers" to minimize that yawing tendency.



Figure 16-6 Windmilling Propeller Creates Drag

The blades of a feathering propeller may be positioned by the pilot to such a high angle that they are streamlined in the direction of flight. In this feathered position, the blades act as powerful brakes to assist engine friction and compression in stopping the windmilling rotation of the propeller. This is of particular advantage in case of a damaged engine, since further damage, caused by a windmilling propeller creates the least possible drag on the airplane and reduces the yawing tendency. As a result, multiengine airplanes are easier to control in flight when the propeller of an inoperative engine is feathered.

Feathering of propellers for training and checkout purposes should be performed only under such conditions and at such altitudes and locations that a safe landing on an established airport could be accomplished readily in the event of difficulty in unfeathering the propeller.

Engine-Out Procedures

The following procedures are recommended to develop in the transitioning pilot the habit of using proper procedures and proficiency in coping with an inoperative engine.

At a safe altitude (minimum 3,000 feet above terrain) and within landing distance of a suitable airport, an engine may be shut down with the mixture control or fuel selector. At lower altitudes, however, shut down should be *simulated by reducing power* by means of the

throttle to the zero thrust setting. The following procedures should then be followed:

- (1) Set mixture and propeller controls as required; both power controls should be positioned for maximum power to maintain at least V_{mc} .
- (2) Retract wing flaps and landing gear.
- (3) Determine which engine failed, and *verify* it by closing the throttle on the dead engine.
- (4) Bank at least 5° into the operative engine.
- (5) Determine the cause of failure, or feather the inoperative engine.
- (6) Turn toward the nearest airport.
- (7) Secure (shut down) the inoperative engine in accordance with the manufacturer's approved procedures and check for engine fire.
- (8) Monitor the engine instruments on the operating engine; and adjust power, cowl flaps, and airspeed as necessary.
- (9) Maintain altitude and an airspeed of at least V_{yse} if possible.

The pilot must be proficient in the control of heading, airspeed, and altitude, in the prompt identification of a power failure, and in the accuracy of shutdown and restart procedures as prescribed in the FAA approved Airplane Flight Manual or Pilot's Operating Handbook.

There is no better way to develop skill in single-engine emergencies than by *continued* practice. The fact that the techniques and procedures of single-engine operation are mastered thoroughly at one time during a pilot's career is no assurance of being able to cope successfully with an engine-out emergency *unless review and practice are continued*. Some engine-out emergencies may be so critical that there may be no safety margin for lack of skill or knowledge. Unfortunately, many light-twin pilots never practice single-engine operation after receiving their multiengine rating.

The pilot should practice and demonstrate the effects (on engine-out performance) of various configurations of gear, flaps, and both; the use of carburetor heat; and the failure to feather the propeller on an inopera-

tive engine. Each configuration should be maintained, at best engine-out rate-of-climb speed long enough to determine its effect on the climb (or sink) achieved. Prolonged use of carburetor heat, if so equipped, at high power settings should be avoided.

The Critical Engine

"P-factor" is present in multiengine airplanes just as it is in single-engine airplanes. Remember, P-factor is caused by the dissimilar thrust of the rotating propeller blades when in certain flight conditions. It is the result of the downward moving blade having a greater angle of attack than the upward moving blade when the relative wind striking the blades is not aligned with the thrust line (as in a nose-high attitude).

In most U.S. designed light-twins, both engines rotate to the right (clockwise) when viewed from the rear, and both engines develop an equal amount of thrust. At low airspeed and high power conditions, the downward moving propeller blade of each engine develops more thrust than the upward moving blade. This asymmetric propeller thrust or "P-factor," results in a center of thrust at the right side of each engine as indicated by lines D1 and D2 in Fig. 16-7. The turning (or yawing) force of the right engine is greater than the left engine because the center of thrust (D2) is much farther away from the center line (CL) of the fuselage—it has a longer level arm. Thus, when the right engine is operative and the left engine is inoperative, the turning (or yawing) force is greater than in the opposite situation of a "good" left engine and a "bad" right engine. In other words, directional control may be difficult when the left engine (the *critical* engine) is suddenly made inoperative.

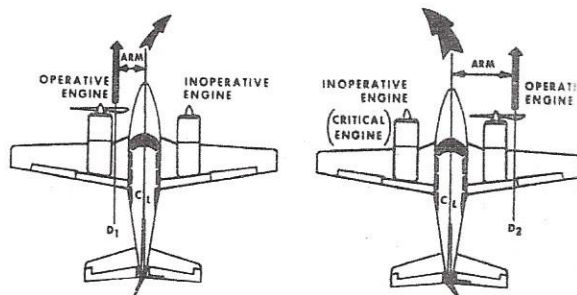


Figure 16-7 Forces Created During Single-Engine Operation

It should be noted that some light-twin engine airplanes are equipped with engines turning in opposite directions; that is, the left engine and propeller turn clockwise and the right engine and propeller turn counterclockwise. With this arrangement, the thrust line of either engine is the same distance from the center line of the fuselage, so there will be no difference in yaw effect between loss of left or right engine.

V_{mc} Demonstrations

Every light-twin engine airplane checkout should include a demonstration of the airplane's engine-out minimum control speed. The engine-out minimum control speed given in the FAA approved Airplane Flight Manual, Pilot's Operating Handbook, or other manufacturer's published limitations is determined during original airplane certification under conditions specified in the Federal Aviation Regulations. These conditions normally are not duplicated during pilot training or testing because they consist of the most adverse situations for airplane type certification purposes. Prior to a pilot checkout, a thorough discussion of the factors affecting engine-out minimum control speed is essential.

Basically, when one engine fails the pilot must overcome the asymmetrical thrust (except on airplanes with center line thrust) created by the operating engine by setting up a counteracting moment with the rudder. When the rudder is fully deflected, its yawing power will depend on the velocity of airflow across the rudder—which in turn is dependent on the airspeed. As the airplane decelerates it will reach a speed below which the rudder moment will no longer balance the thrust moment and directional control will be lost.

During engine-out flight the large rudder deflection required to counteract the asymmetrical thrust also results in a "lateral lift" force on the vertical fin. This lateral "lift" represents an unbalanced side force on the airplane which must be counteracted either by allowing the airplane to accelerate sideways until the lateral drag caused by the sideslip equals the rudder "lift" force or by banking into the operative engine and using a component of the airplane weight to counteract the rudder-induced side force.

In the first case, the wings will be level, the ball in the turn-and-slip indicator will be centered and the airplane will be in a moderate sideslip toward the inoperative engine. In the second case, the wings will be banked 3–5° into the good engine, the ball will be deflected one diameter toward the operative engine, and the airplane will be at zero sideslip.

The sideslipping method has several major disadvantages: (1) the relative wind blowing on the inoperative engine side of the vertical fin tends to increase the asymmetric moment caused by the failure of one engine; (2) the resulting sideslip severely degrades stall characteristics; and (3) the greater rudder deflection required to balance the extra moment and the sideslip drag cause a significant reduction in climb and/or acceleration capability.

Flight tests have shown that holding the ball of the turn-and-slip indicator in the center while maintaining heading with wings level drastically increases V_{mc} as much as 20 knots in some airplanes. (Remember, the value of V_{mc} given in the FAA approved flight manual for the airplane is based on a maximum 5° bank into the operative engine.) Banking into the operative engine *reduces* V_{mc} , whereas decreasing the bank angle away from the operative engine *increases* V_{mc} at the rate of approximately 3 knots per degree of bank angle.

Flight tests have also shown that the high drag caused by the wings level, ball centered configuration can reduce single-engine climb performance by as much as 300 FPM, which is just about all that is available at sea level in a nonturbocharged light twin.

Banking at least 5° into the good engine ensures that the airplane will be controllable at any speed above the certificated V_{mc} , that the airplane will be in a minimum drag configuration for best climb performance, and that the stall characteristics will not be degraded. Engine-out flight with the ball centered is *never* correct.

The magnitude of these effects will vary from airplane to airplane, but the principles are applicable in all cases.

NOTE.—A bank limitation of up to 5° during V_{mc} demonstration is applicable only to certification tests of the airplane and is not intended as a limit in training or testing a pilot's ability to extract maximum performance from the airplane.

For an airplane with nonsupercharged engines, V_{mc} decreases as altitude is increased. Consequently, directional control can be maintained at a lower airspeed than at sea level. The reason for this is that since power decreases with altitude the thrust moment of the operating engine becomes less, thereby lessening the need for the rudder's yawing force. Since V_{mc} is a function of power (which decreases with altitude), it is possible for the airplane to reach a stall speed prior to loss of directional control.

It must be understood, therefore, that there is a certain density altitude above which the stalling speed is higher than the engine-out minimum control speed. When this density altitude exists close to the ground because of high elevations or temperatures, an effective flight demonstration is impossible and should not be attempted. When a flight demonstration is impossible, the check pilot should emphasize orally the significance of the engine-out minimum control speed, including the results of attempting flight below this speed with one engine inoperative, the recognition of the imminent loss of control, and the recovery techniques involved.

V_{mc} is greater when the center of gravity is at the rearmost allowable position. Since the airplane rotates around its center of gravity, the moments are measured using that point as a reference. A rearward CG would not affect the thrust moment, but would shorten the arm to the center of the rudder's horizontal "lift" which would mean that a higher force (airspeed) would be required to counteract the engine-out yaw. Figure 16-8 shows an exaggerated view of the effects of a rearward CG.

Generally, the center of gravity range of most light twins is short enough so that the effect on the V_{mc} is relatively small, but it is a factor that should be considered. Many pilots

would only consider the rear CG of their light-twin as a factor for pitch stability, not realizing that it could affect the controllability with one engine out.

There are many light-twin pilots who think that the only control problem experienced in flight below V_{mc} is a yaw toward the inoperative engine. Unfortunately, this is not the whole story.

With full power applied to the operative engine, as the airspeed drops below V_{mc} , the airplane tends to roll as well as yaw into the inoperative engine. This tendency becomes greater as the airspeed is further reduced, since this tendency must be counteracted by aileron control, the yaw condition is aggravated by aileron yaw (the "down" aileron creates more drag than the "up" aileron). If a stall should occur in this condition, a violent roll into the dead engine may be experienced. Such an event occurring close to the ground could be disastrous. This may be avoided by maintaining airspeed above V_{mc} at all times during single-engine operation. If the airspeed should fall below V_{mc} —for whatever reason—then power must be reduced on the operative engine and the airplane must be banked at least 5° toward the operative engine if the airplane is to be safely controlled.

The V_{mc} demonstrations should be performed at an altitude from which recovery from loss of control could be made safely. One demonstration should be made while holding the wings level and the ball centered, and another demonstration should be made while banking the airplane at least 5° toward the operating engine to establish "zero sideslip." These maneuvers will demonstrate the engine-out minimum control speed for the existing conditions and will emphasize the necessity of banking into the operative engine. *No attempt should be made to duplicate V_{mc} as determined for airplane certification.*

After the propellers are set to high RPM, the landing gear is retracted, and the flaps are in the takeoff position, the airplane should be placed in a climb attitude and airspeed representative of that following a normal takeoff. With both engines developing as near rated takeoff power as possible, power on the critical engine (usually the left) should then be re-

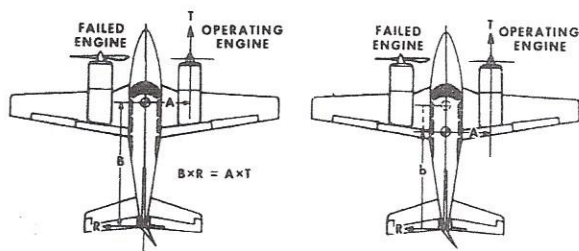


Figure 16-8 Effect of CG Location on Yaw

duced to idle (windmilling, not shut down). After this is accomplished, the airspeed should be reduced slowly with the elevators until directional control no longer can be maintained. At this point, recovery should be initiated by simultaneously reducing power on the operating engine and reducing the angle of attack by lowering the nose. Should indications of a stall occur prior to reaching this point, recovery should be initiated immediately by reducing the angle of attack. In this case, a minimum engine-out control speed demonstration is not possible under existing conditions.

If it is found that the minimum engine-out control speed is reached before indications of a stall are encountered, the pilot should demonstrate the ability to control the airplane and initiate a safe climb in the event of a power failure at the published engine-out minimum control speed.

Accelerate/Stop Distance

The most critical time for an engine-out condition in a twin-engine airplane is during the two or three-second period immediately following the takeoff roll while the airplane is accelerating to a safe engine-failure speed.

Although most twin-engine airplanes are controllable at a speed close to the engine-out minimum control speed, the performance is often so far below optimum that continued flight following takeoff may be marginal or impossible. A more suitable recommended speed, termed by some aircraft manufacturers as minimum safe single-engine speed, is that at which altitude can be maintained while the landing gear is being retracted and the propeller is being feathered.

Upon engine failure after reaching the safe single-engine speed on takeoff, the twin-engine pilot (having lost one-half of the normal power) usually has a significant advantage over the pilot of a single-engine airplane, because, if the particular airplane has single-engine climb capability at the existing gross weight and density altitude, there may be the choice of stopping or continuing the takeoff. This compares with the only choice facing a single-engine airplane pilot who suddenly has lost half of the normal takeoff power—that is stop!

If one engine fails prior to reaching V_{mc} , there is no choice but to close both throttles and bring the airplane to a stop. If engine failure occurs after becoming airborne, the pilot must decide immediately to land or to continue the takeoff.

If the decision is made to continue the takeoff, the airplane must be able to gain altitude with one engine inoperative. This requires acceleration to V_{yse} if no obstacles are involved, or to V_{xse} if obstacles are a factor.

To make a correct decision in an emergency of this type, the pilot must consider the runway length, field elevation, density altitude, obstruction height, headwind component, and the airplane's gross weight. (For simplification purposes, additional factors such as runway contaminants [rubber, soot, water, ice, snow] and runway slope will not be discussed here.) The flightpaths illustrated in Fig. 16-9 indicate that the "area of decision" is bounded by: (1) the point at which V_1 is reached and (2) the point where the obstruction altitude is reached. An engine failure in this area demands an immediate decision. Beyond this decision area, the airplane, within the limitations of engine-out climb performance, can usually be maneuvered to a landing at the departure airport.

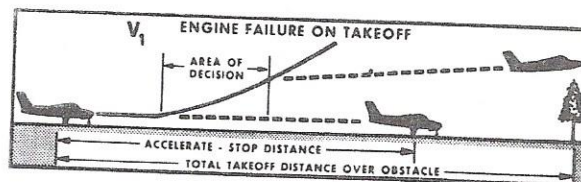


Figure 16-9 Area of Decision

The "accelerate-stop distance" is the total distance required to accelerate the twin-engine airplane to a specified speed and, assuming failure of an engine at the instant that speed is attained, to bring the airplane to a stop on the remaining runway. The "accelerate-go distance" is the total distance required to accelerate the airplane to a specified speed and, assuming failure of an engine at the instant that speed is attained, continue takeoff on the remaining engine to a height of 50 feet.

For example, use the chart in Fig. 16-10 and assume that with a temperature of 80° F., a calm wind at a pressure altitude of 2,000