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Flying Operations

INSTRUMENT FLIGHT PROCEDURES

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This instruction implements AFPD 11-2, Flight Rules and Procedures, by providing guidance and procedures for standard Air Force instrument flying. Since aircraft flight instrumentation and mission objectives are so varied, this instruction is necessarily general regarding equipment and detailed accomplishment of maneuvers. The guidance found in this manual is both technique and procedurally oriented. ***Instruction depicted in bold italics is considered procedure.*** Individual aircraft flight manuals should provide detailed instructions required for particular aircraft instrumentation or characteristics. This instruction, when used with related flight directives and publications, provides adequate guidance for instrument flight under most circumstances, but is not a substitute for sound judgment. Circumstances may require modification of prescribed procedures. Aircrew members charged with the safe operation of United States Air Force aircraft must be knowledgeable of the guidance contained in this manual. This publication applies to the Air National Guard (ANG) when published in the ANGIND 2.

SUMMARY OF REVISIONS

This manual has been extensively rewritten and reformatted which requires a thorough review of the entire manual. It is too difficult to mark all the changes found in this version of the manual due to format restructuring, subject consolidation and paragraph numbering. However, the following chapters or sections will require a more in-depth review. Chapter 1 has changes in the use of single medium displays and the display of flight instrumentation. Chapter 2 has small changes in verbiage and procedures. Chapters 3 and 4 have changes in helicopter instrument procedures based on the current AF equipment inventory. Chapters 5 and 6 clarify procedures and include better explanations concerning NAVAIDs and GPS while Chapter 7 contains updates to Area Navigation (RNAV). Chapter 8 has considerable changes and updates to procedures, requiring a full review. Chapter 9 has extensive changes to departure procedures. This chapter was written in a more instructional tone to aid in understanding and represents the future vision of AFM 11-217. Chapter 10 on holding is a complete revision that now offers pilots holding options. Chapter 11 consists of changes in procedures versus techniques. Chapters 13 and 14 have many changes and procedures that incorporate FAA guidance with existing Air Force procedures/techniques. Chapter 16 has changes to procedures as well as to the missed approach climb gradient. Chapter 23 on ICAO procedures has significant changes throughout and must be reviewed. Chapter 25 has been updated taking into account HUD modernization.

Chapter 12 - High Altitude Approaches

Chapter 13 - Low Altitude Approaches

Chapter 14 - Final Approach

Chapter 15 - Landing from Instrument Approaches

Chapter 16 - Missed Approach

Chapter 17 - 19 [Reserved]

Chapter 20 - Additional Information and Guidance

Figures

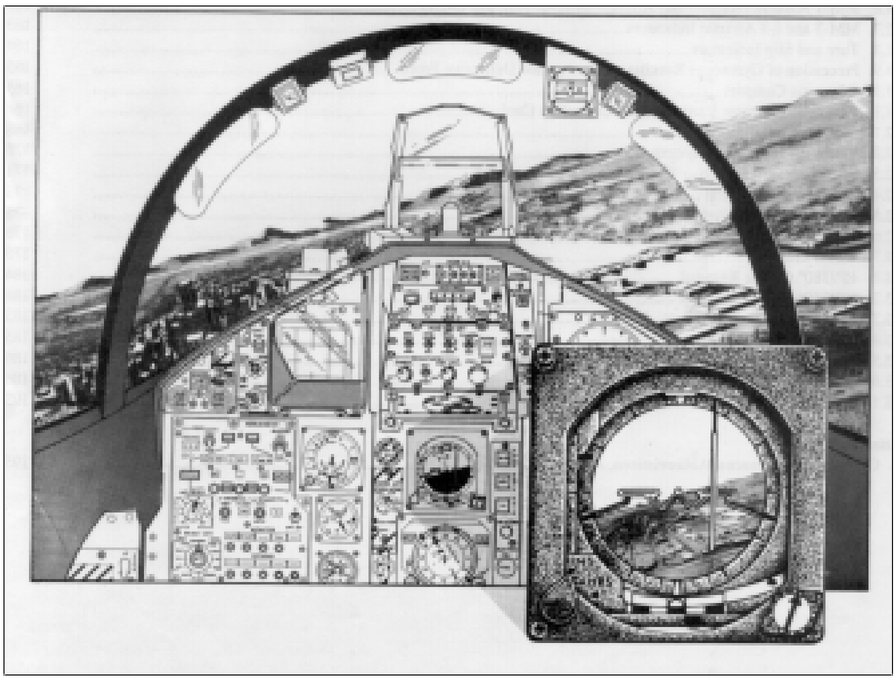
Attachment

Chapter 1

BASIC INSTRUMENT FLYING-FIXED WING

1.1. Instrument Categories (Figure 1.1). Aircraft performance is achieved by controlling the aircraft attitude and power (angle of attack and thrust to drag relationship). Aircraft attitude is the relationship of its longitudinal and lateral axes to the Earth's horizon. An aircraft is flown in instrument flight by controlling the attitude and power as necessary to produce the desired performance. This is known as the "control and performance concept" of attitude instrument flying and can be applied to any basic instrument maneuver. The three general categories of instruments are:

Figure 1.1. Attitude Instrument Flying (para 1.1).



1.1.1. Control Instruments. These instruments display immediate attitude and power indications and are calibrated to permit attitude and power adjustments in definite amounts. In this discussion, the term power is used to replace the more technically correct term thrust or drag relationship. Control is determined by reference to the attitude indicators and power indicators. These power indicators vary with aircraft and may include tachometers, engine pressure ratio (EPR), manifold pressure, fuel flow, etc.

1.1.2. Performance Instruments. These instruments indicate the aircraft's actual performance. Performance is determined by reference to the altimeter, airspeed or mach indicator, vertical velocity indicator, heading indicator, angle of attack indicator, and turn and slip indicator.

1.1.3. Navigation Instruments. These instruments indicate the position of the aircraft in relation to a selected navigation facility or fix. This group of instruments includes various types of course indicators, range indicators, glide slope indicators, and bearing pointers.

NOTE: The head-up display is a system capable of displaying some control, performance, and navigation data simultaneously in a relatively small area. Information received from HUD equipment that is not certified for sole-reference instrument flight must be verified with other cockpit indications.

1.2. Control and Performance Concept.

1.2.1. Effective Steps.

1.2.1.1. Establish. Establish an attitude or power setting on the control instruments that will result in the desired performance. Known or computed attitude changes and approximate power settings will help to reduce the pilot workload.

1.2.1.2. Trim. Trim until control pressures are neutralized. Trimming for hands-off flight is essential for smooth, precise aircraft control. It allows pilots to divert their attention to other cockpit duties with minimum deviation from the desired attitude.

1.2.1.3. Crosscheck. Crosscheck the performance instruments to determine if the established attitude or power setting is providing the desired performance. The crosscheck is both seeing and interpreting. If a deviation is noted, determine the magnitude and direction of adjustment required to achieve the desired performance.

1.2.1.4. Adjust. Adjust the attitude or power setting on the control instruments as necessary.

1.2.2. Attitude Control. Proper control of aircraft attitude is the result of maintaining a constant attitude, knowing when and how much to change the attitude, and smoothly changing the attitude a definite amount. Aircraft attitude control is accomplished by proper use of the attitude reference. The attitude reference provides an immediate, direct, and corresponding indication of any change in aircraft pitch or bank attitude.

1.2.2.1. Pitch Control. Pitch changes are made by changing the "pitch attitude" of the miniature aircraft or fuselage dot definite amounts in relation to the horizon. These changes are measured in degrees or fractions thereof, or bar widths depending upon the type of attitude reference. The amount of deviation from the desired performance will determine the magnitude of the correction.

1.2.2.2. Bank Control. Bank changes are made by changing the "bank attitude" or bank pointers definite amounts in relation to the bank scale. The bank scale is normally graduated at 0°, 10°, 20°, 30°, 60°, and 90° and may be located at the top or bottom of the attitude reference. Normally, use a bank angle that approximates the degrees to turn, not to exceed 30°.

1.2.3. Power Control.

1.2.3.1. Proper power control. Proper power control results from the ability to smoothly establish or maintain desired airspeeds in coordination with attitude changes. Power changes are made by throttle adjustments and reference to the power indicators. Power indicators are not affected by such factors as turbulence, improper trim, or inadvertent control pressures. Therefore, in most aircraft, little attention is required to ensure the power setting remains constant.

1.2.3.2. Power. From experience in an aircraft, you know approximately how far to move the throttles to change the power a given amount. Therefore, you can make power changes primarily by throttle movement and then crosscheck the indicators to establish a more precise setting. The key is to avoid fixating on the indicators while setting the power. A knowledge of approximate power settings for various flight conditions will help you prevent over-controlling power.

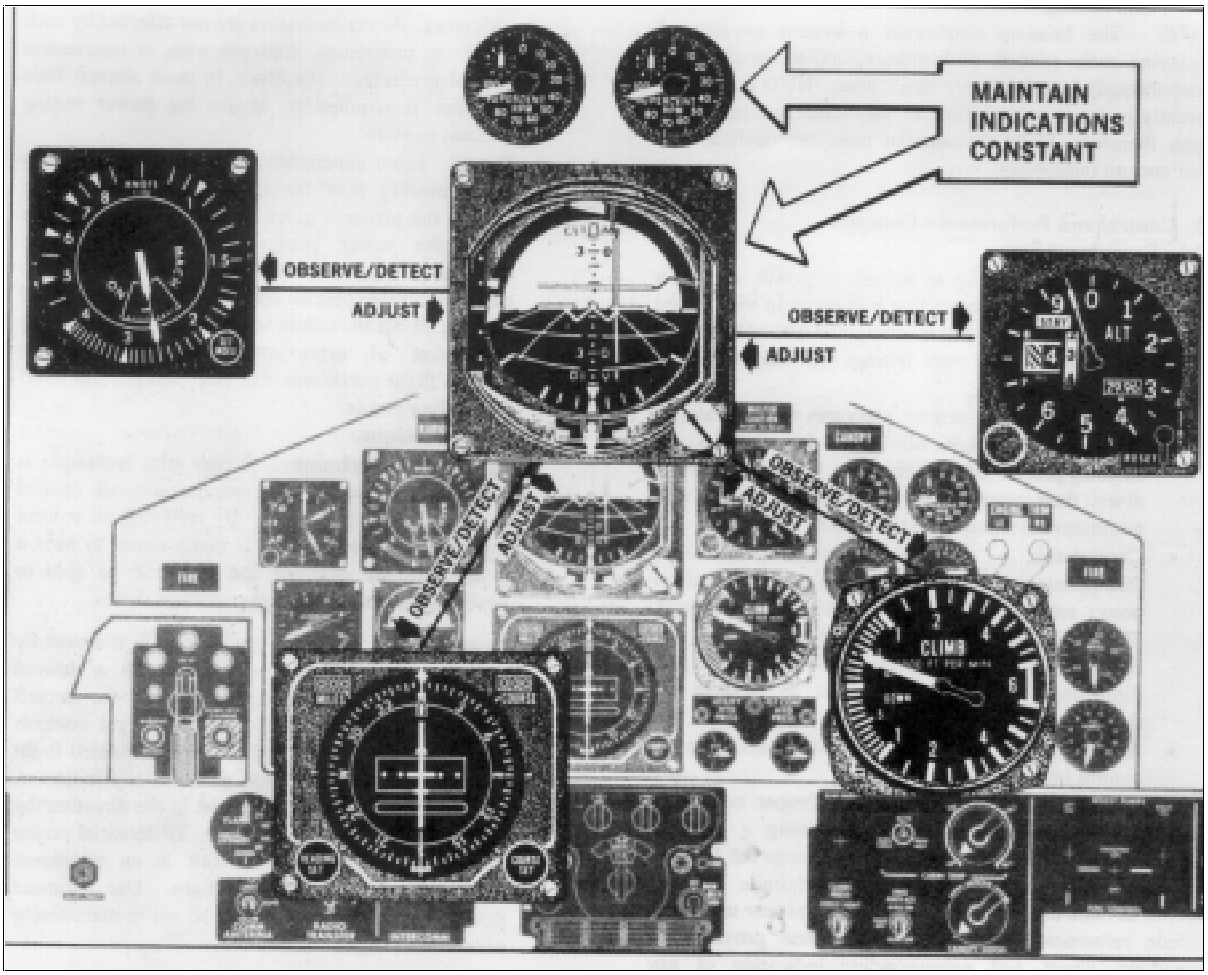
1.2.4. Trim Technique.

1.2.4.1. Proper trim technique. Proper trim technique is essential for smooth and precise aircraft control during all phases of flight. By relieving all control pressures, you will find it is much easier to hold a given attitude constant and you will be able to devote more attention to other cockpit duties.

1.2.4.2. Trimming an aircraft. An aircraft is trimmed by applying control pressures to establish a desired attitude and then adjusting the trim so the aircraft will maintain that attitude when the flight controls are released. Trim the aircraft for coordinated flight by centering the ball of the turn and slip indicator. This is done by using rudder trim in the direction the ball is displaced from the center. Differential power control on multi-engine aircraft is an additional factor affecting coordinated flight. Use balanced power or thrust, when possible, to aid in maintaining coordinated flight.

1.2.4.3. Changes. Changes in attitude, power, or configuration will in most cases require a trim adjustment. Independent use of trim to establish a change in aircraft attitude invariably leads to erratic aircraft control. Smooth and precise attitude changes are best attained by a combination of control pressures and trim adjustments. Trim adjustment, correctly used, is an aid to smooth aircraft control.

Figure 1.2. Instrument Cross-Check Technique (para 1.2.5).

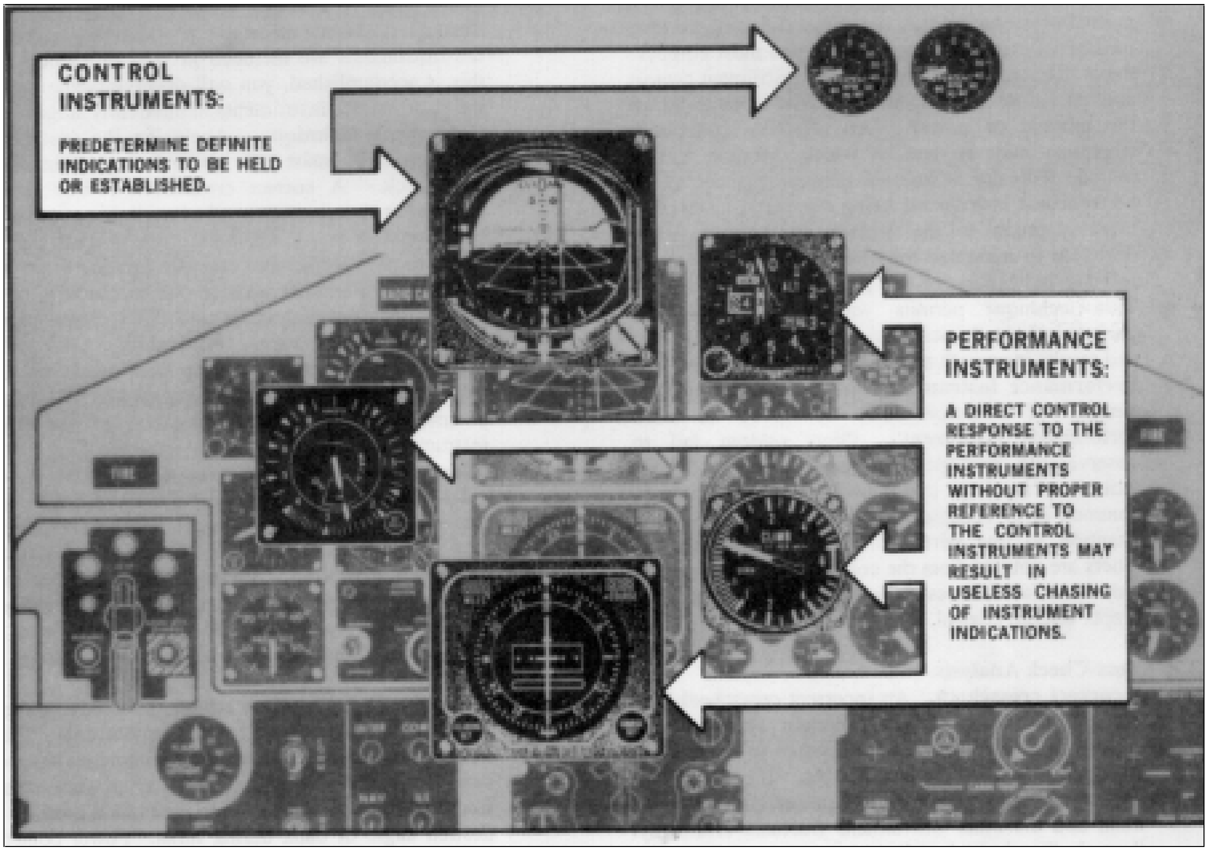


1.2.5. Cross-Check Technique (Figure 1.2).

1.2.5.1. The Control and Performance Concept. The control and performance concept of attitude instrument flying requires you to establish an aircraft attitude or power setting on the control instruments that should result in the desired aircraft performance. Therefore, you must be able to recognize when a change in attitude or power is required. By cross-checking the instruments properly, you can determine the magnitude and direction of the adjustment required.

1.2.5.2. Cross-checking. Cross-checking is the proper division of attention and the interpretation of the flight instruments. Attention must be efficiently divided between the control and performance instruments in a sequence that ensures comprehensive coverage of the flight instruments. Looking at each of the instruments at the proper time is of no value unless you can interpret what you see. Therefore, proper division of attention and interpretation are the two essential parts of a crosscheck.

Figure 1.3. Factors Influencing Cross-Check Techniques (para 1.2.6).



1.2.6. Factors Influencing Instrument Cross-Checks (Figure 1.3).

1.2.6.1. Instrument's Response to Attitude or Power Changes. A factor influencing cross-check technique is the characteristic manner in which instruments respond to changes of attitude or power. The control instruments provide direct and immediate indications of attitude or power changes. Changes in the indications on the performance instruments will lag slightly behind changes of attitude or power. This lag is due to inertia of the aircraft and the operating principles and mechanisms of the performance instruments. Therefore, some lag must be accepted as an inherent factor. This factor will not appreciably affect the tolerances, within which you control the aircraft; however, at times a slight unavoidable delay in knowing the results of attitude or power changes will occur.

1.2.6.2. Lag in Performance Instruments. Lag in the performance instruments should not interfere with maintaining or smoothly changing the attitude or power indications. When the attitude and power are properly controlled, the lag factor is negligible and the indications on the performance instruments will stabilize or change smoothly. Do not be lured into making a flight control movement in direct response to the lag in the indications on the performance instruments without first referring to the control instruments. Sufficient reference to the control instruments will minimize the effect of lag on the performance instruments and nullify the tendency to "chase" the indications.

1.2.6.3. Location of Flight Instruments. Another factor influencing crosscheck technique is the location of the flight instruments. In some aircraft the flight instruments are scattered over a wide area of the instrument panel, making it difficult to bring several instruments into your crosscheck at the same time. Therefore you must rapidly scan each instrument individually back and forth across the instrument panel. More advanced instrument systems, such as the flight director and integrated flight instrument systems have reduced the required scan to a small area so you can see more of the flight instruments with one look. The task of cross-checking these instruments is much easier because you can simultaneously observe the attitude indicator and the proper performance instruments.

1.2.6.4. Pilot's Ability. An important factor influencing crosscheck technique is the ability of the pilot. All pilots do not interpret instrument presentations with the same speed; some are faster than others are in understanding and evaluating what they see. One reason for this is that the natural ability of pilots varies. Another reason is that the experience levels are different. Pilots who are experienced and fly regularly will probably interpret their instruments more quickly than inexperienced pilots will. Pilots who interpret their instruments quickly and correctly do not have to refer back to them for information as often as pilots who are slow to interpret. They are also able to bring several instruments into their crosscheck with one glance, interpreting them simultaneously. Therefore, the speed with which they divide their attention does not have to be as rapid as the pilot's with less ability who must scan the instruments rapidly to stay ahead of the aircraft.

1.2.6.5. Observing Attitude Indicator. The attitude indicator is the only instrument that you should observe continuously for any appreciable length of time. Several seconds may be needed to accomplish an attitude change required for a normal turn. During this period, you may need to devote your attention almost exclusively to the attitude indicator to ensure good attitude control. The attitude indicator is the instrument that you should check the greatest number of times. This is shown by the following description of a normal crosscheck. A pilot glances from the attitude indicator to a performance instrument, back to the attitude indicator, then a glance at another performance instrument, back to the attitude indicator, and so forth. This crosscheck technique can be compared to a wagon wheel. The hub represents the attitude indicator and the spokes represent the performance instruments.

1.2.6.6. Method of cross-checking. The above example of a normal crosscheck does not mean that it is the only method of cross-checking. Often you must compare the indications of one performance instrument against another before knowing when or how much to adjust the attitude or power. An effective crosscheck technique may be one in which attention to the attitude indicator is inserted between glances at the performance instruments being compared. Devoting more attention to the attitude indicator is more desirable to minimize the effects of the fluctuations and lag indications of the performance instruments. This technique permits you to read any one performance instrument during a split-second glance and results in smooth and precise aircraft control.

1.2.6.7. Performance instruments. A proper and relative amount of attention must be given to each performance instrument. Pilots seldom fail to observe the one performance instrument whose indication is most important. The reverse is a common error because pilots often devote so much attention to one performance instrument that the others are omitted from the crosscheck. Additionally, they often fail to crosscheck the attitude indicator for proper aircraft control.

1.2.7. Cross-Check Analysis.

1.2.7.1. Incorrect crosscheck. An incorrect crosscheck can be recognized by analyzing certain symptoms of aircraft control. Insufficient reference to the control instruments is readily recognizable. If you do not have some definite attitude and power indications in mind and the other instruments fluctuate erratically through the desired indications, then you are not referring sufficiently to the control instruments. Imprecise aircraft control usually results in "chasing" the indications.

1.2.7.2. Too much attention. The problem of too much attention being devoted to the control instruments is rarely encountered, except for fixation on the power indicators. This is normally caused by your desire to maintain the performance indications within close tolerances. Positive and continuous inputs based only on the control instruments are not sufficient for maintaining the desired parameters; a systematic crosscheck of the performance instruments is also required.

1.2.7.3. Scanning process. An incorrect crosscheck can result in the omission of or insufficient reference to one or more instruments during the scanning process. You may omit some performance instruments from the crosscheck, although other performance instruments and the control instruments are being properly observed. For example, during a climb or descent, you may become so engrossed with pitch attitude control that you fail to observe an error in aircraft heading.

1.2.7.4. Instrument indications. The indications on some instruments are not as "eye-catching" as those on other instruments. For example, a 4° heading change is not as "eye-catching" as a 300 to 400 feet-per-minute change on the vertical velocity indicator. Through deliberate effort and proper habit, ensure all the instruments are included in your crosscheck. If this is accomplished, you will observe deviations on the performance instruments in their early stages.

1.2.7.5. Crosscheck technique. Analyzing the crosscheck technique will assist you in improving an incorrect crosscheck. A correct crosscheck results in the continuous interpretation of the flight instruments that enables you to maintain proper aircraft control at all times. Remember, rapidly looking from one instrument to another without interpretation is of no value. Instrument systems and the location of the flight instruments vary. Pilot ability also varies. Therefore, you should develop your own rate and sequence of checking the instruments that will ensure a timely and correct interpretation of the flight instruments.

1.2.8. Adjusting Attitude and Power. As previously stated, the control and performance concept of attitude instrument flying requires the adjustment of aircraft attitude and power to achieve the desired performance. A change of aircraft attitude or power is required when any indication other than that desired is observed on the performance instruments. However, it is equally important for you to know what to change and how much pitch, bank, or power change is required.

1.2.8.1. What to Change. Pitch attitude primarily controls altitude and the rate of climb or descent. Pitch attitude control may also be used to maintain airspeed during maneuvers requiring a fixed power setting. Bank attitude control is used to maintain a heading or desired angle of bank during turns. Power controls airspeed except for maneuvers using a fixed power setting; for example, full power for a prolonged climb.

1.2.8.2. How Much to Change. How much to adjust the attitude or power is, initially, an estimate based on familiarity with the aircraft and the amount you desire to change on the performance instruments. After you make a change of attitude or power, observe the performance instruments to see if the desired change occurred. If not, further adjustment of attitude or power is required. Remember, even though changes are estimates, they must be made in exact increments.

1.2.9. Vector Flying. The flight path marker (FPM), or velocity vector (VV), in conjunction with the flight path scale, is the symbol most used during instrument flight on displays capable of showing vector flight paths. Simply put, the FPM is a symbol that displays pitch compensated for angle of attack, drift, and yaw. It shows where the aircraft is actually going, assuming a properly functioning inertial navigation system (INS), and may be used to set a precise climb or dive angle relative to the flight path scale.

1.2.9.1. Command symbol. This ability to show the actual flight path of the aircraft makes the FPM a unique control and performance element. The major advantage of vector (FPM) flying over conventional attitude flying is the ease of setting a precise glide path instead of using the ADI, VVI, and airspeed to approximate a glide path. On HUDs the FPM can also be used to determine where the aircraft will touchdown. Drawbacks to vector flying include the tendency of the display to float around, especially in crosswinds, the bobbing motion of the FPM as it lags behind the movement of the nose of the aircraft, and the degraded usefulness of the FPM when it exceeds the limits of the instrument's field-of-view at high angles of attack and in large drift or yaw situations.

1.2.9.2. Flight path scale. Typically on HUDs, the flight path scale is displayed in a 1:1 angular relationship with the "real world," though some may gradually compress the scale at steeper climb/dive angles to reduce movement of the symbols and create a global display similar to that found on an attitude indicator. On a HUD the expanded flight path scale allows the pilot to make smaller, more precise corrections than is possible using conventional head-down displays. Like the FPM, the flight path scale can be of limited use when it approaches the limits of the HUD's field-of-view.

1.2.9.3. Climb/Dive Marker (CDM). Newer flight instruments will use a CDM as the command flight symbol for vector flying. The CDM will utilize the concept of the above FPM and flight path scale, but both will be caged to the center of the display to prevent the symbology from drifting off the usable area of the instrument.

1.3. Use of Single Medium Displays. A single medium display is a Head-Up display (HUD), Head-Down Display (HDD), or Helmet-Mounted Display (HMD) presenting flight instrumentation. Some single medium displays, including many HUDs, do not provide sufficient attitude cues to enable a pilot to maintain full-time attitude awareness or recover from some unusual attitudes. In addition to meeting the instrumentation requirements of AFI 11-202, Vol 3, single medium displays must also receive HQ USAF/XOO endorsement as a Primary Flight Reference (PRF) before they are used as the stand-alone reference for instrument flight.

1.4. Display of Flight Instrumentation. Electronic displays allow the pilot to optimize cockpit instrumentation for a particular mission by decluttering, removing, or relocating presentations. Display options vary widely from aircraft to aircraft and incorporate different symbologies and terminology for similar functions. In some cases the pilot may be able to configure the cockpit to omit elements necessary for basic attitude awareness and aircraft control. Regardless of the type of aircraft, mission, or mission phase, attitude awareness is a full-time Air Force mission requirement. Persons charged with cockpit instrumentation design, layout, and capability; pilots or other crewmembers who can modify the cockpit display configuration; and implementing directives (for example, Dash 1's, T.O.'s, AFI 36-series manuals and handbooks, etc.) must adhere to the following:

1.4.1. Primary Flight Instrumentation. ***Primary flight instrumentation must always be present. It must provide full-time attitude, altitude, and airspeed information; an immediately discernible attitude recognition capability; an unusual attitude recovery capability; and complete fault indications.***

1.4.2. Position of Flight Instrumentation. ***The elements of information of Primary Flight Instrumentation must be positioned and arranged in a manner that enables the pilot to perform a natural cross-check.***

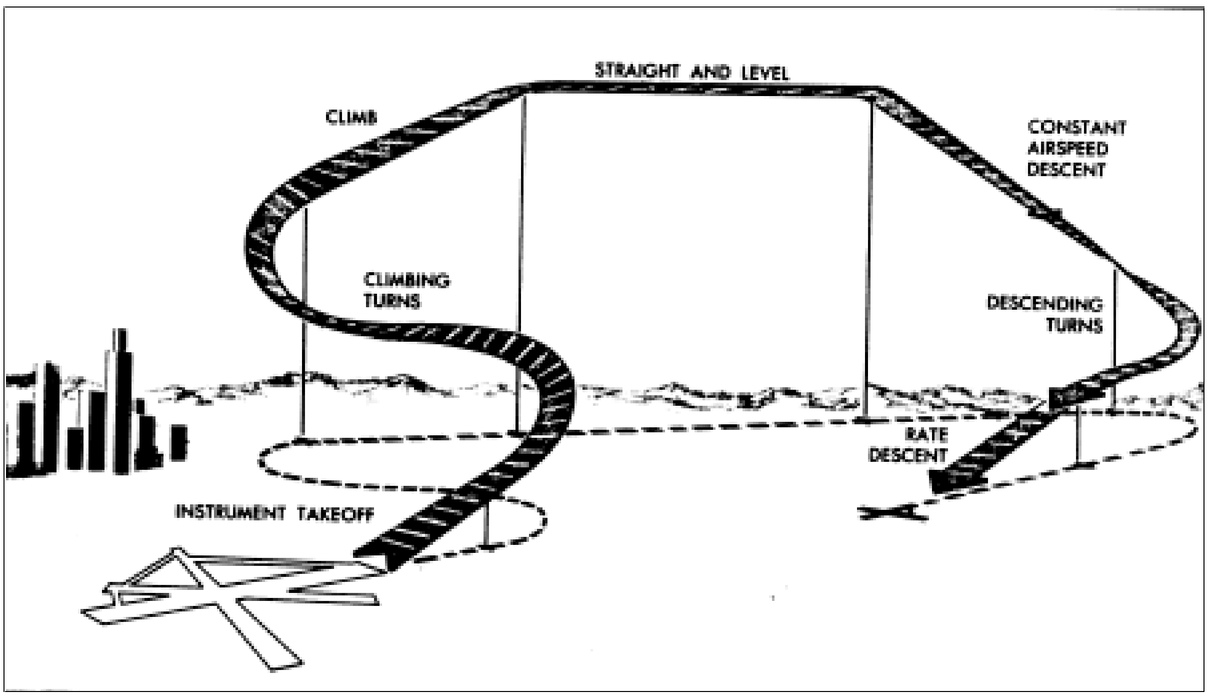
1.4.3. Standardization of Flight Instrumentation. ***Primary Flight Instrumentation must be standardized in terminology, symbology, mechanization, and arrangement***. Standardization of instrumentation display elements provides a common training base and allows the retention of good flying habits during transition to different aircraft. This standardization can only be effective when the pilot acknowledges attitude awareness as a full-time requirement and manages the cockpit accordingly.

Chapter 2

INSTRUMENT FLIGHT MANEUVERS--FIXED WING

2.1. Basic Maneuvers. The maneuvers described in this section are those most commonly used during instrument flight (**Figure 2.1**). Additional maneuvers or some modification of these maneuvers may be required for specific training requirements. The degree of proficiency attained in accomplishing these maneuvers will determine the ease by which you can adapt to actual instrument flight. An instrument flight, regardless of its length or complexity, is a series of connected basic instrument flight maneuvers. Failure to consider each portion of the flight as a basic instrument maneuver often leads to erratic aircraft control.

Figure 2.1. Typical Instrument Flight (para 2.1).



2.2. Planning. The information received from the navigation instruments or an air traffic controller should be considered as advising you what maneuver to perform, when to perform it, or what adjustments, if any, are required. Instrument approach procedure charts and similar publications should be considered as pictorial presentations of a series of connected instrument flight maneuvers. Keeping these considerations in mind and calling upon previous practice, you will find that you are always performing a familiar maneuver. By visualizing the next maneuver, you can plan ahead and know exactly what crosscheck and aircraft control techniques to employ at the time of entry into the maneuver.

2.3. Individual Maneuvers.

2.3.1. Straight and Level Flight. Straight and level unaccelerated flight consists of maintaining desired altitude, heading, and airspeed. Use pitch attitude control to maintain or adjust the altitude. Use bank attitude control to maintain or adjust the heading. Use power control to maintain or adjust the airspeed.

2.3.1.1. Maintaining a Desired Altitude.

2.3.1.1.1. Maintain a specific pitch. Maintaining a desired altitude requires the ability to maintain a specific pitch attitude and, when necessary, to smoothly and precisely adjust this attitude. This ability is developed through proper use of the attitude indicator and is simplified by good trim techniques.

2.3.1.1.2. After leveling off. After leveling off at cruise airspeed, you may adjust the pitch trim knob on the attitude indicator so that the miniature aircraft is aligned with the horizon bar. This will aid in detecting small pitch changes. Subsequent readjustments may be required because of changes in aircraft gross weight and cruise airspeeds. (Refer to your aircraft flight manual; on some equipment, this technique may not be appropriate.)

2.3.1.1.3. Small pitch corrections. The small pitch corrections required to maintain a desired altitude are made in fractions of degrees or bar widths. You should become familiar with the vertical velocity changes that result when specific pitch adjustments are made at various airspeeds and configurations so you can determine what pitch attitude adjustment is required to produce the desired rate of correction when an altitude deviation is observed.

2.3.1.1.4. Making pitch adjustments. When you make these pitch adjustments, the altimeter and vertical velocity indications may lag behind changes of pitch attitude on the attitude indicator. This lag should be recognized and accepted as an inherent error in pressure instruments. The error is even more pronounced at supersonic airspeeds. Because of this error, maintain the adjusted pitch attitude on the attitude indicator while waiting for changes on the altimeter and vertical velocity to occur. Do not make a snap decision that the adjusted pitch change is ineffective and be lured into over-controlling the pitch attitude.

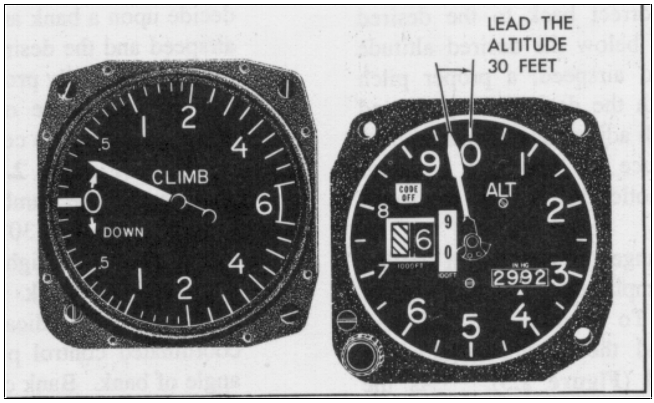
2.3.1.1.5. Vertical velocity indicator. The vertical velocity indicator is a trend instrument. With experience, you can usually estimate the suitability of a pitch adjustment by noting the initial rate of movement of the vertical velocity indicator. For example, assume a pitch adjustment has been made which is expected to result in 200 to 300 fpm rate of climb. If the initial rate of movement on the vertical velocity indicator is rapid and obviously will stabilize at a rate greater than desired, the pitch change was too large. Readjust the pitch attitude rather than wait for a stabilized indication on the vertical velocity indicator.

2.3.1.1.6. Altitude changes. When an aircraft first departs an altitude, an indication often appears on the vertical velocity indicator before one appears on the altimeter. By evaluating this initial rate of movement, you can estimate the amount of pitch change required on the attitude indicator and prevent large altitude deviations. If the estimated pitch change was correct, the vertical velocity will return to zero with a negligible change of altitude on the altimeter.

2.3.1.1.7. Altitude Deviations. When a deviation from the desired altitude occurs, use good judgment in determining a rate of correction. The correction must not be too large and cause the aircraft to "overshoot" the desired altitude, nor should it be so small that it is unnecessarily prolonged. As a guide, the pitch attitude change on the attitude indicator should produce a rate of vertical velocity approximately twice the size of the altitude deviation. For example, if the aircraft were 100 feet off the desired altitude, a 200 fpm rate of correction would be a suitable amount. Adjust the pitch an estimated amount to achieve this rate of correction. This estimated pitch change might require further adjustment after a stabilized vertical velocity is obtained.

2.3.1.1.8. Approaching the desired altitude. When approaching the desired altitude, determine a lead point on the altimeter for initiating a level-off pitch attitude change_and determine the pitch change required to complete the level off as well as the appropriate pitch attitude for level flight. A suitable lead point prevents "overshooting" and permits a smooth transition to level flight. The amount of lead required varies with pilot technique and rate of correction. As a guide, the lead point on the altimeter should be approximately 10 percent of the vertical velocity. For example, if the rate of correction to the desired altitude is 300 fpm, initiate the level off approximately 30 feet before reaching the desired altitude (**Figure 2.2**).

Figure 2.2. **Leading the Level Off.**



2.3.1.2. Maintaining a Desired Heading.

2.3.1.2.1. Zero bank attitude. Maintaining a desired heading is accomplished by maintaining a zero bank attitude in coordinated flight. Heading deviations are not normally as "eye-catching" as altitude deviations. Therefore, be aware of this characteristic and develop a habit of cross-checking the heading deviations. This is especially helpful if there are slight precession errors in the attitude indicator.

2.3.1.2.2. Heading deviation. When a deviation from the desired heading occurs, refer to the attitude indicator and smoothly establish a definite angle of bank that will produce a suitable rate of return. As a guide, the bank attitude change on the attitude indicator should equal the heading deviation in degrees not to exceed 30°. For example, if the heading deviation is 10°, then 10° of bank would produce a suitable rate of correction. This guide is particularly helpful during instrument approaches at relatively slow airspeeds. At higher true airspeeds, a larger angle of bank may be required to prevent a prolonged correction. A correction to a heading deviation of 2° to 5° may be accomplished by application of rudder.

2.3.1.3. Establishing and Maintaining Airspeed.

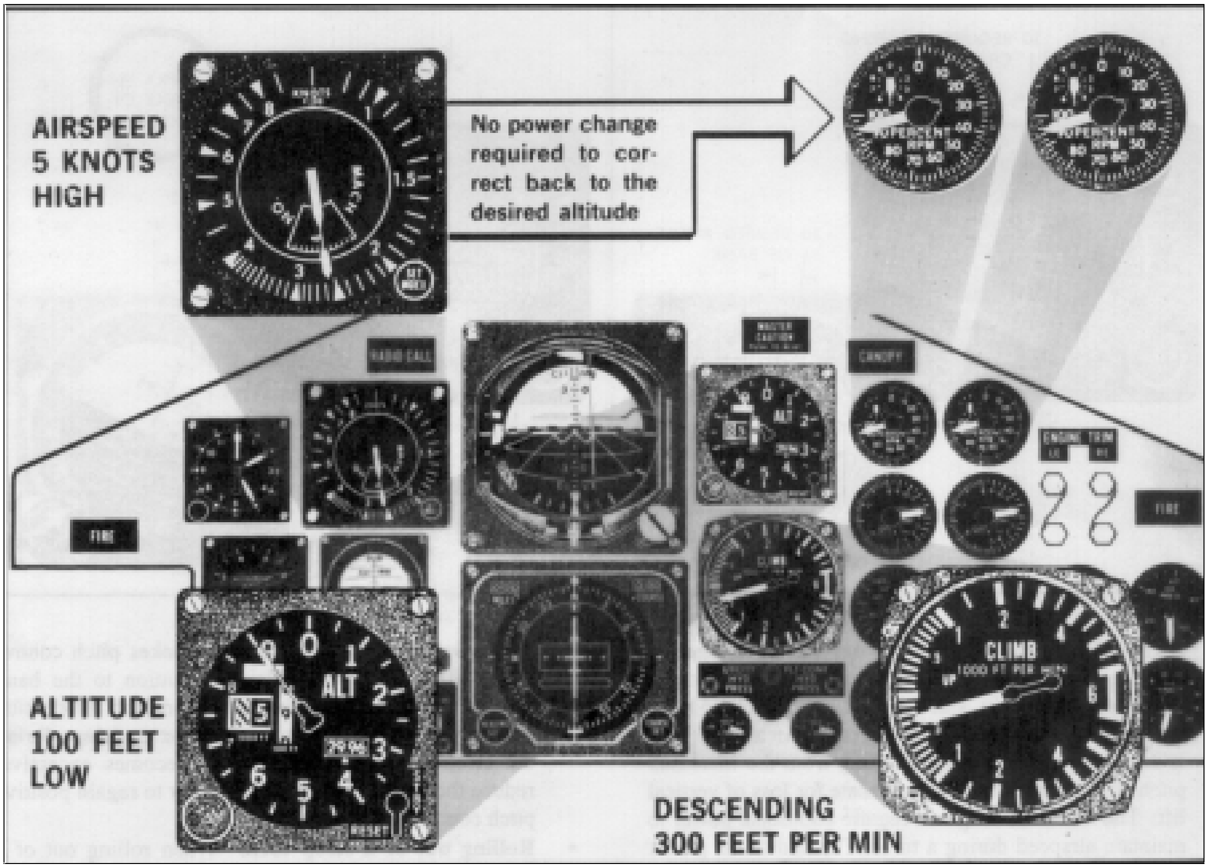
2.3.1.3.1. Airspeed. Establishing or maintaining an airspeed is accomplished by referring to the airspeed or mach indicator and adjusting the power or aircraft attitude. Knowledge of the approximate power required to establish a desired airspeed will aid in making power adjustments. After the approximate power setting is established, a crosscheck of the airspeed indicator will indicate if subsequent power adjustments are required. Make it a point to learn and remember the approximate power settings for the aircraft at various airspeeds and configurations used throughout a normal mission. Avoid fixation on power indicators when setting the power.

2.3.1.3.2. Airspeed deviation. When an airspeed deviation is observed, make a power or pitch adjustment or a combination of both to correct back to the desired airspeed. For example, if below the desired altitude with a higher than desired airspeed, a proper pitch adjustment may regain both the desired airspeed and altitude. Conversely, a pitch adjustment, if made at the desired airspeed, will induce the need for a power adjustment. This is more noticeable at slow airspeeds, particularly in jet aircraft.

2.3.1.3.3. Changes of airspeed. Changes of airspeed in straight and level flight are accomplished by adjusting the power or drag devices. To increase the airspeed, advance the power beyond the setting required to maintain the new airspeed (**Figure 2.3**). As the airspeed increases, the aircraft gains lift and will have a tendency to climb. Adjust the pitch attitude as required to maintain altitude. When the airspeed approaches the desired indication, reduce the power to an estimated setting that will maintain the new airspeed. To reduce the airspeed, reduce the power below the setting estimated for maintaining the new desired airspeed. As the airspeed decreases, the aircraft loses lift and will have a tendency to descend. Adjust the pitch attitude as required to maintain altitude. When the airspeed approaches the desired indication, advance the power to an estimated setting that will maintain the new airspeed. If available, drag devices may be used for relatively large or rapid airspeed reductions. If used, it is normally best to reduce the power to the estimated setting that will maintain the new airspeed and then extend the drag devices. Extending or retracting the drag devices may induce a pitch change. To overcome this tendency, note the pitch attitude on the attitude indicator just before operating the drag devices and then maintain that attitude constant as they are extended or retracted. When approaching the new airspeed, retract the drag devices and adjust power if required.

NOTE: Proper control of pitch and bank attitude requires you to recognize the effects of gyroscopic precession on some attitude indicators. This precession is most noticeable following a turn or change of airspeed. As a result, small altitude and heading deviations may occur when a wings level attitude is established on the attitude indicator following these maneuvers. Therefore, you may have to establish a pitch or bank attitude other than that ordinarily expected. For example, to maintain straight and level flight after completing a normal turn, the attitude indicator may depict a slight turn, climb or descent, or a combination of both. The attitude indicator will gradually resume its normal indications as the erection mechanism automatically corrects these errors. When these errors occur, apply the basic crosscheck techniques.

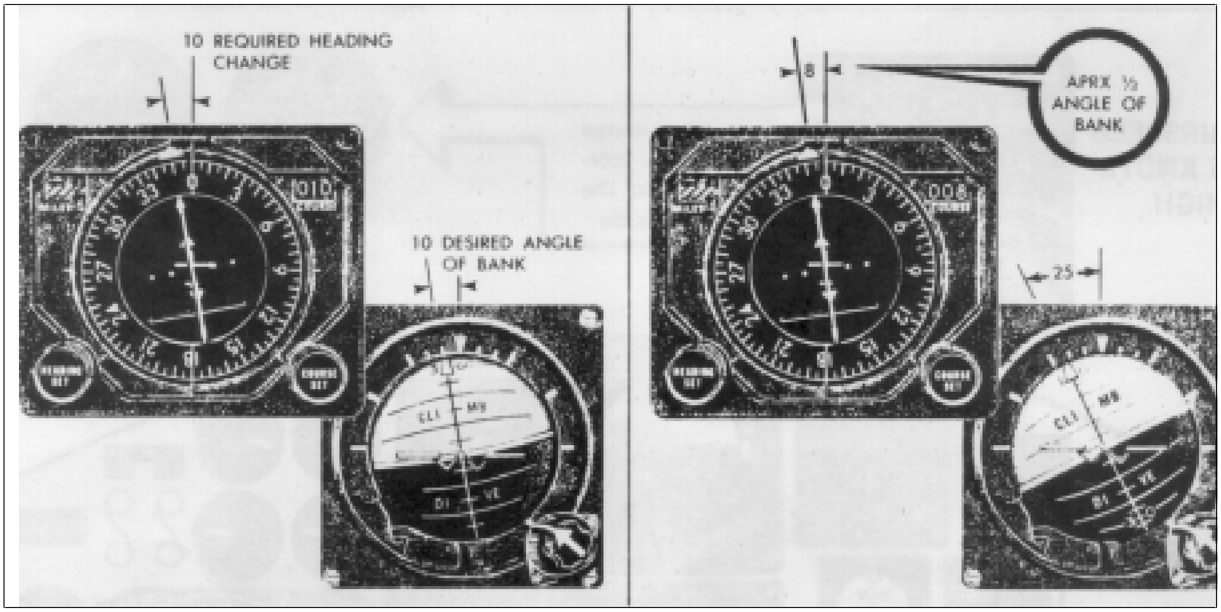
Figure 2.3. **Use of Power.**



2.3.2. Level Turns. Many of the pitch, bank, and power principles discussed in maintaining straight and level flight applies while performing level turns. Performing a level turn requires an understanding of several factors: how to enter the turn, how to maintain bank, altitude, and airspeed during the turn; and how to recover from the turn.

2.3.2.1. Bank Control. Before entering a turn you should decide upon a bank angle. Factors to consider are true airspeed and the desired rate of turn. A slow turn rate may unnecessarily prolong the turn, whereas a high rate of turn may cause overshooting of the heading and difficulty with pitch control. As a guide for turns of 30° or less (**Figure 2.4**), the bank angle should approximate the number of degrees to be turned. For turns of more than 30°, use a bank angle of 30°. High turn airspeeds or flight manual procedures may require other angles of bank. To enter a turn, you should refer to the attitude indicator while applying smooth and coordinated control pressures to establish the desired angle of bank. Bank control should then be maintained throughout the turn by reference to the attitude indicator. Crosscheck the heading indicator or turn needle to determine if the angle of bank is satisfactory. Trim may be helpful during prolonged turns to assist in aircraft control.

Figure 2.4. Level Turns (para 2.3.2).



2.3.2.2. Roll out of a turn. To roll out of a turn on a desired heading, a lead point must be used. The amount of lead required depends upon the amount of bank used for the turn, the rate the aircraft is turning, and your roll out rate. As a guide, a lead point of approximately one-third the angle of bank may be used (**Figure 2.4**). With experience and practice a consistent rate or rollout can be developed. A lead point can then be accurately estimated for any combination of bank angle or rate of turn. Make a note of the rate of movement of the heading indicator during the turn. Estimate the lead required by comparing this rate of movement with the angle of bank and the rate of roll out.

2.3.2.3. Altitude Control. The techniques for maintaining a constant altitude during a turn is similar to those used in maintaining altitude in straight and level flight. During the initial part of the roll-in, hold the same pitch attitude as was used to maintain altitude with the wings level. As the bank is increased, anticipate a tendency for the aircraft to lose altitude because of the change in lift vector. Adjust the pitch attitude as necessary by reference to the miniature aircraft relative to the artificial horizon. After the turn is established, small pitch adjustments may be required to correct for attitude indicator precession. When rolling out of a turn, anticipate a tendency for the aircraft to gain altitude. This results from a combination of an increase in the vertical component of lift and a failure to compensate for trim or back pressure used during the turn. Therefore, be aware of these factors, and monitor the pitch attitude during the rollout in the same manner as during the roll-in. During rollout, anticipate a decrease in pitch equal to the increase in pitch required during roll-in.

2.3.2.4. Airspeed Control. The power control techniques for maintaining an airspeed during a turn is similar to those used during straight and level flight. Anticipate a tendency for the aircraft to lose airspeed in a turn. This is caused by induced drag resulting from the increased pitch attitude required to compensate for loss of vertical lift. The increased drag will require additional power to maintain airspeed during a turn. The additional power required will be less at high true airspeeds than at low true airspeeds. At low airspeeds, particularly in jet aircraft, a large power change may be required. If your response to this power change is slow, the airspeed may decrease rapidly to the point where a descent is required to regain the desired airspeed.

Therefore, at low airspeeds, it may be desirable to add an estimated amount of power as the turn is established rather than waiting for the first indication of a loss in airspeed.

2.3.3. Steep Turns. A steep turn is considered to be a turn in which the angle of bank used is larger than that required for normal instrument flying. For most aircraft the normal instrument turn bank angle is 30°.

2.3.3.1. Entry into a steep turn. Entry into a steep turn is accomplished in the same way as for a normal turn. As the bank is increased past normal, the changing lift vector requires a larger pitch adjustment. The use of trim in steep turns varies with individual aircraft characteristics and pilot technique. Additional power is required to maintain airspeed as the bank is increased.

2.3.3.2. Maintaining the steep turn. During the steep turn, pitch and power control are maintained in the same way as in a normal turn, however, larger pitch adjustments will be required for a given altitude deviation. Varying the angle of bank during the turn makes pitch control more difficult. Give sufficient attention to the bank pointer to maintain the bank angle constant. Precession error in the attitude indicator is more prevalent during the steep turns. If altitude loss becomes excessive, reduce the angle of bank as necessary to regain positive pitch control.

2.3.3.3. Rolling out of a steep turn. When rolling out of a steep turn, you should be alert to correct for the more than normal back trim, pitch attitude, and power used during the turn. Roll out at the same rate used with normal turns. The performance instruments must be cross-checked closely during rollout, since the attitude indicator may have considerable precession error.

2.3.4. Timed Turns and Use of the Magnetic Compass. Heading indicator failure may require use of the magnetic compass for heading information. Remember that this instrument provides reliable information only during straight, level, and unaccelerated flight. Because of this limitation, timed turns are recommended when making heading changes by reference to the magnetic compass.

2.3.4.1. Accomplishing a timed turn. A timed turn is accomplished by establishing a bank attitude on the attitude indicator that will result in a desired rate of turn as shown by the turn needle. A single needle width deflection on a 4-minute turn needle indicates 1 1/2° per second rate of turn, while a double needle width deflection indicates 3° per second rate of turn. A fraction of the preceding amounts can be used to simplify the timing problem. For example, 2/3 needle width deflection indicates 1° per second rate of turn while 11/3 needle width indicates 2° per second rate of turn.

2.3.4.2. Heading change. The heading change is accomplished by maintaining the desired rate of turn for a predetermined time. Start timing when control pressures are applied to begin the turn. Control pressures are applied to rollout when the time has elapsed. As an example, assume that a 45° heading change is desired using a 4-minute turn needle. The aircraft's true airspeed is relatively high making it advisable to make a single needle width turn (11/2° per second). In this case, 30 seconds should elapse from the time control pressures are applied to enter the turn until control pressures are applied to rollout.

2.3.4.3. Alternate method. Although timed turns are preferred when using the magnetic compass as a heading reference, there is an alternate method. Turns to headings can be made by applying control pressures to roll out of a turn when reaching a predetermined "lead" point on the magnetic compass. When using the magnetic compass in this manner, do not exceed 15° of bank in order to minimize dip error. Dip error must also be considered in computing the lead point for rollout. This is particularly noticeable when turning to a heading of north or south. For example, turns to north require a normal lead point plus a number of degrees equal to the flight latitude. Turns to south require turning past the desired heading by the number of degrees equal to the flight latitude minus the normal lead. Dip error is negligible when turning to east or west; therefore, use the normal amount of lead when turning to either of these headings.

2.3.5. Climbs and Descents. Climbing and descending maneuvers are classified into two general types -- constant airspeed and constant rate. The constant airspeed maneuver is accomplished by maintaining a constant power indication and varying the pitch attitude to maintain a specific airspeed. The constant rate maneuver is accomplished by varying both power and pitch to maintain constant a specific airspeed and vertical velocity. Either type of climb or descent may be performed while maintaining a constant heading or while turning. These maneuvers should be practiced using airspeeds, configurations, and altitudes corresponding to those which will be used in actual instrument flight.

2.3.5.1. Constant Airspeed Climbs and Descents.

2.3.5.1.1. Power setting. Before entering the climb or descent, choose a power setting and estimate the amount of pitch attitude change required to maintain the airspeed. Normally, the pitch and power changes are made simultaneously.

2.3.5.1.2. Power change. The power change should be smooth, uninterrupted, and at a rate commensurate with the rate of pitch change. In some aircraft, even though a constant throttle setting is maintained, the power may change with altitude. Therefore, it may be necessary to occasionally crosscheck the power indicators.

2.3.5.1.3. Pitch and power changes. While the power is being changed, refer to the attitude indicator and smoothly accomplish the estimated pitch change. Since smooth, slow power applications will also produce pitch changes, only slight control pressures are needed to establish the pitch change. Additionally, very little trim change is required since the airspeed is constant. With a moderate amount of practice, the pitch and power changes can be properly coordinated so the airspeed will remain within close limits as the climb or descent is entered.

NOTE: Remember, the initial pitch attitude change was an estimated amount to maintain the airspeed constant at the new power setting. The airspeed indicator must be cross-checked to determine the need for subsequent pitch adjustments.

2.3.5.1.4. Airspeed deviation. When making a pitch adjustment to correct for an airspeed deviation, the airspeed indicator will not reflect an immediate change. The results of pitch attitude changes can be determined more quickly by referring to the vertical velocity indicator. For example, while climbing, you note that the airspeed is remaining slightly high and that a small pitch adjustment is required. If the pitch adjustment results in a small increase of vertical velocity, you know (even though the airspeed may not show a change) that the pitch correction was approximately correct.

2.3.5.1.5. Inadvertent pitch change. In a similar manner, the vertical velocity indication will help you note that you have made an inadvertent change in pitch attitude. For example, assume that the desired airspeed and the vertical velocity have been remaining constant but the pitch attitude is allowed to change. The vertical velocity indicator will generally show the result of this inadvertent pitch change more quickly than the airspeed indicator. Therefore, the vertical velocity indicator is an excellent aid in maintaining the airspeed constant.

2.3.5.1.6. Level-off lead point. Upon approaching the desired altitude, select a predetermined level-off lead point. Ten percent of the vertical velocity in feet is a good estimate for the level-off lead point. At the level-off lead point, smoothly adjust the power to an approximate setting required for level flight and simultaneously change the pitch attitude to maintain the desired altitude.

2.3.5.2. Rate Climbs and Descents.

2.3.5.2.1. Maintain vertical velocity and airspeed. Rate climbs and descents are accomplished by maintaining both a desired vertical velocity and airspeed. They are proficiency maneuvers designed to practice the techniques used during instrument approaches. Pitch attitude controls the desired vertical velocity, and power controls the desired airspeed. Proper control techniques require coordinated pitch and power changes or adjustments.

2.3.5.2.2. Estimate pitch change. Before initiating a rate climb or descent, estimate the amount of pitch change required to produce the desired vertical velocity and the amount of power change required to maintain the airspeed constant. Enter the climb or descent by simultaneously changing the pitch and power the predetermined amount. Crosscheck the performance instruments to determine the resultant changes.

2.3.5.2.3. Vertical velocity. A crosscheck of the vertical velocity will indicate the need for subsequent pitch adjustments. A crosscheck of the airspeed will indicate the need for subsequent power adjustments. When approaching the desired altitude, use normal level-off techniques.

2.3.5.3. Pitch and Bank Attitude Control during Climbing and Descending Turns. Constant airspeed or rate climbs and descents may be performed on a constant heading or while turning. (For a constant heading, pitch and bank control techniques are the same as discussed under straight and level flight.) During a turn, the change in lift vector affects pitch control. For example, when entering a turn after a constant airspeed climb or descent has been established, the pitch attitude will have to be decreased slightly to maintain the airspeed. When entering a turn while performing a rate climb or descent, be prepared to increase the pitch attitude slightly to maintain the vertical velocity and add power to maintain the airspeed.

2.3.6. Level-off. Level-offs are required during all phases of instrument flight. The high rates of climbs or descents possible in some aircraft can cause an overshoot of the desired altitude. The following techniques are designed to allow for a precise, easily controlled level-off maneuver.

2.3.6.1. Desired airspeed. At least 1,000 feet below or above the desired altitude, reduce the pitch attitude to obtain a maximum of 1,000 to 2,000 fpm rate of climb or descent. Adjust the power to maintain the desired airspeed. Knowledge of approximate or known values of power and pitch simplifies aircraft control during this phase of flight. When the lead point for level-off is reached, perform a normal level-off.

NOTE: At 1,000 feet below or above the desired altitude, a pitch change of one-half will normally provide a more controllable vertical velocity at the lead point for level-off.

2.3.6.2. Pitch change for level-off. The total pitch change required for level off can be estimated by dividing the vertical velocity by the mach number times 1,000 (or miles per minute times 100). For example, an aircraft climbing or descending at .6 mach with a vertical velocity of 3,600 fpm would require approximately 6° of pitch change to obtain a level flight attitude.

$$\frac{3{,}600\text{ fpm}}{0.6\text{ mach x }1{,}000} = 6° \quad \text{or} \quad \frac{3{,}600\text{ fpm}}{6\text{ mpm x }100} = 6°$$

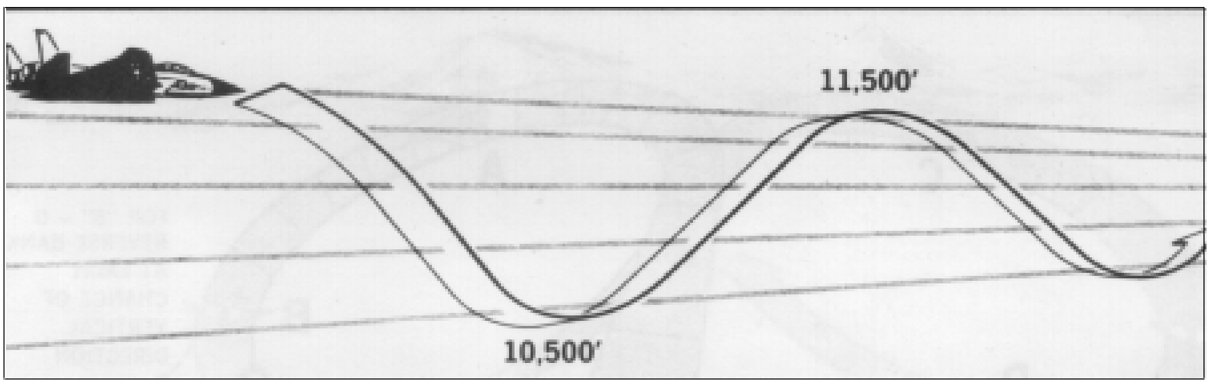
2.3.6.3. Selecting level-off point. Upon approaching the desired altitude, select a predetermined level-off lead point. As a guide, use 10 percent of the vertical velocity. Smoothly adjust the power to an approximate setting required for level flight, and simultaneously change the pitch attitude to maintain the desired altitude.

2.4. Basic Aircraft Control Maneuvers.

2.4.1. Vertical "S" Series. The vertical "S" maneuvers are proficiency maneuvers designed to improved a pilot's crosscheck and aircraft control. There are four types: the A, B, C, and D.

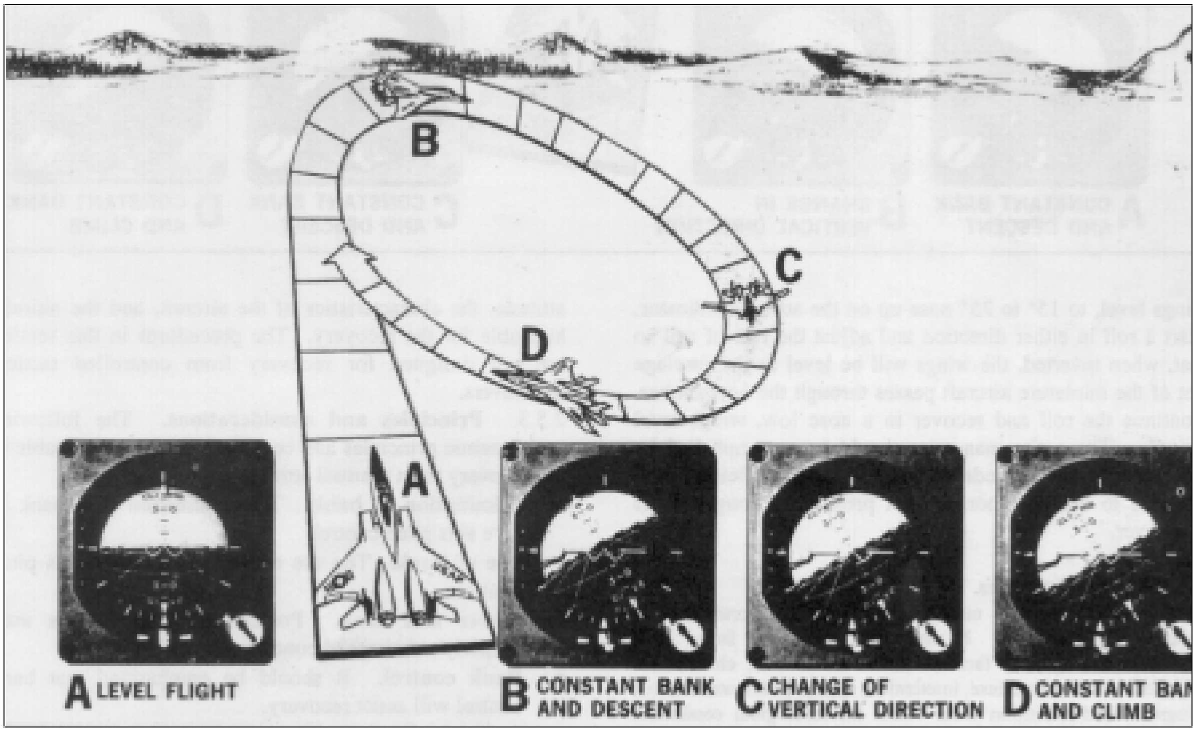
2.4.1.1. Vertical "S"- A. (Figure 2.5) The vertical "S"-A maneuver is a continuous series of rate climbs and descents flown on a constant heading. The altitude flown between changes of vertical direction and the rate of vertical velocity used must be compatible with aircraft performance. The vertical "S"- A if flown at final approach airspeed and configuration is excellent for practicing entry to and control of precision glide paths. The transition from descent to climb can be used to simulate the missed approach. However, allow sufficient altitude for "cleaning up" the aircraft and establishing the climb portion of the maneuver. Level-off, reestablish configuration and airspeed, and repeat as required. When used for this purpose, select an altitude low enough to use realistic power settings.

Figure 2.5. Vertical "S"- A.



2.4.1.2. Vertical "S"- B. (Figure 2.6). The vertical "S"- B is the same as the vertical "S"- A except that a constant angle of bank is maintained during the climb and descent. The angle of bank used should be compatible with aircraft performance (usually that required for a normal turn). The turn is established simultaneously with the initial climb or descent. Maintain the angle of bank constant throughout the maneuver.

Figure 2.6. Vertical "S"- B.

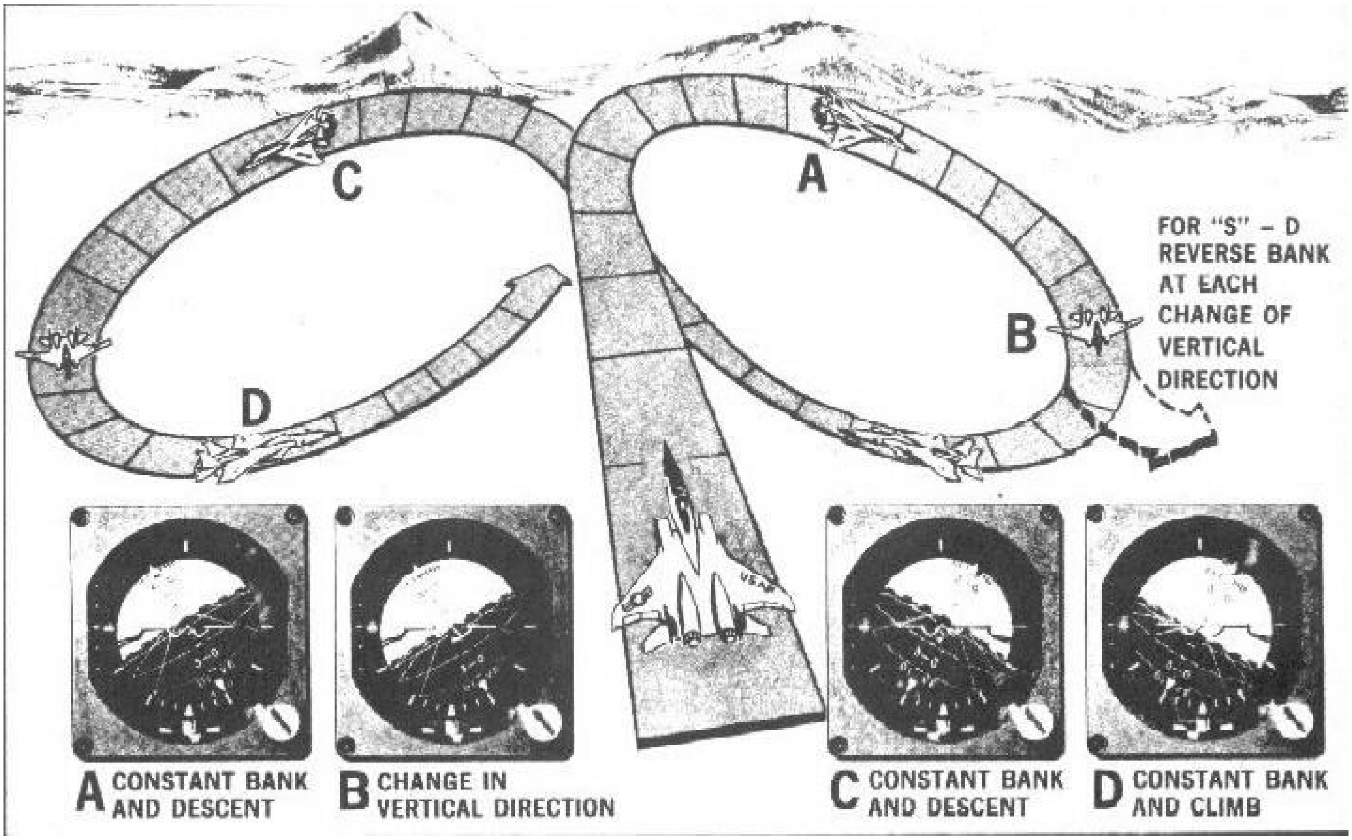


2.4.1.3. Vertical "S"- C. (Figure 2.7). The vertical "S"- C is the same as vertical "S"- B, except that the direction of turn is reversed at the beginning of each descent. Enter the vertical "S" - C in the same manner as the vertical "S"- B.

2.4.1.4. Vertical "S"- D. (Figure 2.7). The vertical "S"- D is the same as the vertical "S"- C, except that the direction of turn is reversed simultaneously with each change of vertical direction. Enter the vertical "S"- D in the same manner as the vertical "S"- B or "S"- C.

2.4.1.5. Vertical "S" initiation. Any of the vertical "S" maneuvers may be initiated with a climb or descent. Conscientious practice of these maneuvers will greatly improve the pilot's familiarity of the aircraft, instrument crosscheck, and overall aircraft control during precision instrument approaches. For this reason, the maneuvers should be practiced at approach speeds and configurations, and at low altitudes, as well as at cruise speeds, clean, and at higher altitudes.

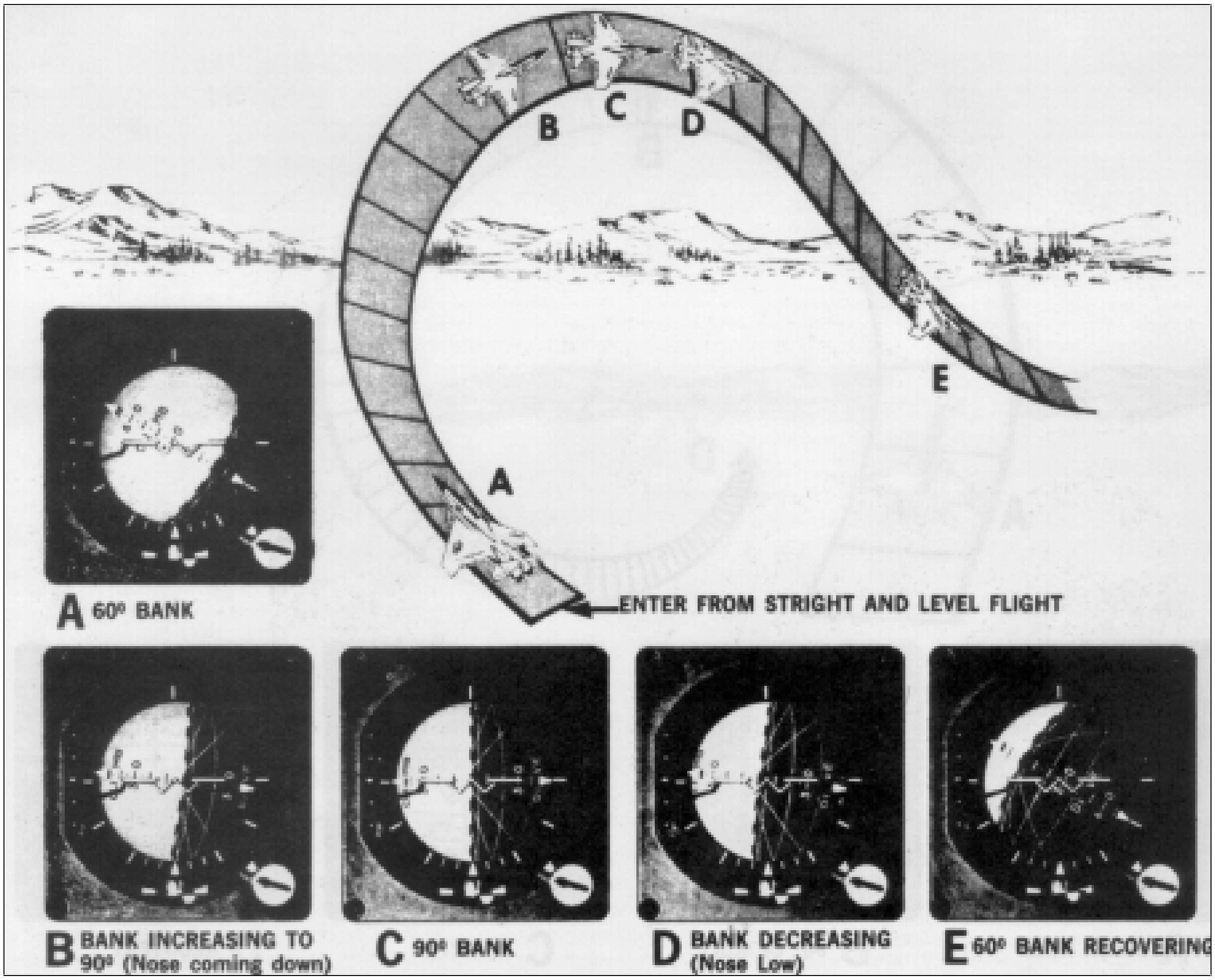
Figure 2.7. Vertical "S"- C and "S"- D.



2.4.2. Confidence Maneuvers. Present missions require some aircraft to be flown in all attitudes under instrument conditions. Such aircraft have attitude indicators capable of indicating these attitudes. Confidence maneuvers are basic aerobatic maneuvers designed to gain confidence in the use of the attitude indicator in extreme pitch and bank attitudes. In addition, mastering these maneuvers will be helpful when recovering from unusual attitudes. The pilot should consult the aircraft flight manual for performance characteristics and limitations before practicing these maneuvers.

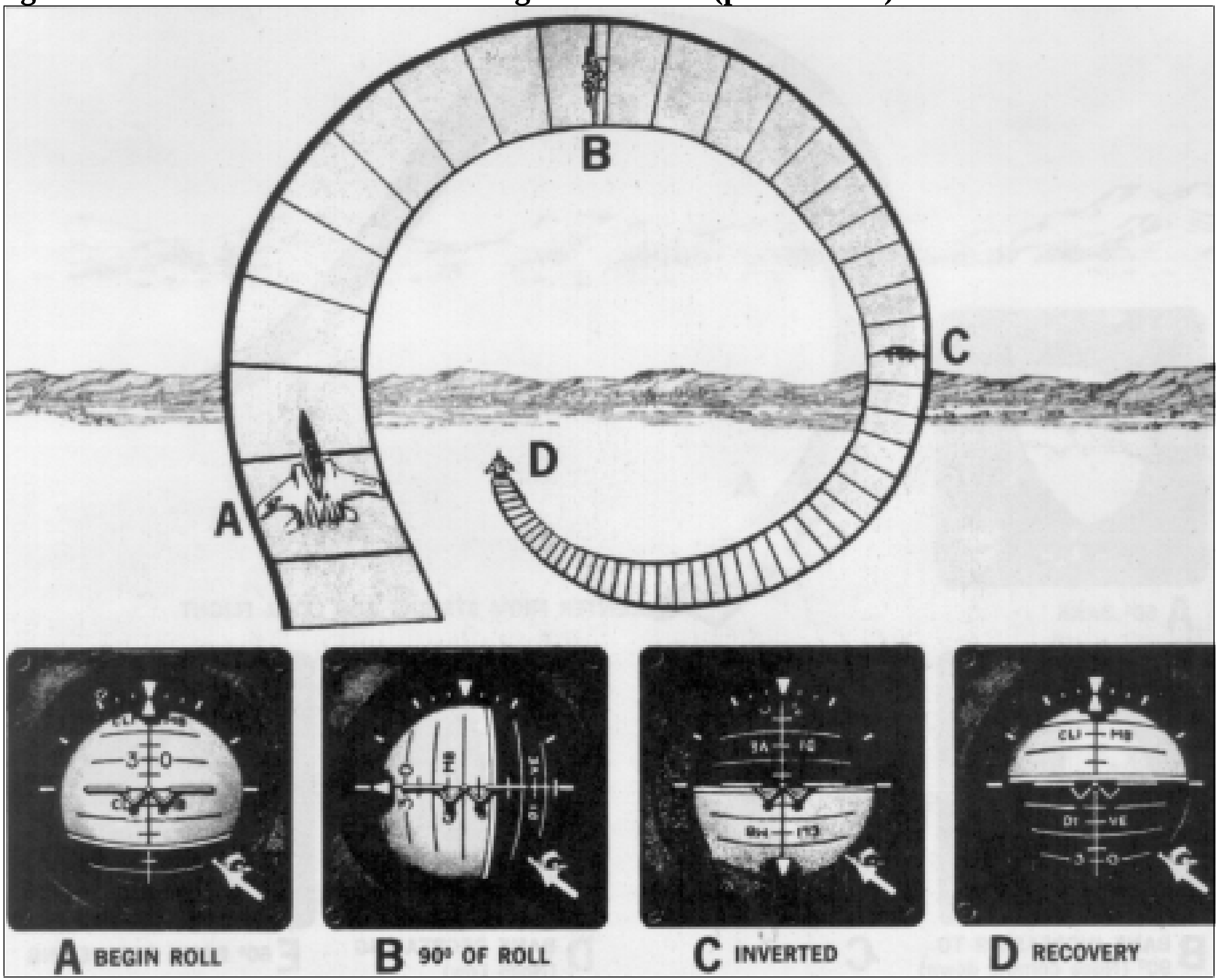
2.4.2.1. Wingover (Figure 2.8). Begin the maneuver from straight and level flight. After obtaining the desired airspeed, start a climbing turn in either direction while maintaining the wing tip of the miniature aircraft on the horizon bar until reaching 60° of bank. Allow the nose of the aircraft to start down while continuing to increase the angle of bank, planning to arrive at 90° of bank as the fuselage dot of the miniature aircraft reaches the horizon bar. Begin decreasing the angle of bank as the fuselage dot of the miniature aircraft reaches the horizon bar so that the wing tip of the miniature aircraft reaches the horizon bar as 60° of bank is reached. Maintain the wing tip on the horizon bar while rolling to a wings level attitude. The rate of roll during the recovery should be the same as the rate of roll used during the entry. Control pitch and bank throughout the maneuver by reference to the attitude indicator.

Figure 2.8. Attitude Indications During Wingover (para 2.4.2.1).



2.4.2.2. Aileron Roll (Figure 2.9). Begin the maneuver from straight and level flight after obtaining the desired airspeed. Smoothly increase the pitch attitude, with the wings level, to 15° to 25° nose up on the attitude indicator. Start a roll in either direction and adjust the rate of roll so that, when inverted, the wings will be level as the fuselage dot of the miniature aircraft passes through the horizon bar. Continue the roll and recover in a nose low, wings level attitude. The entire maneuver should be accomplished by reference to the attitude indicator. Use sufficient back pressure to maintain normal seat pressures throughout the maneuver.

Figure 2.9. Attitude Indications during Aileron Roll (para 2.4.2.2).



2.5. Unusual Attitudes.

2.5.1. Definition. An unusual attitude is an aircraft attitude occurring inadvertently. It may result from one factor or a combination of several factors such as turbulence, channelized attention, instrument failure, inattention, spatial disorientation, lost wingman, and transition from visual meteorological conditions (VMC) to instrument meteorological conditions (IMC). In most instances these attitudes are mild enough to recover by reestablishing the proper attitude for the desired flight condition and resuming a normal crosscheck. As a result of extensive tactical maneuvering, the pilot may experience unusual attitudes even in VMC. This may be aggravated by the lack of a definite horizon or by lack of contrast between the sky and ground or water.

WARNING: ***It is important to immediately transition to instrument references any time you become disoriented or when outside visual references become unreliable***.

2.5.2. Techniques of recovery. Techniques of recovery should be compatible with the severity of the unusual attitude, the characteristics of the aircraft, and the altitude available for the recovery. The procedures in this section are not designed for recovery from controlled tactical maneuvers.

2.5.3. Principles and considerations. The following aerodynamic principles and considerations are applicable to the recovery from unusual attitudes:

2.5.3.1. Elimination of bank. The elimination of a bank in dive aids pitch control

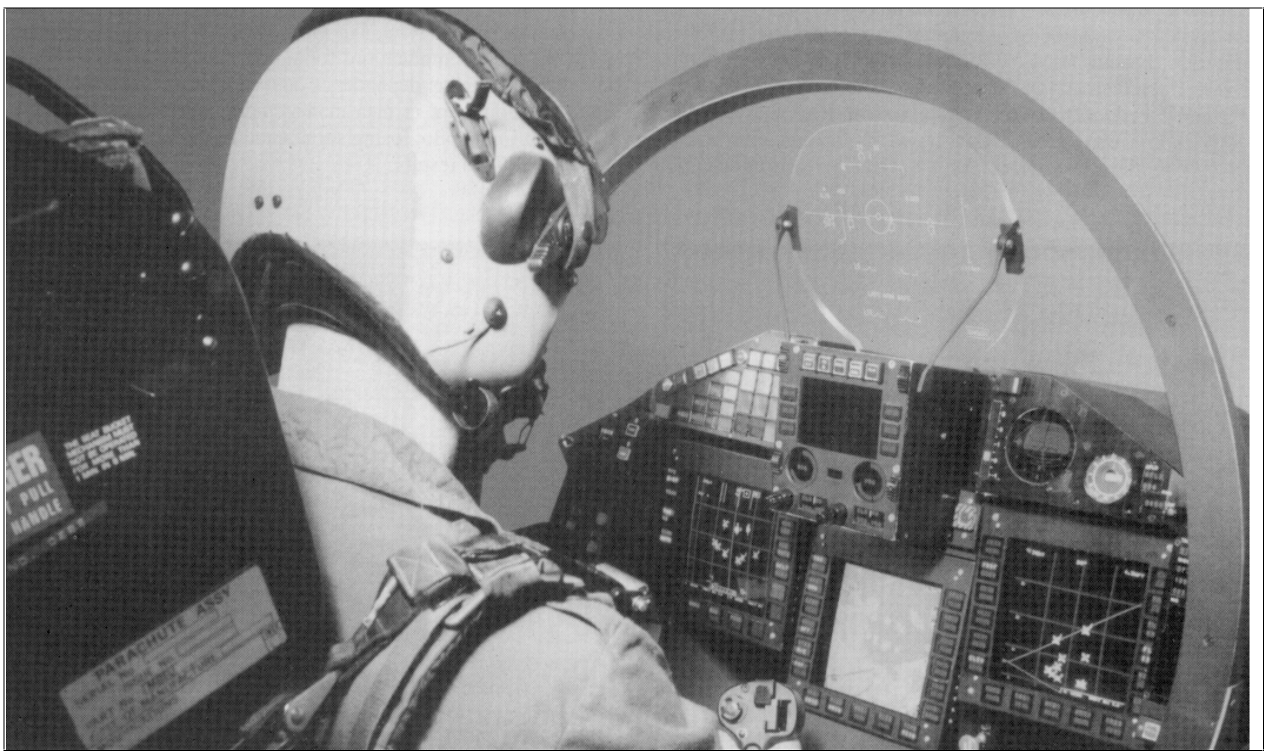
2.5.3.2. Use of bank. The use of bank in a climb aids pitch control.

2.5.3.3. Power and drag. Power and drag devices used properly aid airspeed control.

2.5.3.4. Bank control. It should be emphasized that bank control will assist recovery.

2.5.4. Recognizing an Unusual Attitude. Normally, an unusual attitude is recognized in one of two ways-an unusual attitude "picture" on the attitude indicator or unusual performance on the performance instruments. Regardless of how the attitude is recognized, verify that an unusual attitude exists by comparing control and performance instrument indications prior to initiating recovery on the attitude indicator (**Figure 2.10**). This precludes entering an unusual attitude as a result of making control movements to correct for erroneous instrument indications. During this process, the attitude must be correctly interpreted. Additional attitude indicating sources (stand by attitude indicator, copilot's attitude indicator, etc.) should be used. In some aircraft, the bank steering bar (manual mode) may aid in maintaining level flight (refer to flight manual). If there is any doubt as to proper attitude indicator operation, then recover using attitude indicator inoperative procedures. The following techniques will aid aircraft attitude interpretation on the attitude indicator.

Figure 2.10. Verify That an Unusual Attitude Exists (para 2.5.4).



2.5.4.1. Sky pointer. For attitude indicators with a single bank pointer and bank scale at the top, the bank pointer can be considered a sky pointer. It always points up and should be in the upper half of the case. Rolling towards the bank pointer to place it in the upper half of the case will correct an inverted attitude.

2.5.4.2. Ground pointer. For those attitude indicators with the bank scale at the bottom, rolling in the direction that will place the pitch reference scale right side up will correct an inverted attitude.

NOTE: Ease of pitch interpretation varies with the type of attitude indicator installed. Attitude indicators having pitch reference scales in degrees and gray or black attitude spheres can easily be interpreted for climb or dive indications. For those aircraft not so equipped, the airspeed indicator, altimeter, or vertical velocity indicator generally presents the most easily interpreted indication of a climb or a dive. Attitude interpretation is a skill that must be highly developed by practice in flight and on the ground in simulators or with mockups.

2.5.5. Recovery Procedures--Attitude Indicators Operative. For fixed-wing aircraft, use the following procedures if specific unusual attitude recovery procedures are not in the flight manual.

2.5.5.1. Diving. If diving, adjust power or drag devices as appropriate while rolling to a wings level, upright attitude, and correct to level flight on the attitude indicator. Do not add back pressure until less than 90° of bank.

2.5.5.2. Climbing. If climbing, use power as required and bank as necessary to assist pitch control and to avoid negative G forces. As the fuselage dot of the miniature aircraft approaches the horizon bar, adjust pitch, bank, and power to complete recovery and establish the desired aircraft attitude. When recovering from a steep climb, care must be exercised in some aircraft to avoid exceeding bank limitations.

2.5.5.3. Bank and power. During unusual attitude recoveries, coordinate the amount of bank and power used with the rate at which airspeed and pitch are being controlled. Bank and power used must be compatible with aircraft and engine characteristics.

2.5.6. Recovery Procedures--Attitude Indicators Inoperative. With an inoperative attitude indicator, successful recovery from unusual attitudes depends greatly on pilot proficiency and early recognition of attitude indicator failure. For example, attitude indicator failure should be immediately suspected if control pressures are applied for a turn without corresponding attitude indicator changes. Another example would be satisfactory performance instrument indications that contradict the "picture" on the attitude indicator. Should an unusual attitude be encountered with an inoperative attitude indicator, the following procedures are recommended:

2.5.6.1. Climb or dive. Determine whether the aircraft is in a climb or a dive by referring to the airspeed, altimeter, and vertical velocity indicators.

2.5.6.2. Diving. If diving, roll to center the turn needle and recover from the dive. Adjust power or drag devices as appropriate. (Disregarding vertical attitudes, rolling "away" from the turn needle and centering it will result in an upright attitude).

2.5.6.3. Climbing. If climbing, use power as required. If the airspeed is low or decreasing rapidly, pitch control may be aided by maintaining a turn of approximately standard rate on the turn needle until reaching level flight. If the turn needle in a flight director system is used, center the turn needle. This is because it is very difficult to determine between a standard rate turn and full needle deflection.

2.5.6.4. Level flight. Upon reaching level flight, center the turn needle. The aircraft is level when the altimeter stops. The vertical velocity indicator lag error may cause it not to indicate level until the aircraft passes level flight.

WARNING: Spatial disorientation may become severe during the recovery from unusual attitudes with an inoperative attitude indicator. Extreme attitudes may result in an excessive loss of altitude and possible loss of aircraft control. Therefore, if a minimum safe altitude for unusual attitude recovery is not in the flight manual, decide upon an altitude at which recovery attempts will be discontinued and the aircraft abandoned. On aircraft equipped with an operative autopilot, it may be used to assist in a last chance recovery from unusual attitudes.

WARNING: Due to the inadequate attitude information possibly found on HUDs presently in the inventory, attempts to recover from unusual attitudes using the HUD may further aggravate the situation.

Chapter 3

BASIC INSTRUMENT FLYING-HELICOPTER

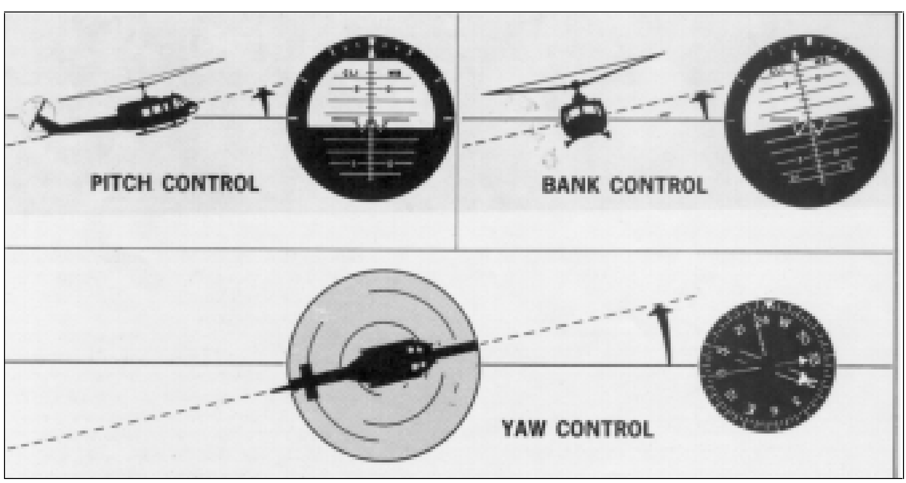
3.1. Instrument Categories. This chapter contains helicopter unique instrument procedures that are not covered elsewhere in this manual. In addition, you should be very familiar with the navigation instruments (chapter 5), electronic aids to navigation (chapter 6), and navigation procedures (chapter 7) that apply to all aircraft. Your flight should be planned and conducted according to chapters 8 through 11 and 13 through 22 (as applicable) of this manual. Helicopter performance is achieved by controlling the aircraft attitude and power. This attitude is the relationship of the longitudinal and lateral axes to the Earth's horizon (**Figure 3.1**). An aircraft is flown in instrument flight by controlling the attitude and power as necessary to produce the desired performance. This is known as the "control and performance concept" of attitude instrument flying and can be applied to any basic instrument maneuver. The three general categories of instruments are:

3.1.1. Control Instruments. These instruments display attitude and power indications and are calibrated to permit attitude and power adjustments in definite amounts. In this discussion, the term power is used to replace the more technically correct term thrust to drag relationship. Power is controlled by reference to the power indicators. These vary with different helicopters and may include torque (either pounds or percentage of), manifold pressure, etc.

3.1.2. Performance Instruments. These instruments indicate the aircraft's actual performance. Performance is determined by reference to the altimeter, airspeed, vertical velocity indicator, heading indicator, and turn and slip indicator.

3.1.3. Navigation Instruments. These instruments indicate the position of the aircraft in relation to a selected navigation facility, fix, or relative position. This group of instruments includes various types of course indicators, range indicators, glide slope indicators, and bearing pointers.

Figure 3.1. Attitude Instrument Flying (para 3.1).



3.2. Control and Performance Concept.

3.2.1. Procedural Steps.

3.2.1.1. Establish. Establish attitude or power setting on the control instruments that should result in the desired performance.

3.2.1.2. Trim. Trim using stick or force trim and friction as needed.

3.2.1.3. Crosscheck. Crosscheck the performance instruments to determine if the established attitude or power setting is providing the desired performance.

3.2.1.4. Adjust. Adjust the attitude or power setting on the control instruments if a correction is necessary.

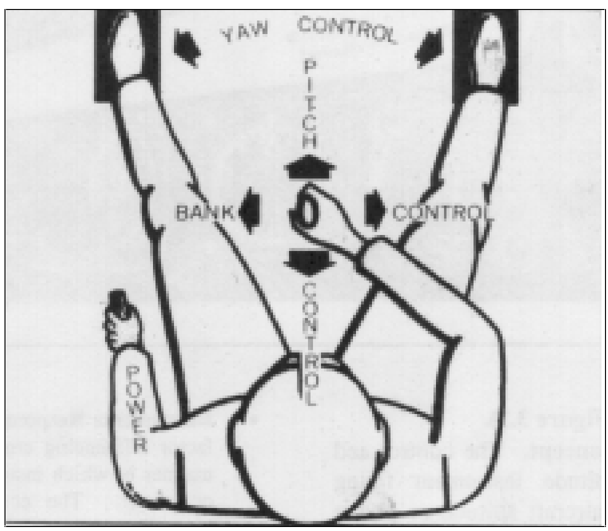
3.2.2. Attitude Control.

Proper control of aircraft attitude is the result of maintaining a constant attitude, knowing when and how much to change the attitude, and smoothly changing the attitude a definite amount. Helicopter attitude is maintained by proper use of the attitude indicator. The attitude indicator provides an immediate, direct, and corresponding indication of any change in aircraft pitch or bank attitude.

3.2.2.1. Pitch Control (Figures 3.1 and 3.2). Pitch changes are made by cyclic inputs to change the "pitch attitude" of the miniature aircraft or fuselage dot definite amounts in relation to the horizon. These changes are referred to as bar widths or fractions thereof, or degrees depending upon the type of attitude indicator. A bar width is approximately 2 degrees on most attitude indicators. The amount of deviation from the desired performance will determine the magnitude of the correction.

3.2.2.2. Bank Control. Bank changes are made by cyclic inputs to change the "bank attitude" or bank pointers definite amounts in relation to the bank scale. The bank scale is normally graduated at 0°, 10°, 20°, 30°, 60°, and 90° and may be located at the top or bottom of the attitude indicator.

Figure 3.2. Attitude and Power Control (para 3.2.2).



3.2.3. Power Control.

3.2.3.1. Proper power control. Proper power control results from the ability to smoothly establish or maintain desired airspeeds and altitudes in coordination with attitude changes. Power changes are made by collective pitch adjustments and reference to the power indicator. Power indicators are not usually affected by such factors as turbulence, improper trim, or inadvertent control pressures.

3.2.3.2. Collective experience. From experience in your aircraft, you know approximately how far to move the collective to change the power a given amount. Therefore, you can make power changes primarily by collective movement and then crosscheck the indicator to establish a more precise setting. The key is to avoid over fixation on the indicator while setting the power. A knowledge of power settings for various flight conditions will help prevent over controlling power.

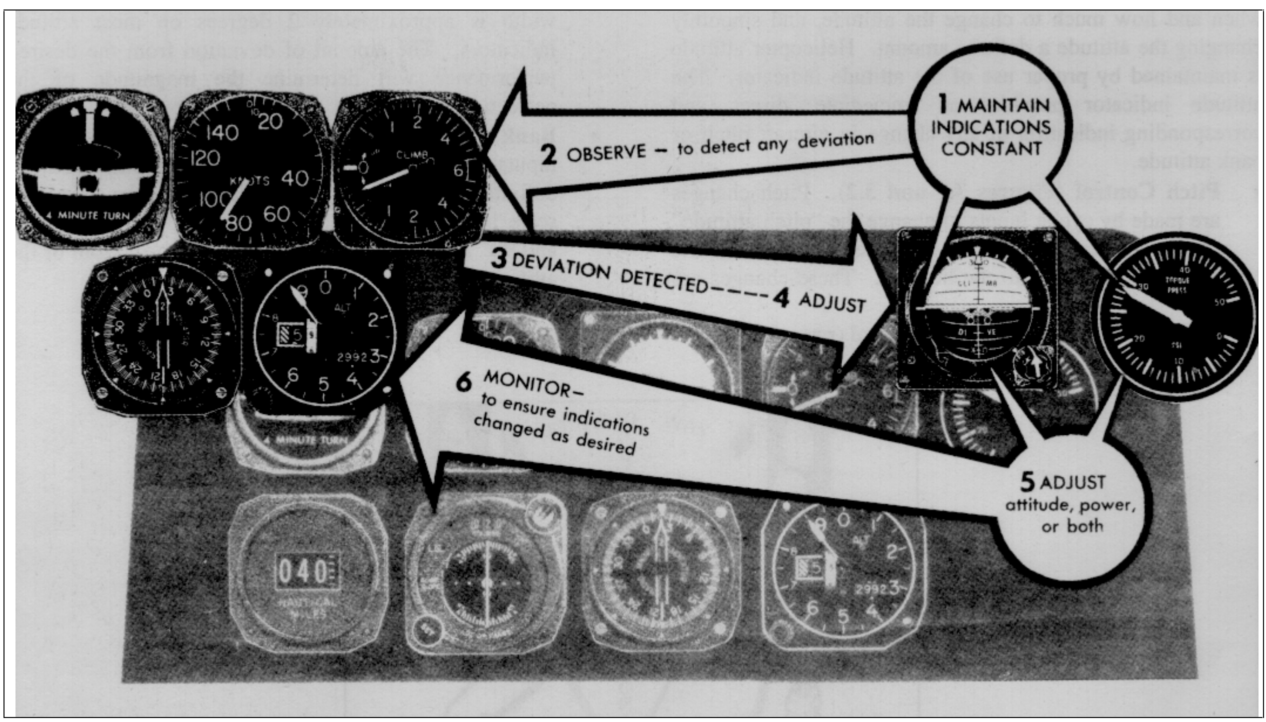
3.2.4. Trim Techniques. The inherent instability of helicopters requires the pilot to trim the aircraft accurately in order to reduce the workload to an acceptable level.

3.2.4.1. Independent trim systems. For those helicopters equipped with independent trim systems, trimming nose up/down, lateral right/left planes are relatively simple. Small changes are made in the desired direction until the control pressures are neutralized and the aircraft maintains a relatively stable desired flight path.

3.2.4.2. Force trim systems. For those helicopters equipped with a force trim system, the ability to trim the aircraft accurately is somewhat difficult and comes only with experience. Depressing the force trim button releases all trim axes simultaneously. The pilot must ensure those in trim are maintained exactly, while the corrections to the out of trim axes are made.

3.2.4.3. Yaw axis control. The key to smooth and accurate instrument flight in a helicopter is the ability to maintain coordinated flight. This is because the yaw axis is usually the most unstable axis in helicopters, particularly in those aircraft not equipped with a Stability Augmentation System (SAS). Therefore, this axis requires the most attention by the pilot. The instability in the yaw axis is compounded by power changes that cause a yawing moment and require an immediate pedal correction. Induced vertigo is commonly the result of this moment. Therefore power changes should be kept to a minimum and, when required, should be applied slowly and smoothly. Pilot anticipation of pedal adjustments during power changes will help to keep yaw moments to a minimum.

Figure 3.3. Instrument Cross-Check (para 3.2.5).



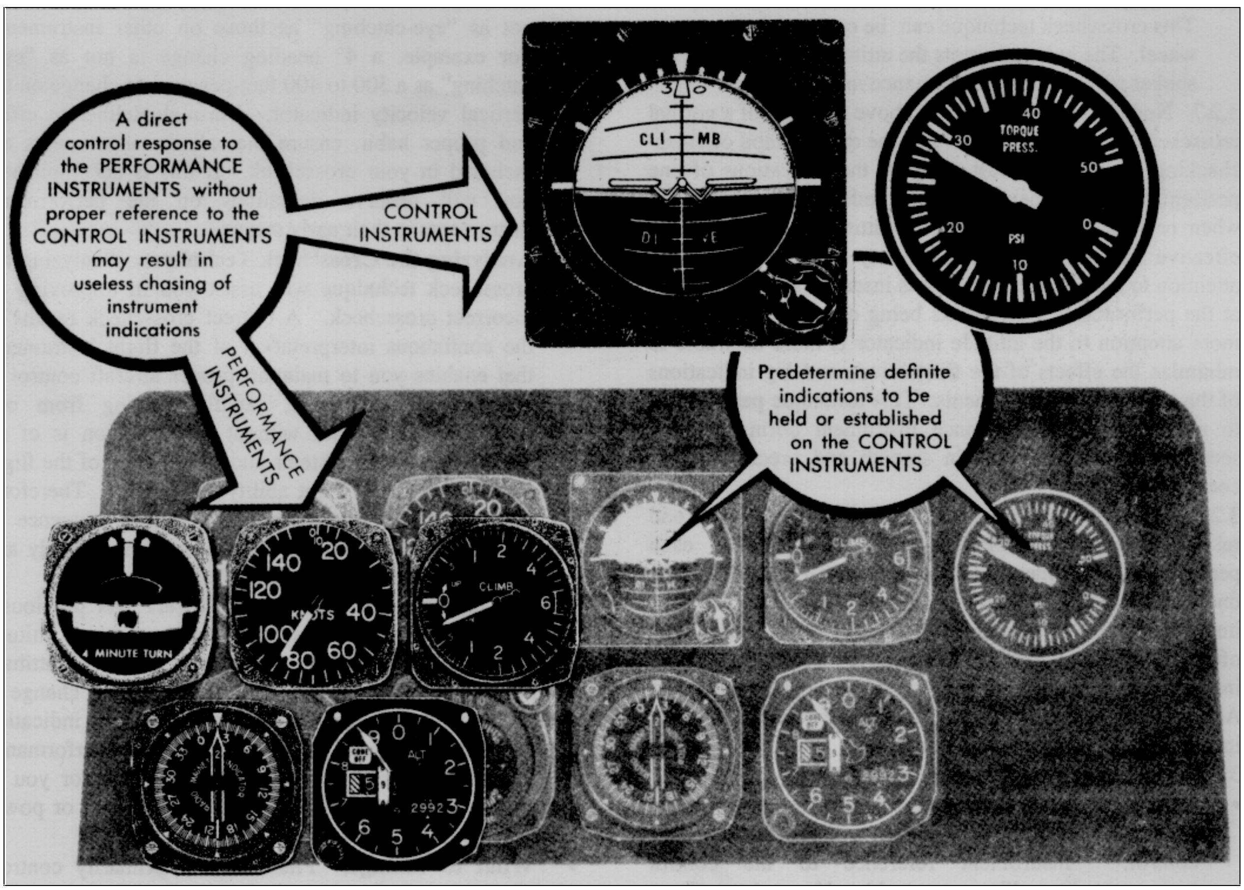
3.2.5. Cross-Check Technique (Figure 3.3).

3.2.5.1. Control and performance concept. The control and performance concept of attitude instrument flying requires you to establish an aircraft attitude or power setting on the control instrument that should result in the desired aircraft performance. Therefore, you must be able to recognize when a change in attitude or power is required. By cross-checking the instruments properly, you can determine the magnitude and direction of the adjustment required.

3.2.5.2. Cross-checking. Cross-checking is a proper division of attention and the interpretation of the flight instruments. Attention must be efficiently divided between the control and performance instruments in a sequence that ensures comprehensive coverage of the flight instruments. Looking at each of the instruments at the proper time is of no value unless you can interpret what you see. Therefore, proper division of attention and interpretation are the two essential parts of a crosscheck.

3.2.5.3. Crosscheck techniques. Crosscheck techniques or the sequence for checking the instruments varies among pilots and throughout various phases of flight. Therefore, you should become familiar with the factors to be considered in dividing your attention properly, and you should know the symptoms that will help you to recognize an incorrect crosscheck technique.

Figure 3.4. Factors Influencing Cross-Check Techniques (para 3.2.6).



3.2.6. Factors Influencing Instrument Cross-Checks (Figure 3.4).

3.2.6.1. Instruments Response to Attitude or Power Changes. A factor influencing crosscheck technique is the characteristic manner in which instruments respond to changes of attitude or power. The control instruments provide direct and immediate indications of attitude or power changes.

3.2.6.2. Lag on Performance Instruments. Changes in the indications on the performance instruments will lag slightly behind changes of attitude or power. This lag is due to inertia of the aircraft and the operating principles and mechanisms of the performance instruments. Therefore, some lag must be accepted as an inherent factor. This factor will not appreciably affect the tolerances within which you control the aircraft; however, at times a slight unavoidable delay in knowing the results of attitude or power changes will occur. Lag in the performance instruments should not interfere with maintaining or smoothly changing the attitude or power indications. When the attitude and power are properly controlled, the lag factor is negligible and the indications on the performance instruments will stabilize or change smoothly. Do not be lured into making a flight control movement in direct response to the lag in the indications on the performance instruments without first referring to the control instruments. Sufficient reference to the control instruments will minimize the effect of lag on the performance instruments and nullify the tendency to "chase" the indications.

3.2.6.3. Location of Flight Instruments. Another factor influencing crosscheck technique is the location of the flight instruments. In some aircraft the flight instruments are scattered over a wide area of the instrument panel, making it difficult to bring several instruments into your crosscheck at the same time. Therefore, you must rapidly scan each instrument individually back and forth across the instrument panel. More advanced instrument systems, such as the flight director and integrated flight instrument systems have reduced the required scan to a small area so you can see more of the flight instruments with one look. The task of cross-checking these instruments is much easier because you can simultaneously observe the attitude indicator and the proper performance instruments.

3.2.6.4. Pilot's Ability. An important factor influencing crosscheck technique is the ability of the pilot. All pilots do not interpret instrument presentations with the same speed; some are faster than others are in understanding and evaluating what they see. One reason for this is that the natural ability of pilots varies. Another reason is that the experience levels are different. Pilots who are experienced and fly regularly will probably interpret their instruments more quickly than inexperienced pilots. Pilots who interpret their instruments quickly and correctly do not have to refer back to them for information as often as pilots who are slow to interpret. They are also able to bring several instruments into their crosscheck with one glance, interpreting them simultaneously. Therefore, the speed with which they divide their attention does not have to be as rapid as the pilot's with less ability, who must scan the instruments rapidly to stay ahead of the aircraft.

3.2.6.5. Observing Attitude Indicator. The attitude indicator is the only instrument that you should observe continuously for any appreciable length of time. Several seconds may be needed to accomplish an attitude change required for a normal turn. During this period, you may need to devote your attention almost exclusively to the attitude indicator to ensure good attitude control. The attitude indicator is the instrument that you should check the greatest number of times. This is shown by the following description of a normal crosscheck. A pilot glances from the attitude indicator to a performance instrument, back to the attitude indicator, then a glance at another performance instrument, back to the attitude indicator, and so forth. This crosscheck technique can be compared to a wagon wheel. The hub represents the attitude indicator and the spokes represent the performance instruments.

3.2.7. Normal Crosscheck. The above example of a normal crosscheck does not mean that it is the only method of cross-checking. Often you must compare the indications of one performance instrument against another before knowing when or how much to adjust the attitude or power. An effective crosscheck technique may be one in which attention to the attitude indicator is inserted between glances at the performance instruments being compared. Devoting more attention to the attitude indicator is more desirable to minimize the effects of the fluctuations and lag indications of the performance instruments. This technique permits you to read any one performance instrument during a split-second glance and results in smooth and precise aircraft control.

3.2.8. Performance Instrument Attention. A proper and relative amount of attention must be given to each performance instrument. Pilots seldom fail to observe the one performance instrument whose indication is most important. The reverse is a common error because pilots often devote so much attention to one performance instrument that the others are omitted from the crosscheck. Additionally, they often fail to crosscheck the attitude indicator for proper aircraft control.

3.2.9. Cross-Check Analysis.

3.2.9.1. Incorrect crosscheck. An incorrect crosscheck can be recognized by analyzing certain symptoms of aircraft control. Insufficient reference to the control instruments is readily recognizable. If you do not have some definite attitude and power indications in mind and the other instruments fluctuate erratically through the desired indications, then you are not referring sufficiently to the control instruments. Imprecise aircraft control usually results in "chasing" the indications.

3.2.9.2. Control Instrument Fixation. The problem of too much attention being devoted to the control instruments is rarely encountered, except for fixation on the power indicators. This is normally caused by your desire to maintain the performance indications within close tolerances. Positive and continuous inputs based only on the control instruments are not sufficient for maintaining the desired parameters; a systematic crosscheck of the performance instruments is also required.

3.2.9.3. Scanning Process. An incorrect crosscheck can result in the omission of or insufficient reference to one or more instruments during the scanning process. You may omit some performance instruments from the crosscheck, although other performance instruments and the control instruments are being properly observed. For example, during a climb or descent, you may become so engrossed with pitch attitude control that you fail to observe an error in aircraft heading.

3.2.9.4. Indications. The indications on some instruments are not as "eye-catching" as those on other instruments. For example, a 4° heading change is not as "eye-catching" as a 300 to 400 feet-per-minute change on the vertical velocity indicator. Through deliberate effort and proper habit, ensure that all the instruments are included in your crosscheck. If this is accomplished, you will observe deviations on the performance instruments in their early stages.

3.2.9.5. Analyzing the Crosscheck Technique. Analyzing the crosscheck technique will assist you in improving an incorrect crosscheck. A correct crosscheck results in the continuous interpretation of the flight instruments that enables you to maintain proper aircraft control at all times. Remember, rapidly looking from one instrument to another without interpretation is of no value. Instrument systems and the location of the flight instruments vary. Pilot ability also varies. Therefore, you should develop your own rate and sequence of checking the instruments that will ensure a timely and correct interpretation of the flight instruments.

3.2.10. Adjusting Attitude and Power. As previously stated, the control and performance concept of attitude instrument flying requires the adjustment of aircraft attitude and power to achieve the desired performance. A change of aircraft attitude or power is required when any indication other than that desired is observed on the performance instruments. However, it is equally important for you to know what to change and how much pitch, bank, or power change is required.

3.2.10.1. What to Change. Pitch attitude primarily controls airspeed and the rate of change in airspeed. Bank attitude control is used to maintain a heading or desired angle of bank during turns. Collective power controls altitude changes and the rate of altitude change. Remember that power is used primarily to maintain your altitude and control the rate of climb or descent and that cyclic control is used primarily in maintaining airspeed and bank angle.

3.2.10.2. How Much to Change. How much to adjust the attitude or power is, initially, an estimate based on familiarity with the aircraft and the amount you desire to change on the performance instruments. In an UH-1N for example, 2% of torque approximates 100 feet per minute of climb or descent or 5 knots of increase or decrease in airspeed. After you make a change in attitude or power, observe the performance instruments to see if the desired change occurred. If not, further adjustment of attitude or power is required. Remember, even though changes are estimates, they must be made in exact increments.

3.3. Display of Flight Instrumentation. The advent of electronic displays has given the pilot the ability to optimize cockpit instrumentation for a particular mission by adding, removing, or relocating presentations on multi-function displays. This new dimension in cockpit management can be an asset if the selection of instrument displays is based on the requirement that, regardless of the type of mission, the pilot must always be aware of the aircraft's attitude. No mission can be safely or effectively executed if attitude awareness is lost.

3.3.1. Primary Flight Instrumentation. ***Primary flight instrumentation must always be present and must provide full-time attitude, altitude, and airspeed information; an immediately discernible attitude recognition capability; an unusual attitude recovery capability; and complete fault indications.***

3.3.2. Position of Flight Instrumentation. ***The elements of information of Primary Flight Instrumentation must be positioned and arranged in a manner that enables the pilot to perform a natural crosscheck.***

3.3.3. Standardization of Flight. ***Primary flight instrumentation will be standardized in terminology, symbology, mechanization, and arrangement.*** Standardization of instrumentation display elements provides a common training base and allows the retention of good flying habits during transition to different aircraft. This standardization can only be effective when the pilot acknowledges attitude awareness as a full-time requirement and manages the cockpit accordingly.

3.4. Single-Medium Displays. ***For a single-medium display (e.g., head-up or head-down multifunction display) to solely satisfy flight instrumentation requirements, it must adhere to para 3.3. and will always display:***

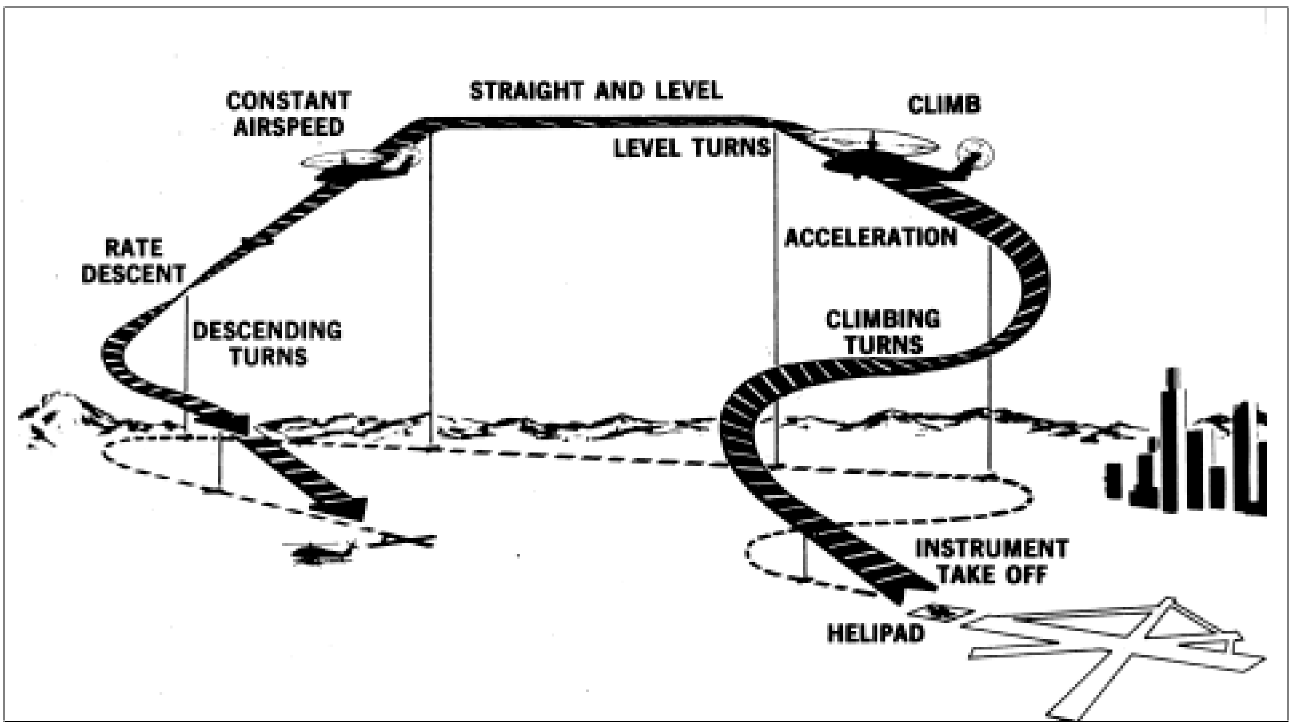
- ***Climb/dive angle (or pitch and vertical velocity)***
- ***Bank angle***
- ***Barometric altitude***
- ***Indicated or calibrated airspeed***
- ***Prominent horizon reference***

Chapter 4

INSTRUMENT FLIGHT MANEUVERS - HELICOPTER

4.1. Application. This section outlines techniques for accomplishing commonly used flight maneuvers in helicopters. Any instrument flight, regardless of how long or complex, is simply a series of connected basic flight maneuvers as illustrated in **Figure 4.1**. Failure to consider each portion of the flight as a basic instrument maneuver often leads to erratic aircraft control. The maneuvers that are described here are general in nature; therefore, slight variations may be required for specific helicopters and in-flight situations. The degree of proficiency developed while accomplishing the maneuvers outlined will allow you to execute any variation or additional maneuver. The information received from the navigation instruments or an air traffic controller should be considered as advising you what maneuver to perform, when to perform it, or what adjustments, if any, are required. Instrument approach procedure charts and similar publications should be considered as pictorial presentations of a series of connected instrument flight maneuvers. Keeping these considerations in mind and calling upon previous experience, you will find that you are always performing a familiar maneuver. By visualizing the next maneuver, you can plan ahead and know exactly what crosscheck and aircraft control techniques to employ.

Figure 4.1. Typical Instrument Flight (para 4.1).



4.2. Planning. This section outlines the helicopter unique procedures that must be considered prior to any instrument flight. These procedures should be taken into consideration even though you have planned your flight in accordance with the flight planning criteria in the rest of this manual.

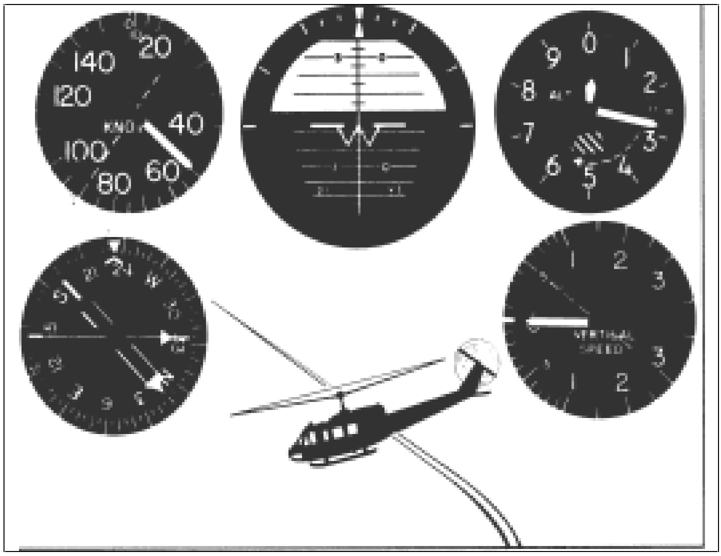
4.3. The Instrument Takeoff (ITO). The ITO is accomplished by referring to outside visual references and to the flight instruments. The amount of attention given to each reference varies with the individual, the type of aircraft, and existing weather conditions. The ITO is a composite visual and instrument takeoff when conditions permit, and should not be confused with a "hooded takeoff." The ITO procedures and techniques are invaluable aids during takeoffs at night, toward and over water or deserted areas, and during periods of reduced visibility. It is important to immediately transition to instrument references any time you become disoriented or when outside visual references become unreliable.

4.3.1. Preparing for the ITO. Before performing an ITO, you should perform an adequate before-takeoff check of all flight and navigation instruments to include publications. Select the appropriate navigational aids to be used for the departure, and set the navigation instruments and switches as required. The ATC clearance and departure procedures must be thoroughly understood before takeoff. It is a good operating practice to have the appropriate instrument approach procedure charts available in the event an instrument approach is necessary immediately after takeoff. Review of the approach for an emergency return should include frequencies, final approach course, decision height (DH) or minimum descent altitude (MDA), and minimum safe, sector, or emergency safe altitudes. Brief all crewmembers on specific duties during an emergency return.

4.3.2. Performing the ITO from hover or the ground. In helicopters, an ITO may be accomplished from a hover or from the ground as visibility restrictions permit. Normally, a composite takeoff is accomplished using normal VMC procedures and combining reference to the flight instruments with outside visual references to provide a smooth transition from VMC to IMC flight. Helicopter ITOs may have to be accomplished entirely on instruments due to restrictions to visibility induced by rotor downwash on dust, sand, or snow. This downwash may reach 60 to 100 knots, depending upon the size and weight of the aircraft. Since helicopters often operate from unprepared or remote locations in the presence of loose dirt or snow, downwash can easily result in the loss of visual references. This downwash also effects pitot-static instrumentation. In fact, aircrew manuals warn that airspeed indications should be considered unreliable when forwarded airspeed is less than 25 to 40 knots, depending upon size and weight of aircraft. Additionally, altimeters and vertical velocity indicators will actually indicate a loss of altitude as power is applied for takeoff. Prior to takeoff, the attitude indicators should be adjusted by aligning the adjustment knobs with the zero trim dots (the J-8 attitude indicator is adjusted by aligning the miniature aircraft with the 90° bank indexes). These settings will provide a constant attitude reference for the ITO regardless of aircraft attitude at the time of adjustment. After the aircraft is aligned with the runway or takeoff pad, to prevent forward movement of helicopters equipped with wheel-type landing gear, set the parking brakes or apply the toe brakes. If the parking brake is used, it must be unlocked prior to the ITO. Apply sufficient friction to the collective pitch control to minimize over controlling and to prevent collective pitch creep. However, in order not to limit pitch control movement, the application of excessive friction should be avoided.

4.3.3. The Takeoff. After a recheck of all instruments for proper operation, start the takeoff (**Figure 4.2**) by applying collective pitch of a predetermined power setting. Add power smoothly and steadily to gain airspeed and altitude simultaneously and to prevent settling to the ground. (Helicopters with wheel-type landing gear may also elect to make running takeoffs if operating from smooth surfaces.) As power is applied and the helicopter becomes airborne, maintain the desired heading with the pedals and use forward cyclic to establish the desired ITO pitch attitude. When a positive climb indication is obtained, adjust the pitch attitude as specified in the flight manual. As soon as the takeoff attitude is established, crosscheck the vertical velocity indicator and altimeter to ensure you are still climbing. While the aircraft is below airspeeds required for accurate altitude or vertical velocity indicator (VVI) readings, predetermined power settings and pitch attitudes will provide the most reliable source of climb information. A rapid crosscheck must be started at the time the aircraft leaves the ground and should include all available instruments in order to provide you a smooth transition to coordinated flight.

Figure 4.2. The Instrument Takeoff (para 4.3).



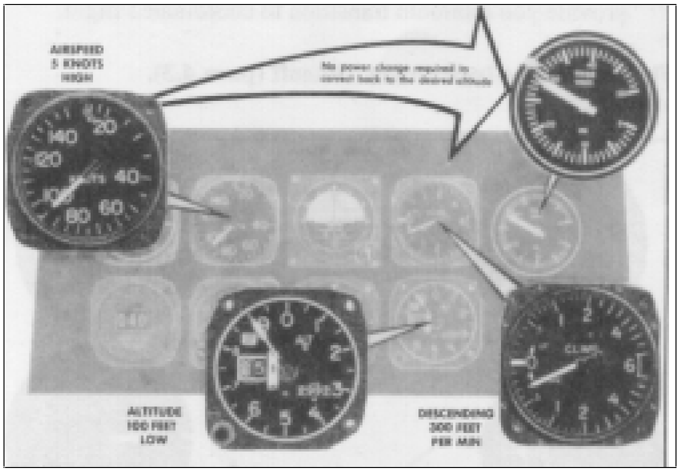
4.4. Individual Maneuvers.

4.4.1. Straight and Level Flight. Straight and level unaccelerated flight consists of maintaining desired altitude, heading, and airspeed. Use power control to maintain or adjust the altitude; use pitch attitude to maintain or adjust the airspeed; and use bank control to maintain or adjust the heading.

4.4.1.1. Establishing and maintaining an altitude. Establishing or maintaining an altitude is accomplished by referring to the altimeter and VVI for actual aircraft performance and adjusting the power or aircraft attitude to obtain or maintain the desired altitude. A knowledge of the approximate power required to establish a desired altitude or rate of change of vertical velocity will aid in making power adjustments. After the approximate power setting is established, a crosscheck of the altimeter and the VVI will indicate if subsequent power adjustments are required. You should make it a point to learn and remember the approximate power settings for your aircraft at various altitudes, airspeeds, and configurations used throughout a normal mission.

4.4.1.1.1. Altitude deviation. When an altitude deviation is observed, a power or pitch adjustment (or a combination of both) may be required to correct back to the desired altitude. For example, if below the desired altitude with a higher than desired airspeed, an increase in pitch may regain both the desired altitude and airspeed. Conversely, a pitch adjustment (if made at the desired altitude) will induce the need for a power adjustment (**Figure 4.3**).

Figure 4.3. Altitude Control (para 4.4.1.1).



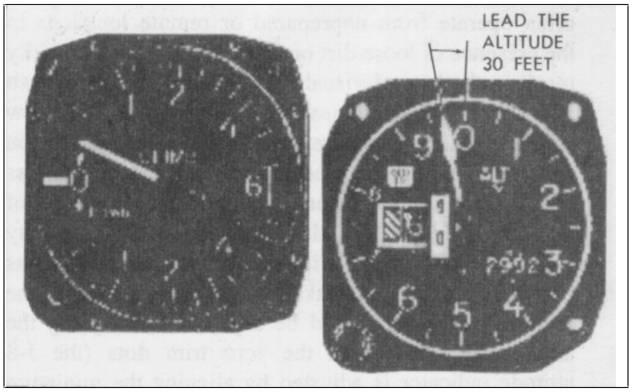
4.4.1.1.2. Power adjustment. With experience, you can usually estimate the suitability of power adjustment by noting the initial rate of movement of the VVI. If the initial rate of movement on the VV I is rapid and obviously will stabilize at a rate greater than desired, the power change was too large. Readjust the power rather than wait for a stabilized indication on the VVI.

4.4.1.1.3. Initial altitude deviation. When you first deviate from an altitude, an indication often appears on the VVI before appearing on the altimeter. By evaluating this initial rate of movement, you can estimate the amount of power change required to prevent large altitude deviations. If the estimated power change is correct, the vertical velocity will return to zero with a negligible change of altitude.

4.4.1.1.4. Vertical correction. When a deviation from the desired altitude occurs, determine a rate of vertical correction and apply a power change to correct back to the desired altitude. The correction must not be too large, resulting in the aircraft "overshooting" the desired altitude, nor should it be so small that the correction is unnecessarily prolonged. As a guide, the power change should produce a rate of vertical velocity approximately twice the value of the altitude deviation. For example, if the aircraft is 100 feet off the desired altitude, a 200 foot per minute rate of correction would be a suitable amount. By knowing the present rate of climb or descent and the results to be expected from a power change, you can closely estimate how much to change the power. The adjusted power must be held constant until the rate of correction is observed on the VVI. If it differs from that desired, then further adjustment of the power is required.

4.4.1.1.5. Lead point. When approaching the desired altitude, determine a lead point on the altimeter for initiating a level-off power change. A suitable lead point prevents "overshooting" and permits a smooth transition to level flight. The amount of lead required varies with pilot technique and rate of correction. As a guide, the lead point on the altimeter should be approximately 10 percent of the vertical velocity. For example, if the rate of correction to the desired altitude is 300 feet per minute, initiate the level off approximately 30 feet before reaching the desired altitude (**Figure 4.4**).

Figure 4.4. Leading the Level Off (para 4.4.1.1).

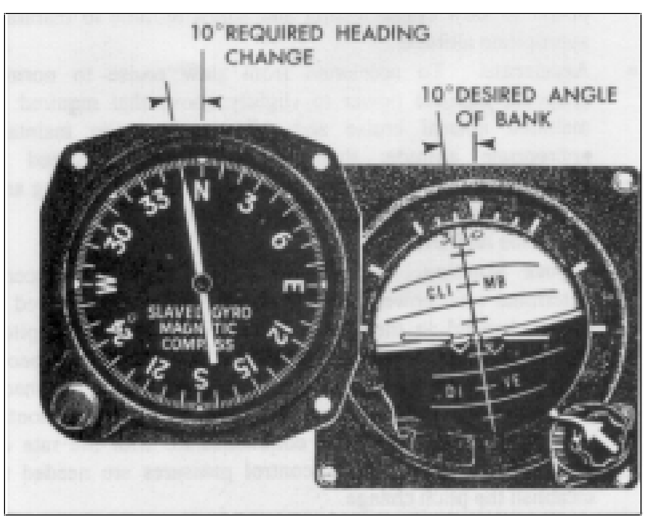


4.4.1.1.6. Chasing Indications. Devoting too much attention to the VVI can lead to "chasing" its indications and result in erratic power control. Although the VVI is an important performance instrument, limitations, such as oscillations in rough air, lag, etc., should be thoroughly understood to prevent over controlling the power. For this reason, you must recognize and understand that sufficient reference to the power indicator is necessary to ensure smooth and precise power adjustments for effective altitude control.

4.4.1.2. Maintaining a Desired Heading. Maintaining a desired heading is accomplished by maintaining a zero bank attitude and coordinated flight. Heading deviations are not normally as "eye-catching" as altitude deviations. Therefore, be aware of this characteristic and develop a habit of cross-checking the heading indicator frequently to prevent significant heading deviations.

4.4.1.2.1. Heading Deviation. When a deviation from the desired heading occurs, refer to the attitude indicator and smoothly establish a definite angle of bank that will produce a suitable rate of return. As a guide, the bank attitude change on the attitude indicator should equal the heading deviation in degrees not to exceed a standard rate turn (unless compensating for wind in a holding pattern or as required on radar final). For example, if the heading deviation is 10°, then 10° of bank on the attitude indicator would produce a suitable rate of correction (**Figure 4.5**).

Figure 4.5. Bank Control (para 4.4.1.2).



4.4.1.3. Establishing and maintaining a desired airspeed. Maintaining a desired airspeed requires the ability to maintain a specific pitch attitude and, when necessary, to smoothly and precisely adjust the attitude. This ability is developed through proper use of the attitude indicator and is simplified by good trim techniques.

4.4.1.3.1. Adjusting Attitude Indicator. After leveling off at cruise airspeed, you may adjust the pitch trim knob on the attitude indicator so that the miniature aircraft is aligned with the horizon bar. This will aid in observing small pitch changes. Subsequent readjustments may be required because of the changes in aircraft center of gravity and cruise airspeeds.

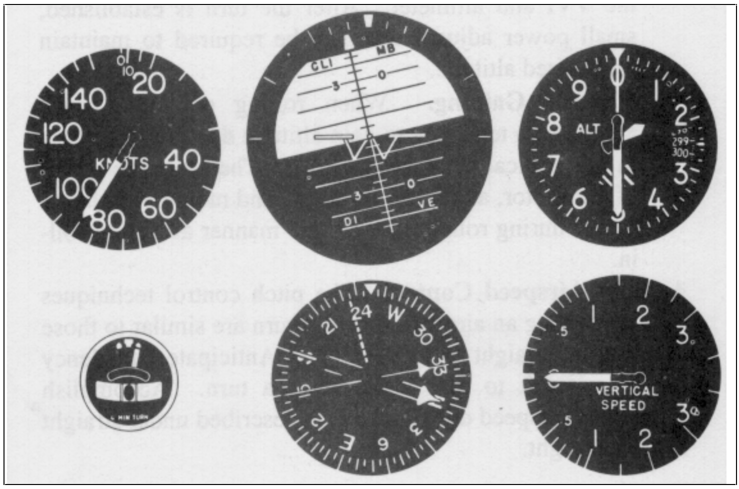
4.4.1.3.2. Small Corrections. The small corrections required to maintain a desired airspeed is made in degrees of pitch. With practice you can determine what pitch attitude adjustments are required to produce the desired rate of correction.

4.4.1.3.3. Pitch adjustments. When you make these pitch adjustments, airspeed and vertical velocity indications will lag behind changes of pitch attitude. This lag should be recognized and accepted as an inherent error in the differential pressure instruments. Because of this error, do not make a premature decision that the pitch change is ineffective. This can lure you into over controlling the pitch attitude.

4.4.1.3.4. Changes of Airspeed. Changes of airspeed in straight and level flight are accomplished by adjusting the pitch attitude and power. To increase airspeed, decrease the pitch attitude to a predetermined number of degrees and increase power to maintain altitude. When airspeed approaches the desired indication, adjust pitch to a setting that will maintain the new airspeed and adjust power to maintain altitude. To reduce airspeed, increase the pitch attitude to a predetermined number of degrees and reduce power to maintain altitude. When the airspeed approaches the desired indication, adjust pitch to a setting that will maintain the new airspeed and adjust power to maintain altitude.

4.4.2. Turns. Many of the pitch, bank, and power principles discussed in maintaining straight and level flight apply while performing level turns. Performing a level turn requires an understanding of the following factors: how to enter the turn; how to maintain bank, altitude, and airspeed during the turn; and how to recover from the turn. Turns can be classified as either normal (standard rate or less) and steep, but in either case, the pitch, bank, and power principles of straight and level flight apply. Helicopters normally operate under instrument conditions between 80 and 120 knots. From **Figure 4.6**, we can see that at these speeds, 15° to 20° of bank will result in a standard rate turn, which is 3° per second. While any rate greater than standard is considered a steep turn, most helicopters practice steep turns using 30° of bank, which is the maximum angle of bank recommended under instrument conditions.

Figure 4.6. Level Turns (para 4.4.2).



4.4.2.1. Bank Control.

4.4.2.1.1. Before Turning. Before entering a turn, decide upon the angle of bank to be used. Factors to consider are true airspeed and the desired rate of turn. A slow turn rate may unnecessarily prolong the turn, whereas a high rate of turn may cause overshooting of the heading and difficulty with aircraft control. As a guide, for small turns (15° or less), the angle of bank should approximate the number of degrees to be turned. For turns of more than 15°, a standard rate turn is normally used.

4.4.2.1.2. Turning. To enter a turn, refer to the altitude indicator while applying smooth, coordinated control pressures to establish the desired angle of bank. Bank control should then be maintained throughout the turn by reference to the attitude indicator. Crosscheck the heading indicator or turn needle to determine if the rate of turn is satisfactory. Trim may be helpful during prolonged turns to assist in aircraft control.

4.4.2.1.3. Rolling Out. To roll out of a turn on a desired heading, a lead point must be used. The amount of lead required depends upon the amount of bank used for the turn, the rate the aircraft is turning, and the rate at which you roll out. As a guide, use a lead point on the heading indicator equal to approximately one-third of the angle of bank. With experience and practice, a consistent rate of rollout can be developed. A lead point can then be accurately estimated for any combination of bank angle and rate of turn. Make a note of the rate of movement of the heading indicator during the turn. Estimate the lead required by comparing this rate of movement with the angle of bank and the rate of rollout.

4.4.2.2. Altitude Control.

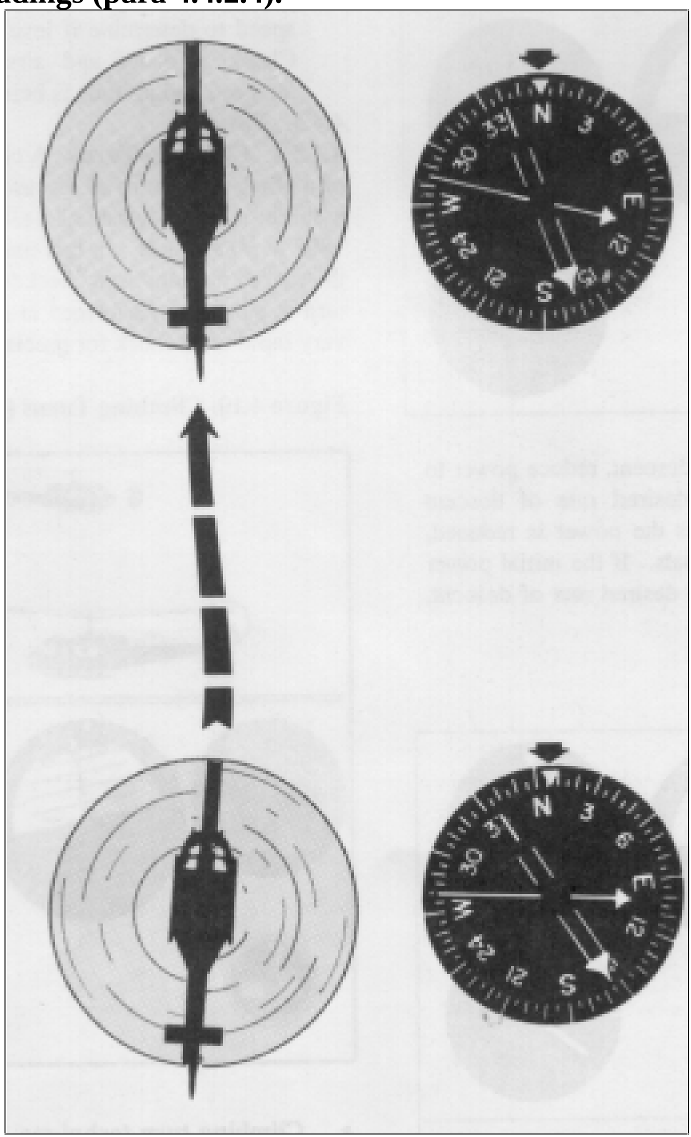
4.4.2.2.1. Techniques. The techniques for maintaining a constant altitude during a turn are similar to those used in maintaining straight and level flight. During the initial part of the roll-in, hold the same pitch and power that was used to maintain altitude with the wings level. As the bank is increased, anticipate a tendency for the aircraft to lose altitude because of the change in lift vector. Adjust the power as necessary after referring to the VVI and altimeter. After the turn is established, small power adjustments may be required to maintain the desired altitude.

4.4.2.2.2. Altitude Gaining. When rolling out of a turn, anticipate a tendency to gain altitude due to an increase in the vertical component of lift. Therefore, be aware of this factor, anticipate its effect, and monitor pitch and power during rollout in the same manner as during roll-in.

4.4.2.3. Airspeed Control. The pitch control techniques for maintaining an airspeed during a turn are similar to those used during straight and level flight. Anticipate a tendency for the aircraft to lose airspeed in a turn. Accomplish changes of airspeed during a turn as described under straight and level flight.

4.4.2.4. Turns to Headings. A turn to a heading (**Figure 4.7**) consists of a level turn to a specific heading as read from the heading indicator and is performed at normal cruise. Turns to specified headings should be made in the shortest direction. The turn is entered and maintained as described in the level turn maneuver. Since the aircraft will continue to turn as long as the bank is held, the rollout must be started before reaching the desired heading. The amount of lead used to roll out on a desired heading should be equal to one-third the angle of bank. The rollout on a heading is performed in the same manner as the rollout of the level turn. When the heading for starting the rollout is reached, cyclic control is applied in the direction opposite the turn.

Figure 4.7. Turns to Headings (para 4.4.2.4).



4.4.3. Accelerations and Decelerations. An acceleration or a deceleration is a proficiency maneuver that can be practiced during straight and level flight.

4.4.3.1. Practicing. To practice this maneuver, establish normal cruise airspeed. Coordinate power changes with all available attitude instruments.

4.4.3.2. Decelerate. To decelerate from normal cruise to slow cruise, reduce power below what is required to maintain slow cruise airspeed and adjust attitude as necessary to maintain level flight; then as the desired airspeed is approached, increase power to slow cruise setting and adjust attitude to maintain appropriate altitude.

4.4.3.3. Accelerate. To accelerate from slow cruise to normal airspeed, increase power to slightly above that required to maintain normal cruise and adjust attitude to maintain appropriate altitude; then as the desired airspeed is approached, reduce power to normal cruise power setting and adjust attitude to maintain the desired altitude.

4.4.4. Climbs and Descents.

4.4.4.1. Before Starting. Before entering a climb or descent, determine what power setting will be required. If airspeed is to be changed in the climb, estimate the amount of pitch attitude change required to establish the desired airspeed; especially if the pitch and power changes are to be made simultaneously. The power change should be smooth, uninterrupted and at a rate commensurate with the rate of pitch change. Only slight control pressures are needed to establish the pitch change.

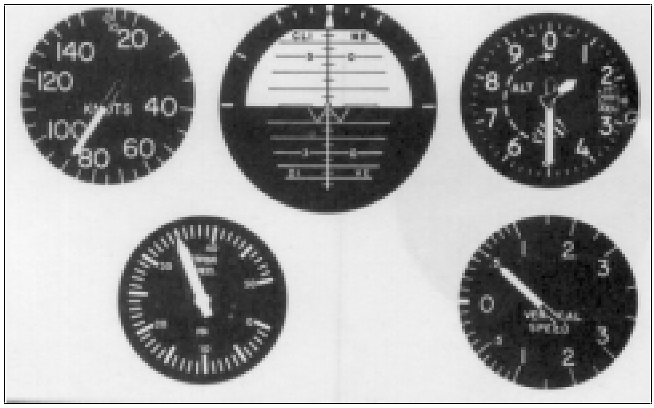
4.4.4.2. Immediate Changes. When making a pitch adjustment on the attitude indicator to correct for an airspeed deviation, the airspeed indicator will not reflect an immediate change. The results of pitch attitude changes can often be determined more quickly by cross-checking the change in vertical velocity indication. For example, while climbing, a pilot notes that the airspeed is remaining slightly high and realizes that a small pitch adjustment is required. If the pitch adjustment results in a small increase of vertical velocity, the pilot knows, even though the airspeed may not yet show a change, that the pitch correction was approximately correct. When properly used in attitude instrument flying, the vertical velocity indicator is an excellent aid in maintaining airspeed.

4.4.4.3. Desired Altitude. Upon approaching the desired altitude, select a predetermined level-off point on the altimeter. As a guide, use 10 percent of the vertical velocity. Smoothly adjust the power to an approximate setting required for level flight and simultaneously adjust the pitch attitude, if required to maintain the desired airspeed.

4.4.4.4. Rate Climbs and Descents. Rate climbs and descents are accomplished by maintaining both a desired vertical velocity and airspeed. They are proficiency maneuvers designed to practice the techniques used during instrument approaches. Pitch attitude control is used to establish and maintain the desired airspeed. Power control is used to maintain the desired vertical velocity. Proper control techniques require coordinated pitch and power changes or adjustments.

4.4.4.5. Normal Cruise Climb. To enter a climb from normal cruise, increase power to the setting that will produce a desired rate of climb (**Figure 4.8**). As power is increased, a correction for trim is made with pedals. If cruise and climb airspeeds are the same, there will be no apparent change of attitude, as read from the attitude indicator. If the amount of power applied does not produce the desired rate, make minor adjustments. During climb, the heading, attitude, and airspeed are maintained with cyclic control. Rate of climb is controlled with power and trim is maintained with pedals. Once established in a constant rate maneuver, deviations in desired VVI/airspeed must be properly interpreted. For example, VVI excursions can result because of incorrect power or inadvertent changes in pitch attitude (airspeed). Corrections are made on the control instruments with reference to the performance instruments.

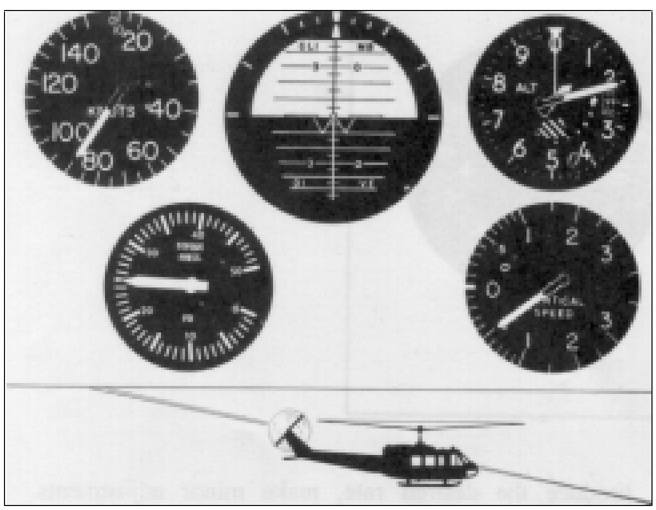
Figure 4.8. Rate Climb (para 4.4.4).



4.4.4.6. Normal cruise level off. To level off at a cruise altitude, adjust the cyclic to establish the desired attitude with reference to the attitude indicator. Adjust power to maintain normal cruise airspeed.

4.4.4.7. Entering descent. To enter a descent, reduce power to a setting that results in the desired rate of descent (**Figure 4.9**). Maintain trim as the power is reduced, and correct for torque with pedals. If the initial power reduction does not produce the desired rate of descent, make additional adjustments.

Figure 4.9. Rate Descent (para 4.4.4).



4.4.4.8. During descent. During descent, the heading, attitude, and airspeed are maintained with cyclic control. Rate of descent is controlled with power and trim is maintained with pedals. To level off from the descent, apply power prior to reaching the desired altitude. This will arrest the descent rate in sufficient time to prevent going below the desired altitude. The amount of lead depends on the weight of the aircraft and the rate of descent. A good rule of thumb is to use about 10% of your VVI as a lead point to begin adding power. For example, if you have a 500 fpm rate of descent, begin adding power about 50 feet above the desired altitude.

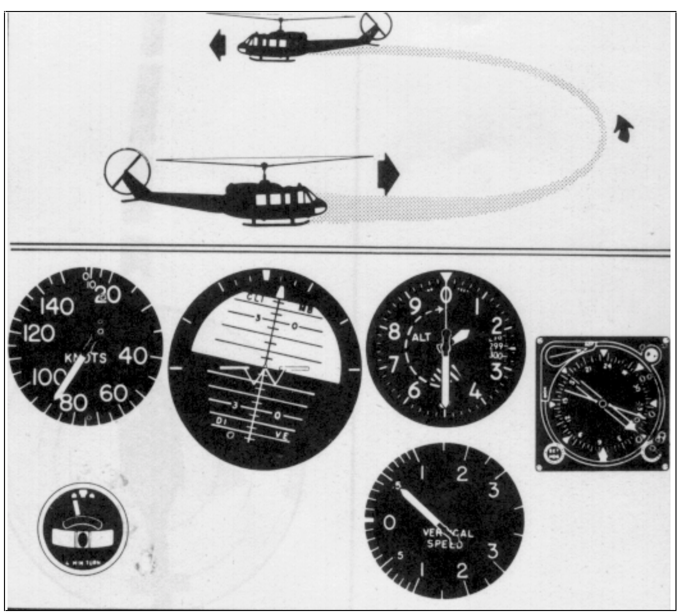
4.4.4.9. Level off lead point. When the proper altitude for starting the level off is reached, apply power to the predetermined power setting and check the vertical speed to determine if level flight has been established. Check altimeter and airspeed to ensure the proper airspeed and altitude is being maintained.

4.4.5. Turns.

4.4.5.1. Climbing Turns. A climbing turn is a combination of a climb and a turn as discussed previously. For practice, a climbing turn consists of a climb of 500 feet and a turn of 180° in 60 seconds. In this maneuver the rate of climb and the rate of turn are both checked against time. The climbing turn is generally performed at normal cruise and requires a very rapid crosscheck for precise execution.

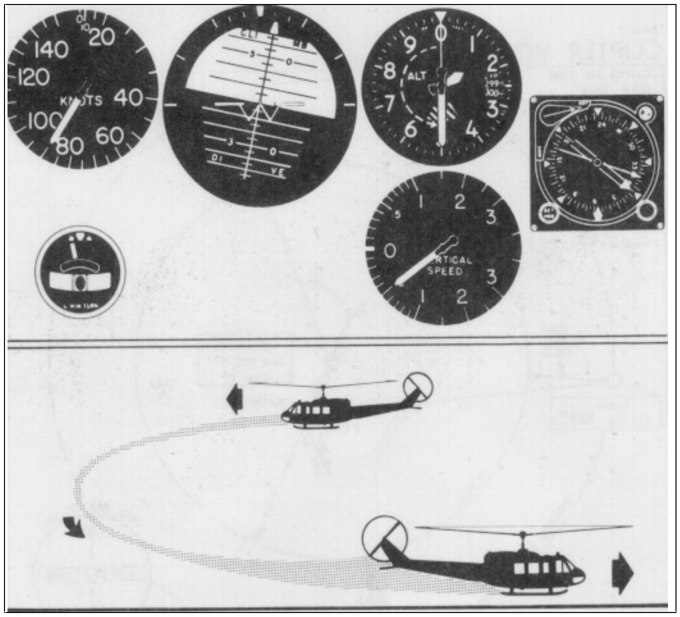
4.4.5.1.1. Climbing turn technique. The climbing turn (**Figure 4.10**) is started as the second hand of the clock passes the 3-, 6-, 9-, or 12-o'clock positions. As the power is applied to the predetermined setting, torque corrections should be made with pedals to maintain trim. The initial bank should be established with reference to the attitude indicator. To maintain the rate of turn, minor bank corrections are made with reference to the turn-and-slip indicator. During the climbing turn, the rate of turn and airspeed are maintained with cyclic control; the rate of climb, with power; and trim, with pedals. Use power to adjust the rate of climb if the deviation from desired airspeed is more than 5 knots. (Use ± 5 knots for minor pitch correction during climbs and descents.) After 30 seconds, the aircraft will have turned approximately 90° and climbed approximately 250 feet. If the instruments indicate other than the desired readings, adjust the rate of climb and/or turn to achieve the desired performance. Make another check after 45 seconds have elapsed and adjust the aircraft's performance again, if necessary. Normally, the recovery should be started as the second hand reaches the original starting position (60 seconds). However, regardless of the time factor, a recovery should be made when the desired heading and altitude have been reached.

Figure 4.10. Climbing Turns (para 4.4.5.1).



4.4.5.2. Descending Turns. A descending turn (**Figure 4.11**) is a combination of a descent and a turn as discussed previously. For practice, a descending turn consists of a descent of 500 feet and a turn of 180° in 60 seconds. In this maneuver, the rate of descent and the rate of turn are both checked against time. The descending turn is generally performed at normal cruise airspeed and requires a very rapid crosscheck for precise execution.

Figure 4.11. Descending Turns (para 4.4.5.2).



4.4.5.2.1. Descending turn technique. The descending turn is started as the second hand of the clock passes the 3-, 6-, 9- or 12-o'clock position. As the power is reduced to the predetermined setting, torque correction should be made with the pedals to maintain trim. The initial bank should be established with reference to the attitude indicator. To maintain the rate of turn, minor bank corrections are made with reference to the turn-and-slip indicator. During the descending turn, the rate of turn and airspeed are maintained with cyclic control; rate of descent, with power; and trim, with pedals. Power is used to adjust the rate of descent only if the desired airspeed is exceeded by ± 5 knots. (The ± 5 knots is used for minor pitch correction during climbs and descents.) After 30 seconds, the aircraft will have turned approximately 90° and descended approximately 250 feet. If the instruments indicate other than the desired readings, the rate of descent and (or) turn should be adjusted as necessary. A further check can be made at the expiration of 45 seconds. Adjustments in the rate of descent and (or) turn should again be made if necessary. Normally, the recovery should be started as the second hand reaches the original starting position (60 seconds). However, regardless of the time factor, a recovery should be made when the desired heading and altitude have been reached.

4.4.6. Steep Turns. A turn is considered to be a steep turn if the angle of bank used is larger than that required for normal instrument flying. Most helicopters use a 30° bank for practicing steep turns.

4.4.6.1. Entry. Entry into a steep turn is accomplished in the same way as for a normal turn. As the bank is increased past normal, the change in lift vector occurs which requires an increase in power. The use of trim in steep turns varies with individual helicopter characteristics and pilot techniques. However, proper coordination will aid aircraft control and reduce pilot workload. Adjust pitch to maintain airspeed as the bank is increased.

4.4.6.2. During the steep turn. Pitch and power control are maintained in the same way as in a normal turn; however, larger power adjustments may be required for a given altitude deviation. Inadvertently varying the angle of bank during the turn makes altitude control more difficult. Give sufficient attention to the bank pointer to maintain a constant bank angle. Precession error in the attitude indicator is more prevalent during steep turns. If altitude loss becomes excessive, reduce the angle of bank as necessary to regain positive altitude control.

4.4.6.3. Rolling out of a steep turn. Be alert to correct for the more than normal trim, pitch, and power used during the turns. Attempt to roll out at the same rate used during normal turns. Proper pitch and bank attitude control require you to recognize the effects of gyroscopic precession on attitude indicators. Precession is most noticeable following a turn or change of airspeed and varies between attitude indicators. As a result, small airspeed, altitude, and heading deviations may occur when a wings level attitude is established on the attitude indicator following maneuvers. Therefore, you may have to temporarily establish an adjusted pitch or bank attitude on the attitude indicator to maintain straight and level flight with reference to the performance instruments. The attitude indicator will gradually resume its normal indications as the erection mechanism automatically corrects these errors.

4.5. Emergency Descent. Basic instrument techniques may be used to safely perform an emergency descent in instrument meteorological conditions (IMC). Because there is no set procedure for executing an emergency descent, you must consider all variables when executing an emergency descent. If your helicopter is equipped with a radar altimeter, it is a good technique to set the low altitude warning marker at or slightly above the required flare altitude. This will give you a reminder to start a flare if the flare altitude is reached prior to breaking out of IMC.

4.5.1. Power-On Descent. If a long distance must be covered, then a constant airspeed descent could be selected using higher than normal airspeeds. If a short distance is to be covered, then a constant rate descent could be selected using high rates of descent and slower than normal airspeeds.

4.5.2. Power-Off Descent (Autorotation). If an emergency exists that requires the execution of an autorotation, enter smoothly by lowering the collective and closely cross-checking the control and performance instruments. Pay particular attention to keeping the helicopter in coordinated flight. Using the techniques described for constant airspeed descents will aid in flying the autorotation. Turns during autorotation are accomplished by using the same techniques as outlined in descending turns. If required, determine the angle of bank required by considering the time and altitude available to accomplish the turn. The rotor rpm will tend to increase during turning autorotations and must be incorporated into the crosscheck. Knowing (and briefing) the approximate ceiling will aid in determining when to begin a systematic scan for outside references. Crew coordination will be critical and should be briefed prior to flight by the aircraft commander.

4.6. Instrument Approaches. The ability of the helicopter to maneuver in a smaller amount of airspace has led to some differences between fixed-wing and helicopter instrument procedure obstacle clearance criteria. AFJMAN 11-226 (Terminal Instrument Procedures or TERPs) outlines these differences as they apply to the rotary-wing environment.

4.6.1. Helicopter Only Approaches. Helicopter only approaches are identified by the term "COPTER", the type of facility producing final approach course guidance, and a numerical identification of the final approach course; for example, COPTER VOR 336 (**Figure 4.12**), COPTER TACAN 001 (**Figure 4.13**). The criteria for copter only approaches is based on the unique maneuvering capability of the helicopter at airspeeds not exceeding 90 knots. On the basis of this airspeed, these special helicopter only approaches may be used with the helicopter being considered an approach Category A aircraft. Currently, the nomenclature for these approaches in the minima block may be an H-(Army and Air Force, **Figure 4.13**), an S- or S-L.A, (Navy). These approaches should all be considered "straight-in" and, therefore, a visibility only approach may be accomplished. Once the instrument approach has been accomplished, you should plan to touch down on the threshold of the procedure runway or helipad. (**Figure 4.12 inset**).

Figure 4.12. Copter Only Approach (para 4.6.1).

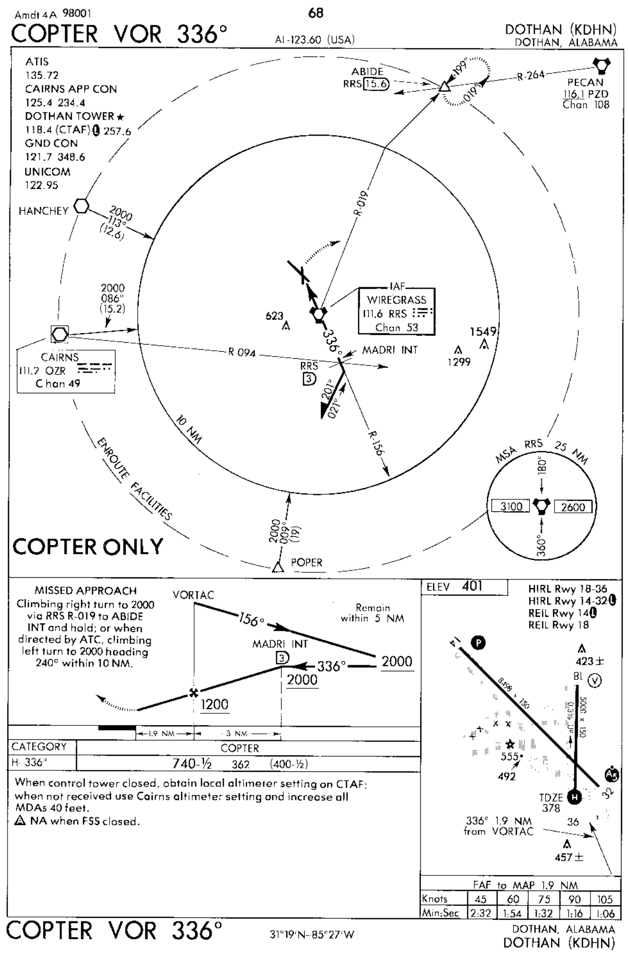
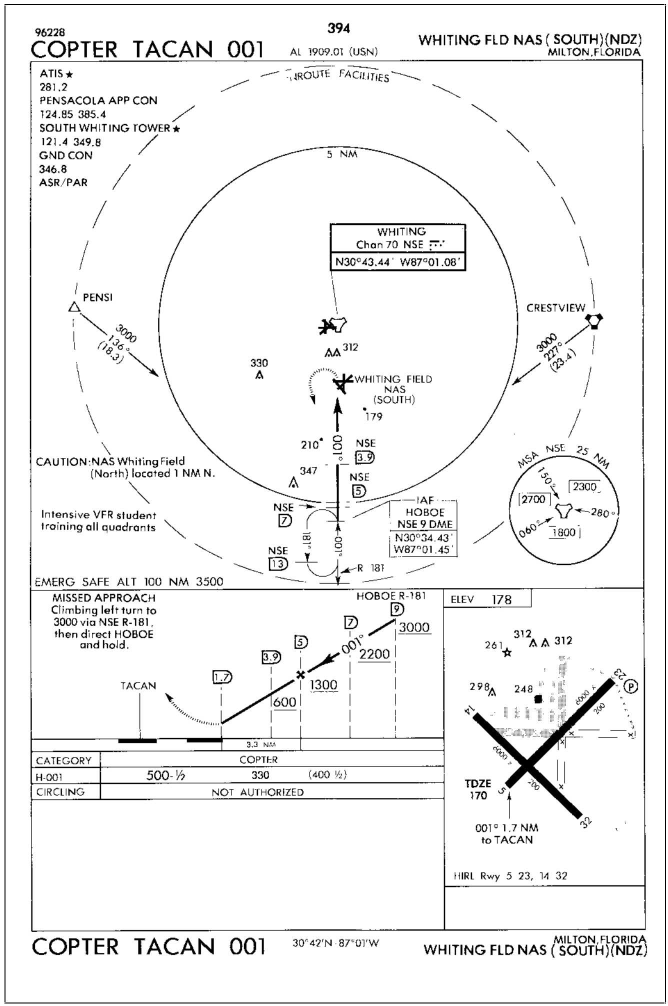


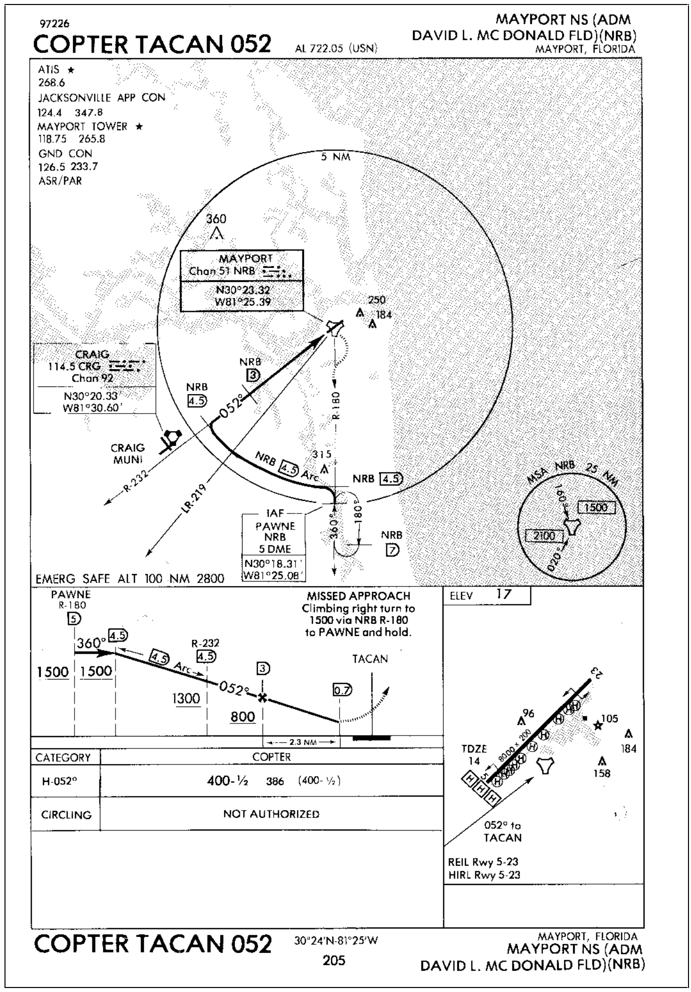
Figure 4.13. Copter TACAN (para 4.6.1).



4.6.1.1. Low altitude approach. In a low altitude approach, a maximum 500 feet per nautical mile descent is normally planned. In copter only approaches, however, the gradient may be as high as 800 feet per nautical mile.

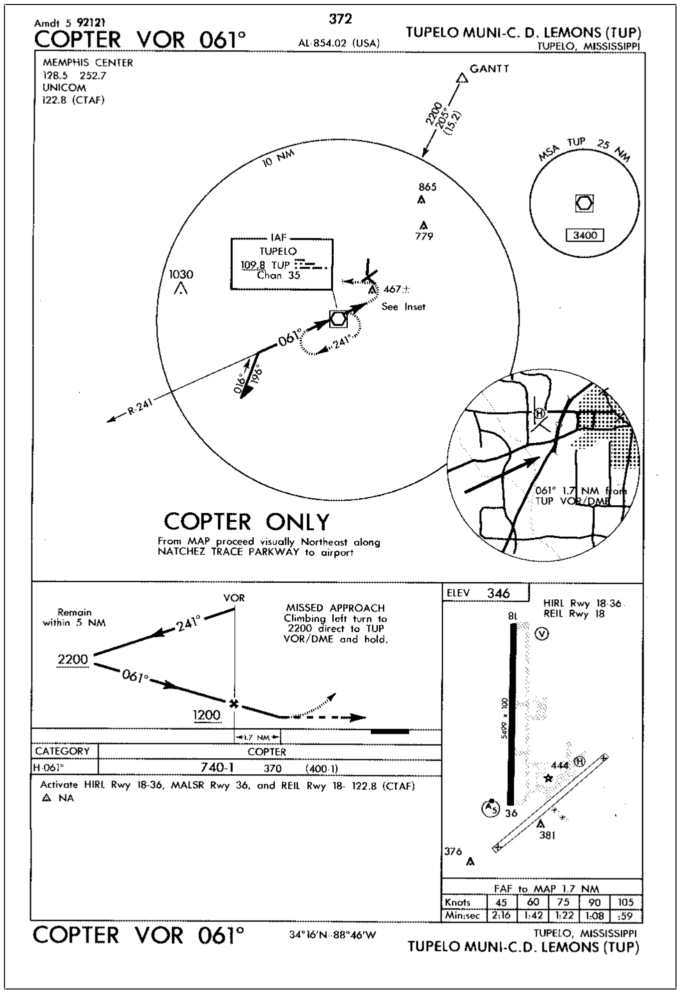
4.6.1.2. Short procedures. Looking at **Figure 4.14**, we can see an example of a very short procedure. The initial approach fix is only .5 miles from the DME arc procedural track. From the final approach fix (FAF) to the missed approach point (MAP) is 2.3 miles. While this approach should not be difficult to accomplish, careful review could prevent you from becoming rushed during the maneuver.

Figure 4.14. Short Final Approach (para 4.6.1.2).



4.6.1.3. Point in space. While the point in space approach (**Figure 4.15**) is rare, it does illustrate how approach design takes advantage of helicopter capability. This approach (see AFJMAN 11-226) places the helicopter up to 2,600 feet from the landing pad, and the pilot is expected to proceed visually, by ground reference, to the pad. If planning to use this type of approach, pay careful attention to weather conditions upon arrival, as VMC conditions are required to maneuver.

Figure 4.15. Point in Space Approach (para 4.6.1.3).



4.6.1.4. Review missed approach. Review the published missed approach departure instruction to ensure you can achieve the published climb gradient. For copter only procedures, the missed approach is based on a climb gradient of at least 304 feet per mile, twice the angle used for fixed-wing instrument approach procedures (IAP). If a 90 knot missed approach is performed, then this climb gradient equates to a 456 foot per minute minimum rate of climb, no wind.

4.7. Altimeter Setting Procedures. The altitude indicated on the altimeter may be in error if the altimeter check is conducted with the rotors turning. This error is due to the difference in pressure caused by the rotor downwash. The difference in pressure causes the altimeter to indicate lower than actual. Use one of the following procedures to obtain a valid altimeter check prior to takeoff. The specific procedure to use depends upon the situation and the sequence of items in the checklist for each helicopter model. The overpressure condition resulting from the rotor downwash varies with different helicopters (model or design). If this condition is significant, the aircraft flight manual should contain this information.

4.7.1. Procedure Number 1. Use this procedure if the check is completed prior to rotor engagement at a known elevation and with a current altimeter setting.

- **Set altimeter.** ***Set the reported altimeter setting on the barometric scale***.
- **Compare.** ***Compare the indicated altitude to the elevation of a known checkpoint.*** The maximum allowable error is 75 feet. If the altimeter error exceeds 75 feet, the instrument is out of tolerance for instrument flight.

4.7.2. Procedure Number 2. Use this procedure if at a known elevation but a current altimeter setting is not obtained prior to rotor engagement.

- **Prior to rotor engagement.** ***Set the altimeter to the known elevation and note the barometric setting***.
- **After rotor engagement.** ***Obtain and set the current altimeter setting on the barometric scale.***
- **Compare.** ***Compare the current field barometric pressure set in the altimeter with the altimeter setting noted prior to rotor engagement.*** If the difference exceeds 0.075, the instrument is out of tolerance for instrument flight.

4.7.3. Procedure Number 3. Use this procedure if the rotor is engaged at an unknown elevation.

- **Check point.** ***Taxi to a check point of known elevation and set the current altimeter setting on the barometric scale.***
- **Compare.** ***Compare the indicated altitude to the elevation of a known checkpoint.*** The maximum allowable error is 75 feet. If the altimeter exceeds 75 feet, the instrument is out of tolerance for instrument flight.

NOTE: Due to difference in pressure caused by rotor downwash, the altimeter will show a decrease after the rotor is engaged. Consider this temporary altimeter error when determining tolerance limits. Do not reset the altimeter for this decrease.

4.8. Unusual Attitudes.

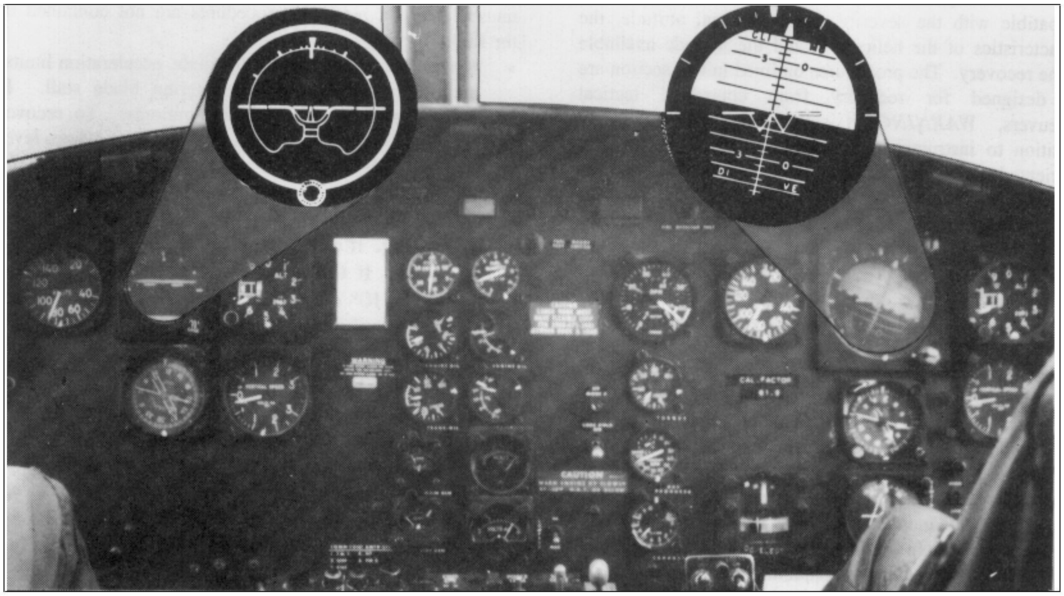
4.8.1. Inadvertent attitude. An unusual attitude is an aircraft attitude occurring inadvertently. It may result from one factor or a combination of several factors such as turbulence, distraction from cockpit duties, instrument failure, inattention, spatial disorientation, and transition from VMC to IMC. In most instances, these attitudes are mild enough to recover from by reestablishing the proper attitude for the desired flight condition and resuming a normal crosscheck.

4.8.2. Techniques. Techniques of recovery should be compatible with the severity of the unusual attitude, the characteristics of the helicopter, and the altitude available for the recovery. The procedures outlined in this section are not designed for recovery from controlled tactical maneuvers.

WARNING: ***It is imperative to immediately transition to instrument references any time you become disoriented or when outside visual references become unreliable.***

4.8.3. Recognizing an Unusual Attitude. Normally, an unusual attitude is recognized in one of two ways: an unusual attitude "picture" on the attitude indicator or unusual performance on the performance instruments. Regardless of how the attitude is recognized, verify that an unusual attitude exists by comparing control and performance instrument indications prior to initiating recovery on the attitude indicator (**Figure 4.16**). This precludes entering an unusual attitude as a result of making control movements to correct for erroneous instrument indications. During this process, the attitude must be correctly interpreted. Additional attitude indicating sources (stand by attitude indicator, copilot's attitude indicator, etc.) should be used. In some aircraft the bank steering bar (manual mode) may aid in maintaining level flight (refer to flight manual). If there is any doubt as to proper attitude indicator operation, then recover using attitude indicator inoperative procedures. The following techniques will aid aircraft attitude interpretation on the attitude indicator.

Figure 4.16. Recognizing an Unusual Attitude (para 4.8.3).



4.8.3.1. Bank scale at the top. For attitude indicators with a single bank pointer and bank scale at the top, the bank pointer can be considered a sky pointer. It always points up and should be in the upper half of the case. Rolling towards the bank pointer to place it in the upper half of the case will correct an inverted attitude.

4.8.3.2. Bank scale at the bottom. For those attitude indicators with the bank scale at the bottom, rolling in the direction that will place the pitch reference scale right-side-up will correct an inverted attitude.

NOTE: Ease of pitch interpretation varies with the type of attitude indicator installed. Attitude indicators having pitch reference scales in degrees and gray or black attitude spheres can easily be interpreted for climb or dive indications. For those aircraft not so equipped, the airspeed indicator, altimeter, or vertical velocity indicator generally present the most easily interpreted indication of a climb or a dive. Attitude interpretation is a skill that must be highly developed by flight practice, ground simulators and experience.

4.8.4. Recovery Procedures -- Attitude Indicators Operative. Recoveries from helicopter unusual attitudes are unique due to rotary-wing aerodynamics as well as application of the control and performance concept to helicopter flight. Application of improper recovery techniques can result in blade stall, power settling, or an uncontrollable yaw if recovery is delayed. Due to these differences, unusual attitude recoveries for helicopters are decidedly different from fixed-wing recoveries and require immediate action. Use the following guidance if specific unusual attitude recovery procedures are not contained in the flight manual:

4.8.4.1. Diving. If diving, consider altitude, acceleration limits, and the possibility of encountering blade stall. If altitude permits, avoid rolling pullouts. To recover from a diving unusual attitude, roll to a wings level indication then establish a level flight attitude on the attitude indicator. Adjust power as necessary and resume a normal crosscheck.

4.8.4.2. Climbing. If climbing, consider pitch attitude and airspeed. If the inadvertent pitch attitude is not extreme (10° or less from level flight), smoothly lower the miniature aircraft back to a level flight indication, level the wings, and resume a normal crosscheck using power as required. For extreme pitch attitudes (above 10°), bank the aircraft in the shorter direction toward the nearest 30° bank index. The amount of bank used should be commensurate with the pitch attitude and external conditions, but do not exceed 30° of bank in making the recovery. Allow the miniature aircraft to fall toward the horizon. When the aircraft symbol is on the horizon, level the wings and adjust the aircraft attitude to a level flight indication. Use power as necessary throughout the recovery.

NOTE: In helicopters encountering an unusual attitude as a result of blade stall, collective must be reduced before applying attitude corrections if the aircraft is in a climbing unusual attitude. This will aid in eliminating the possibility of aggravating the blade stall condition. To aid in avoiding blade stall in a diving unusual attitude recovery, reduce power and bank attitude before initiating a pitch change. In all cases avoid abnormal positive or negative G loading which could lead to additional unusual attitudes or aircraft structural damage.

4.8.5. Recovery Procedures -- Attitude Indicators Inoperative. With an inoperative attitude indicator, successful recovery from unusual attitudes depends greatly on pilot proficiency and early recognition of attitude indicator failure. For example, attitude indicator failure should be immediately suspected if control pressures are applied for a turn without corresponding attitude indicator changes. Another example would be satisfactory performance instrument indications that contradict the "picture" on the attitude indicator. Should an unusual attitude be encountered with an inoperative attitude indicator, the following procedures are recommended:

4.8.5.1. Climb or dive. Determine whether the aircraft is in a climb or a dive by referring to the airspeed, altimeter, and vertical velocity indicators.

4.8.5.2. Diving. If diving, roll to center the turn needle and recover from the dive. Adjust power as appropriate. (Disregarding vertical attitudes, rolling "away" from the turn needle and centering it will result in an upright attitude.)

4.8.5.3. Climbing. If climbing, use power as required. If the airspeed is low or decreasing rapidly, pitch control may be aided by maintaining a standard rate turn on the turn needle until reaching level flight. If the turn needle in a flight director system is used, center the turn needle. This is because it is very difficult to determine between a standard rate turn and full needle deflection.

4.8.5.4. Level off. Upon reaching level flight, center the turn needle. The aircraft is level when the altimeter stops. The vertical velocity indicator lag error may cause it not to indicate level until the aircraft passes level flight.

Chapter 5

NAVIGATION INSTRUMENTS

5.1. Application. The navigation instruments explained in this chapter are common to the majority of USAF aircraft. These instruments are the radio magnetic indicator (RMI), course indicator (CI), range indicator, bearing-distance-heading indicator (BDHI), and flight director (**Figure 5.1**).

5.2. Basic Systems.

5.2.1. Radio Magnetic Indicator (RMI) (Figure 5.1).

5.2.1.1. RMI displays. The RMI displays aircraft heading with navigational bearing data. It normally consists of a rotating compass card and two bearing pointers. The compass card is actuated by the aircraft compass system. The aircraft magnetic heading is displayed on the compass card beneath the top index. The bearing pointers display automatic direction finding (ADF), VHF Omnidirectional Range (VOR), or TACAN magnetic bearing to the selected navigation station. Placards on the instrument or near a selector switch are normally used to identify the bearing pointer display. VOR or TACAN radials are displayed under the tail of their respective bearing pointers. Bearing pointers do not function in relation to instrument landing system (ILS) signals.

5.2.1.2. Compass system malfunction. If there is a malfunction in the compass system or compass card, the ADF bearing pointer continues to point to the station, and displays relative bearing only. With a malfunction in the compass system or compass card, the VOR or TACAN bearing may still indicate magnetic bearing. Until verified by radar or other navigational equipment, consider this bearing information unreliable.

NOTE: VOR and TACAN bearing pointers do not "point" to an area of maximum signal strength as does ADF. VOR and TACAN navigation receivers electronically measure the magnetic course that is displayed by the pointers.

5.2.2. Course Indicator (CI) (Figure 5.2). The course indicator operates independently of the RMI. It displays aircraft heading and position relative to a selected VOR/TACAN course, and lateral and vertical position relative to an ILS localizer and glide slope.

5.2.2.1. VOR or TACAN Display.

5.2.2.1.1. Course indicator. When the course indicator is used to display VOR or TACAN information, aircraft heading and position are indicated relative to a selected course. The desired course is set in the course selector window with the course set knob.

5.2.2.1.2. The heading pointer. The heading pointer connected to the course set knob and the compass system, displays aircraft heading relative to the selected course. When the aircraft heading is the same as the course selected, the heading pointer indicates 0° heading deviation at the top of the course indicator. The heading deviation scales, at the top and bottom of the course indicator, are scaled in 5° increments up to 45°. The TO-FROM indicator indicates whether the course selected, if properly intercepted and flown, will take the aircraft to or from the station (**Figure 5.3**). When the aircraft passes a line from the station perpendicular to the selected course, the TO-FROM indicator changes. Aircraft heading has no effect on the TO-FROM indications.

Figure 5.1. Navigation Instruments (para 5.1).

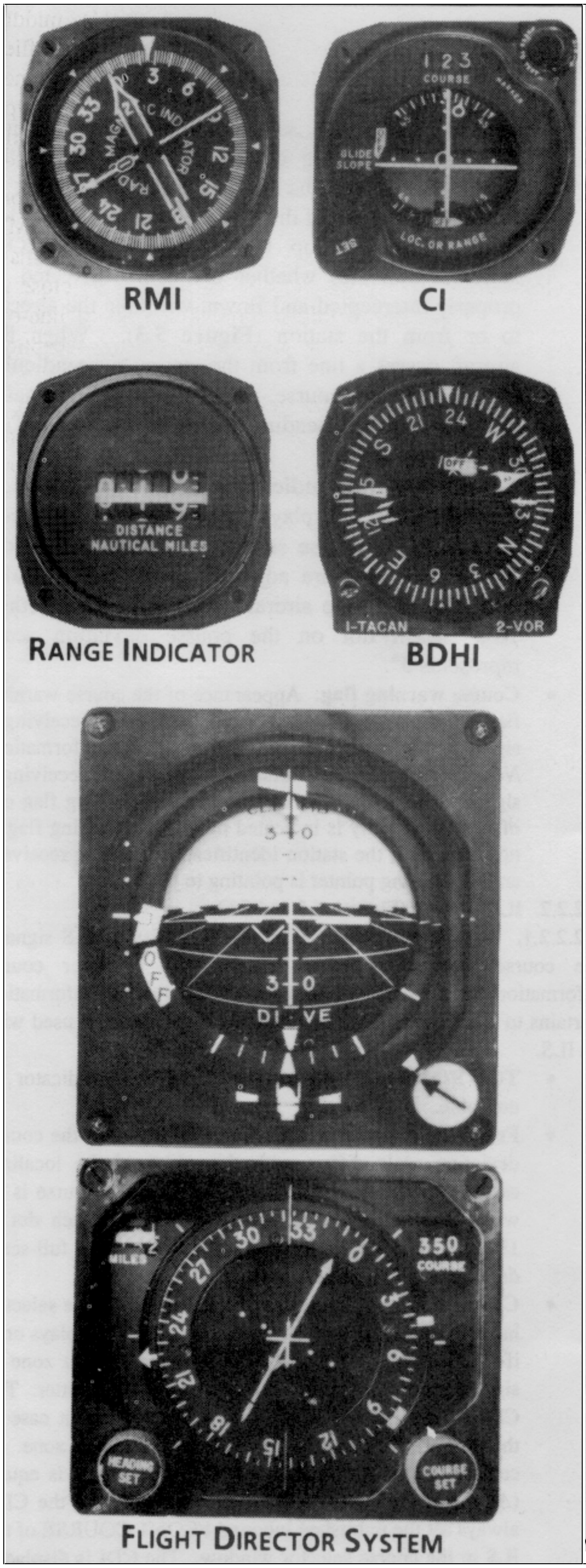


Figure 5.2. Radio Magnetic Indicator (RMI) and Course Indicator (CI) (para 5.2.2).

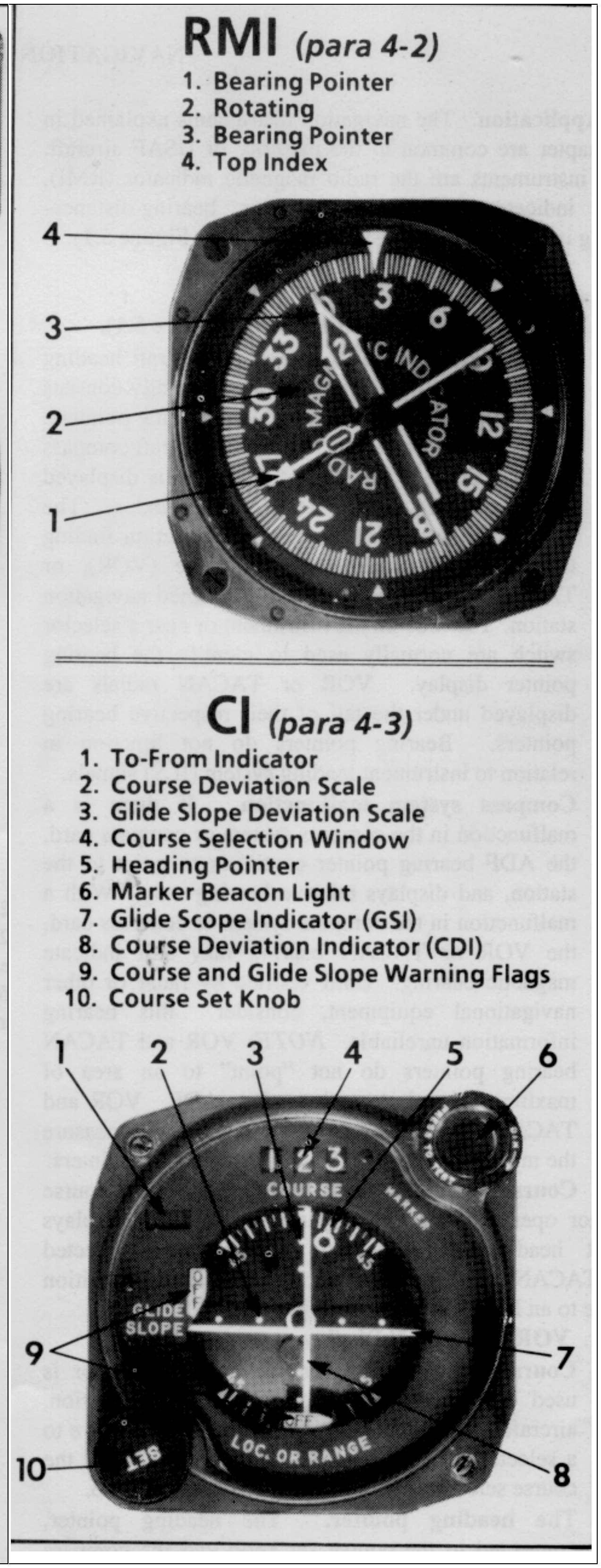
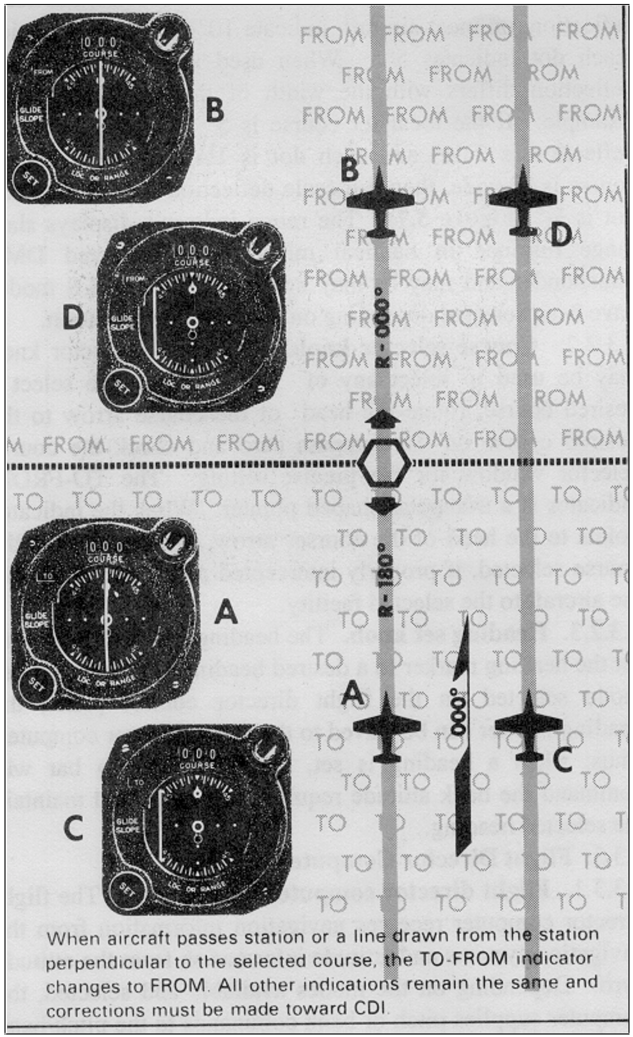
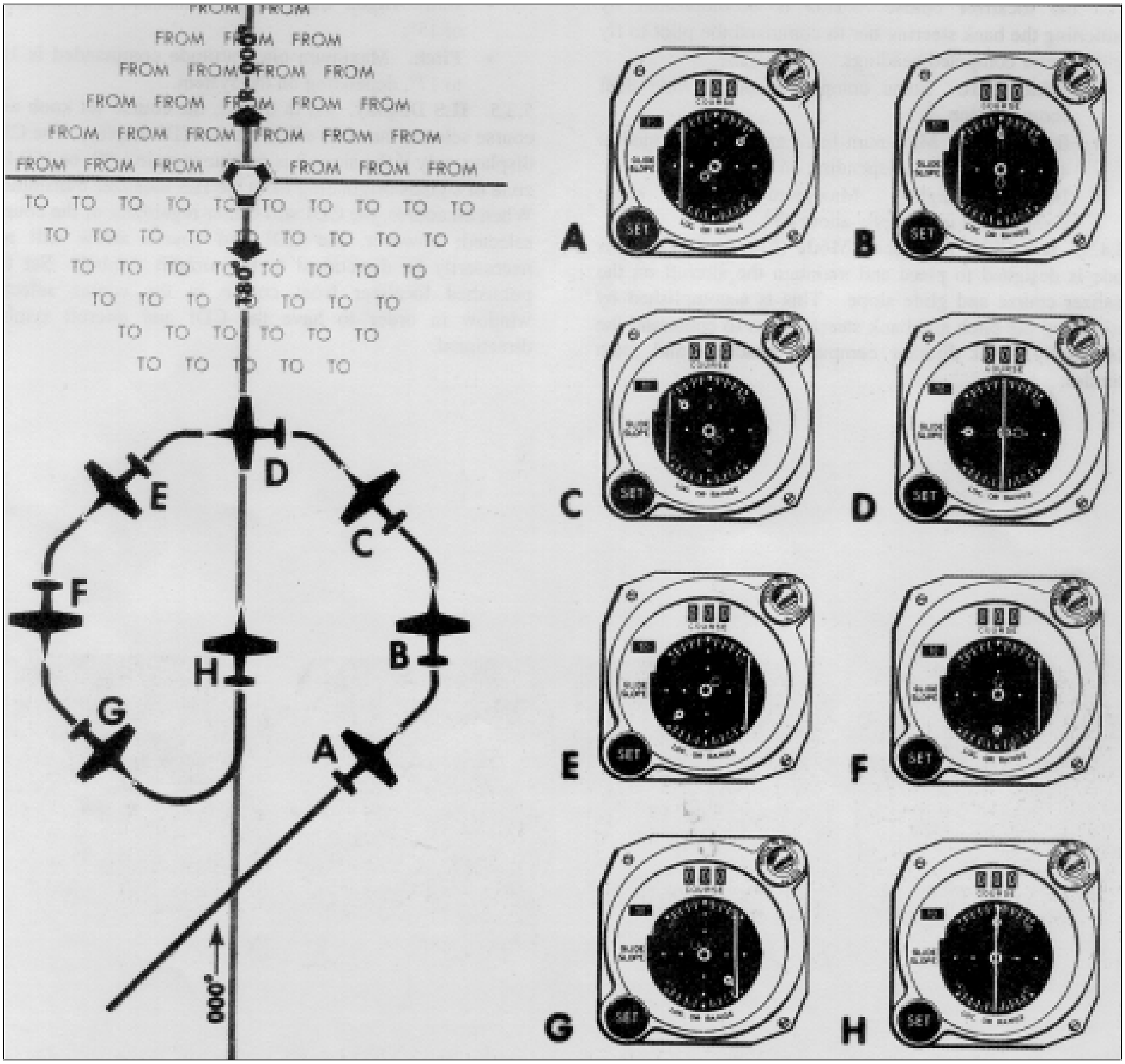


Figure 5.3. Principle of TO-FROM Indicator (para 5.2.2.1).



5.2.2.1.3. Course deviation indicator. The course deviation indicator (CDI) displays aircraft course deviation relative to the course selected (**Figure 5.4**). Most course indicators are adjusted so the CDI is fully displaced when the aircraft is off course more than 10°. Each dot on the course deviation scale represents 5°.

Figure 5.4. Course Indicator Displays in Relation to the Selected Course (para 5.2.2.1).



5.2.2.1.4. Course warning flag. Appearance of the course warning flag indicates that the course indicator is not receiving a signal strong enough for reliable navigation information.

NOTE: Although the course indicator may be receiving a signal strong enough to keep the course warning flag out of view, reliability is indicated only if the warning flag is not displayed, the station identification is being received, and the bearing pointer is pointing to the station.

Figure 5.5. ILS Course Indicator Presentations for a 5°-Wide Localizer and a 1°-Wide Glide Slope (Front Course)(para 5.2.2.2).

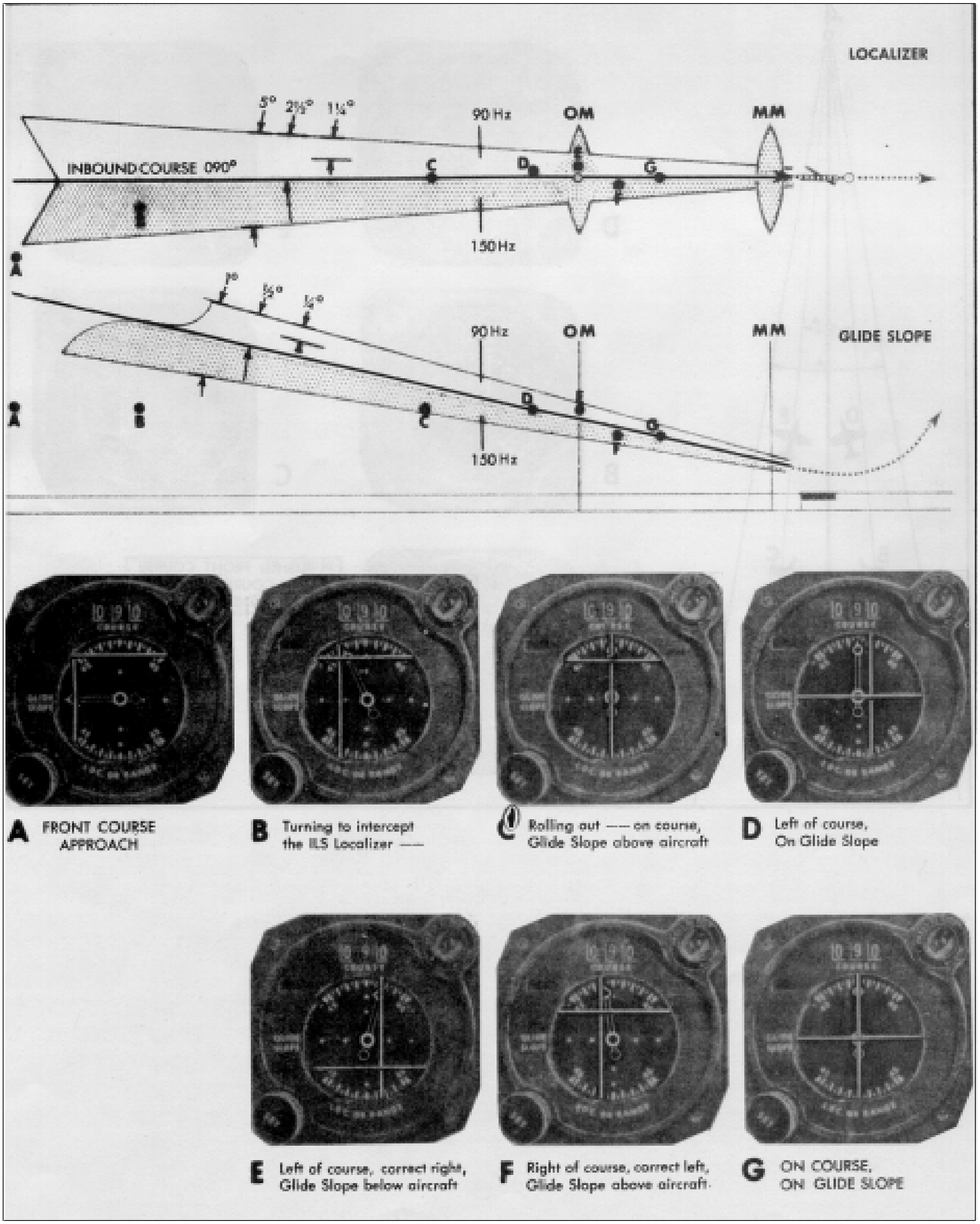
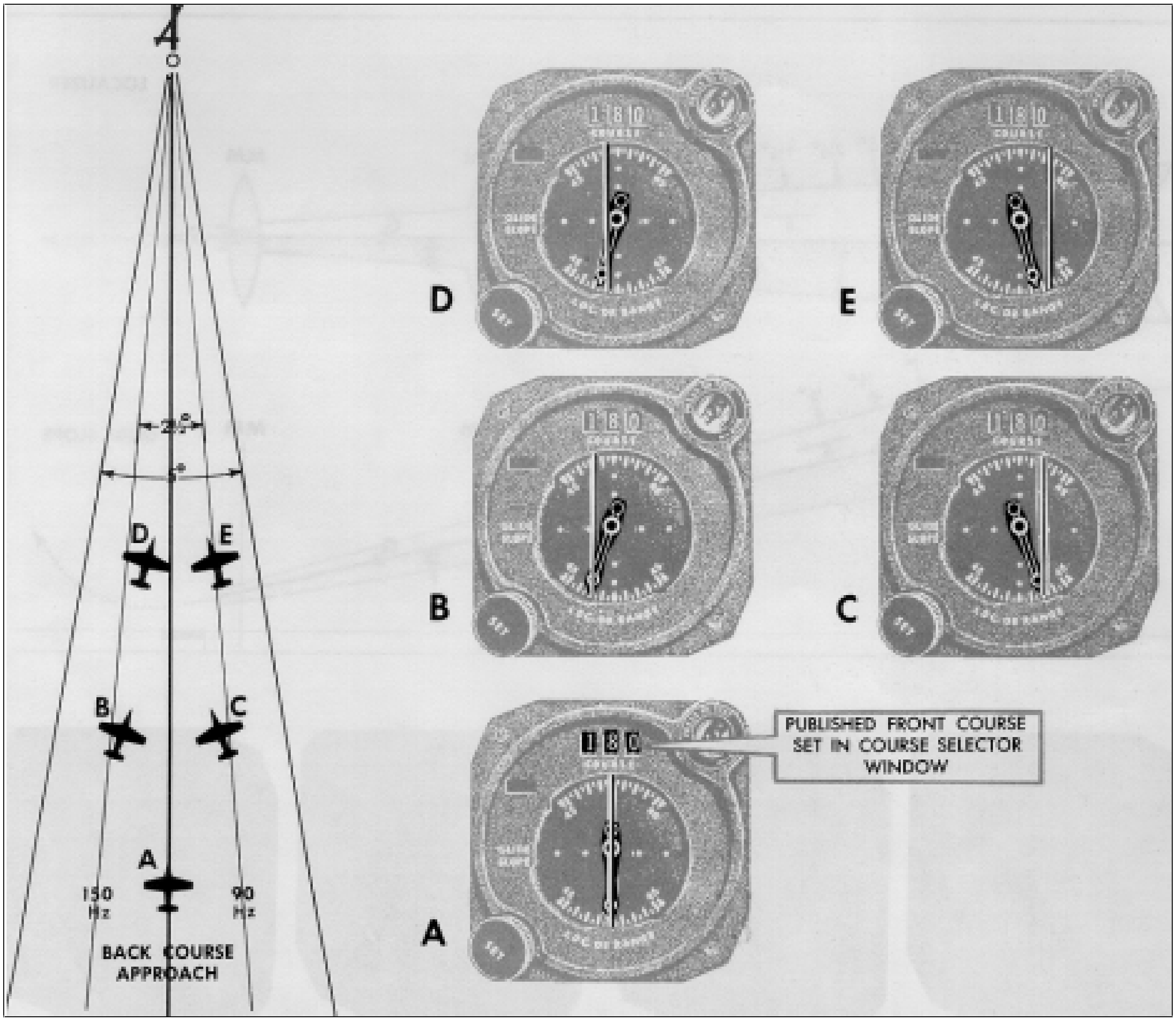


Figure 5.6. Localizer Course Indicator Presentations for a 5°-Wide Localizer (Back Course) (para 5.2.2.2).



5.2.2.2. ILS Display (Figures 5.5 and 5.6).

5.2.2.2.1. Localizer Course. When used to display ILS signals, the course indicator provides precise ILS localizer course information for a specified approach. The following information pertains to course indicator functions and displays when used with an ILS:

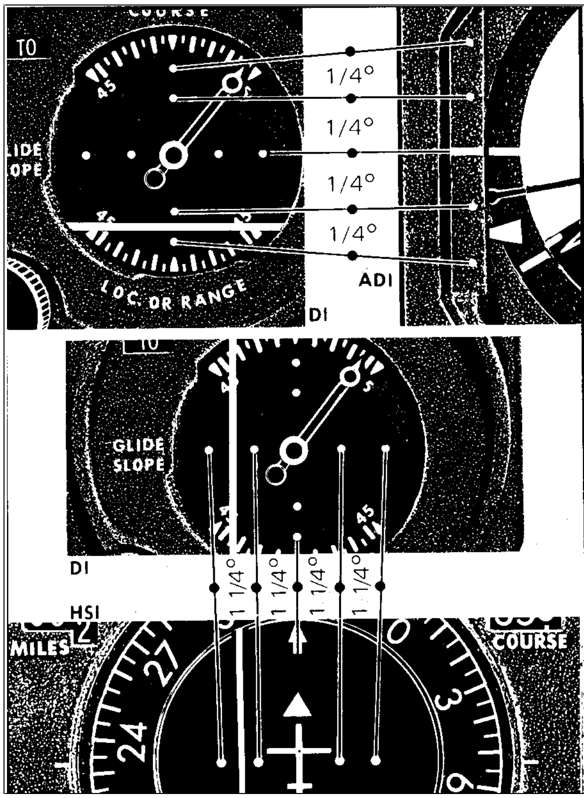
5.2.2.2.1.1. TO-FROM indicator. The TO-FROM indicator is unusable.

5.2.2.2.1.2. Full-scale deflection. Full-scale deflection on the course deviation scale differs with the width of the localizer course (up to 6°). Example: If the localizer course is 5° wide, then full-scale deflection is 2½° and each dot is 1¼°; if the localizer course is 3° wide, then full-scale deflection is 1½° and each dot is ¾°.

5.2.2.2.1.3. Course selected. The course set knob and course selected have no effect on the CDI display. The CDI displays only if the aircraft is on course or in a 90- or 150-Hz zone of signals originating from the ILS localizer transmitter. The CDI always deflects to the left of the instrument case in the 150-Hz zone and to the right in the 90-Hz zone. It centers when the signal strength of both zones is equal. (Although the course selected has no effect on the CDI, always set the published inbound FRONT COURSE of the ILS in the course selector window. This will ensure the heading pointer is directional in relation to the CDI displacement.

5.2.2.2.2. Glide slope indicator. The glide slope indicator (GSI) displays glide slope position in relation to the aircraft. If the GSI is above or below center, the glide slope is above or below the aircraft respectively. Full-scale deflection of the GSI is dependent upon the width of the glide slope (1.4°). Example: The glide slope width is 1.4°, full-scale deflection would be .7°, and each dot would be .35° (**Figure 5.7**).

Figure 5.7. Example of Course and Glide Slope Deviation Indications vs. Actual Displacement Relative to Distance From Touchdown for a 5°- Wide Localizer and a 1° - Wide Glide Slope (para 5.2.2.2.2 and para 5.3.2.1).



The GSI is more sensitive than the CDI, HSI, or the ADI.

1. Actual deviation figures may vary due to atmospheric conditions and transmitter-receiver errors.
2. Deviation figures do not take into consideration the distance an aircraft's main gear may be BELOW the location of its glide slope antenna.
3. Figures are based on localizer width of 5°, runway length of 8,000' localizer transmitter 1,000' beyond the departure end of the runway, touchdown point 1,000' from threshold, and a 1°-wide glide slope.
4. Dot values shown in this illustration are valid for most aircraft. Consult your aircraft flight manual to ensure correct display interpretation.

VERTICAL DEVIATION FROM GLIDE SLOPE

MILES FROM TOUCHDOWN	5	4	3	2	1
ONE DOT (¼°) DEVIATION	130'	104'	78'	52'	26'
TWO DOT (½°) DEVIATION	260'	208'	156'	104'	52'

LATERAL DEVIATION FROM LOCALIZER COURSE

MILES FROM TOUCHDOWN	5	4	3	2	1
ONE DOT (1¼°) DEVIATION	838'	706'	573'	441'	308'
TWO DOT (2½°) DEVIATION	1677'	1412'	1147'	882'	617'

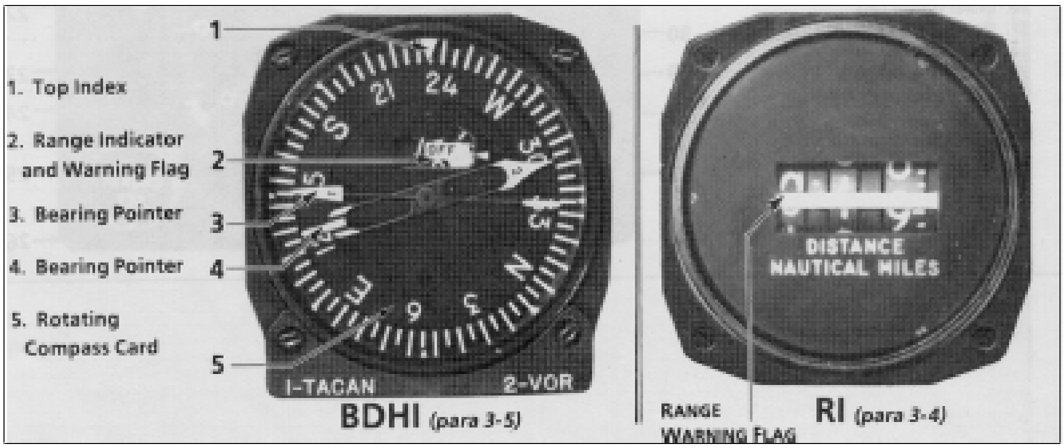
5.2.2.2.3. Warning flags. Appearance of the course or glide slope warning flags indicate that the course or glide slope signal strength is not sufficient. Absence of the identifier indicates the signal is unreliable.

WARNING: It is possible under certain conditions for the CDI or GSI to stick in any position with no warning flags while a reliable station identification is being received. Pilots should use extreme caution and maintain good situational awareness while flying an ILS or localizer approach in actual weather conditions.

5.2.2.2.4. Marker beacon. The marker beacon light and aural tone indicate proximity to a 75-MHz marker beacon transmitter; for example, ILS outer marker (OM), middle marker (MM), inner marker (IM), etc. As the aircraft flies through the marker beacon signal pattern, the light flashes and the aural tone sounds in Morse code indicating the type of beacon. The marker beacon light functions independently of ILS/VOR/TACAN signals.

5.2.3. Range Indicator. Range indicators display slant range distance in nautical miles to a DME transponder. For practical purposes, you may consider this a horizontal distance except when the aircraft is very close to the station. DME range information is subject to line-of-sight restrictions and altitude directly affects the reception range.

Figure 5.8. Bearing Distance Heading Indicator (BDHI) (para 5.2.4).



5.2.4. Bearing-Distance-Heading Indicator (BDHI) (Figure 5.8).

5.2.4.1. BDHI Display. The BDHI displays aircraft heading with navigational bearing data and range information. Except for the range indicator, the BDHI is similar in appearance and function to the RMI previously described.

5.2.4.2. BDHI Components. The BDHI consists of a rotating compass card, two bearing pointers, a range indicator, and a range warning flag. Some BDHIs also have a heading marker, a heading set knob, and a power warning flag.

5.2.4.3. Compass Card Actuation. The compass card is actuated by the aircraft compass system, which normally includes pilot-operated controls that permit the BDHI compass card to operate in a slaved or non-slaved direct gyro (DG) mode. In the slaved mode, the aircraft magnetic heading is displayed beneath the top index or lubber line. In the nonslaved DG mode, the compass card serves as a heading reference after being corrected to a known heading. The card is manually corrected for the DG mode by a switch on the compass control panel.

5.2.4.4. Heading Marker. The heading marker, if incorporated, may be positioned on the compass card by use of the heading set knob. Once positioned, the marker remains fixed relative to the compass card. When the aircraft is on the selected heading, the heading marker is aligned beneath the upper lubber line.

5.2.4.5. Bearing Pointers. The bearing pointers indicate the ADF, VOR, or TACAN magnetic bearing to the selected navigation station. Placards on the instrument or near a selector switch are used in most aircraft to identify the bearing pointer display.

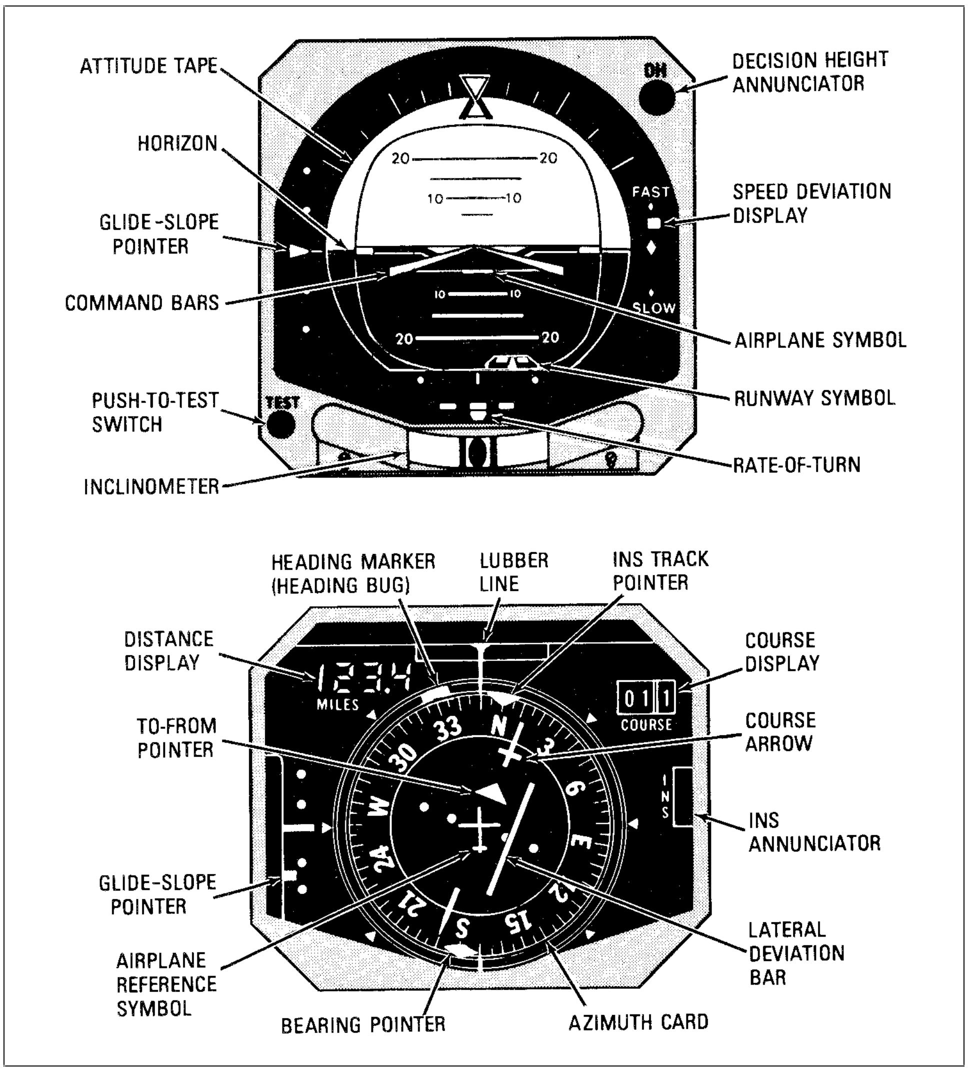
NOTE: The bearing pointers do not function in relation to ILS signals.

5.2.4.6. Malfunctions. If there is a malfunction in the compass system or compass card, an ADF bearing pointer continues to point to the station and displays relative bearing only.

5.2.4.7. TACAN/VOR Pointers. With a malfunction in the compass system or compass card, TACAN/VOR pointers may continue to indicate proper magnetic bearings. Until verified by radar or other navigation equipment, consider this bearing information unreliable.

5.3. Flight Director. The flight director provides the pilot with displays of pitch and bank attitudes and the navigation situation of the aircraft. The flight director when combined with round dial performance instruments is termed the flight director system (FDS). When the flight director is combined with vertical scale instruments it is termed the integrated flight instrument system (IFIS). The three components of the flight director of major interest are the attitude director indicator (ADI), the horizontal situation indicator (HSI), and the flight director computer.

Figure 5.9. Typical Flight Director (para 5.3.1).



5.3.1. Attitude Director Indicator (ADI) (Figure 5.9).

5.3.1.1. Parts of Attitude Director Indicator. The attitude director indicator consists of attitude indicator, rate of turn and slip indications, glide slope indicator, command bars, attitude warning flag, glide slope warning flag, and course warning flag. Additional information displayed on some ADIs includes radar altitude information, approach speed deviation, and a runway symbol that displays lateral and vertical displacement from the runway.

5.3.1.2. Glide Slope Pointer. The glide slope pointer (GSP) displays glide slope position in relation to the aircraft. If the GSP is above or below center the glide slop is above or below the aircraft respectively. GSP scale deflection differs with the width of the glide slope (1° to 1.8°). Example: If the glide slope width was 1°, full-scale deflection would be ½° and each dot would be ¼° (**Figure 5.7).**

5.3.1.3. Command Bars. The command bars display command steering information to fly or to maintain a desired flight path. The attitude of the aircraft must be adjusted as necessary to satisfy the pitch or bank commands. To satisfy these commands, the aircraft must be maneuvered so that the airplane symbol (fixed delta shape) is "flown into" the bars until the two are snugly aligned.. Keeping the airplane symbol and command bars snugly aligned will provide the amount of bank necessary to roll in, turn, roll out, and maintain a selected heading or ILS course and the proper pitch attitude necessary to fly to, or maintain the desired flight path. When the airplane symbol and command bars are aligned, the aircraft is either correcting to or is on the desired flight path.

NOTE: Warning flags are incorporated in the ADI to indicate failure or unreliability of presentations. Check the aircraft flight manual for specific warning flags applicable to your aircraft. In some ADIs, if power fails to the pitch and bank steering bars, no warning flags will appear, and the pitch and bank steering bars will center. Monitor the identifier to ensure that the signal is reliable. In most aircraft a warning flag appears when the signal strength is insufficient.

5.3.2. Horizontal Situation Indicator (HSI) (Figure 5.9).

5.3.2.1. Horizontal situation indicator. The horizontal situation indicator is, in most respects, a combination of a heading indicator, radio magnetic indicator, course indicator, and range indicator. The aircraft heading is displayed on a rotating compass card under the upper lubber line. The card is calibrated in 5° increments. The bearing pointers indicate the magnetic bearing from the aircraft to the selected ground station (VOR, TACAN, or ADF): The fixed aircraft symbol and course deviation indicator display the aircraft relative to a selected course as though the pilot was above the aircraft looking down. When used with VOR or TACAN, full-scale deflection, on most aircraft, indicate 10° of course deviation (each dot indicates 5°). When used with ILS, full-scale deflection differs with the width of the localizer course. Example: If the localizer course is 5° wide, the full-scale deflection is 2 ½° and each dot is 1¼°. If the localizer course is 3° wide, then full-scale deflection is 1½° and each dot is ¾° (**Figure 5.7**). The range indicator displays slant range distance in nautical miles to the selected DME transponder and may or may not operate when ILS modes have been selected depending on equipment installation. Additional displays available on electronic horizontal situation indicators include ARC formats to display a segment of the standard display as well as MAP formats used to pictorially display bearing and distance to NAVAIDs or waypoints.

5.3.2.2. Course Selector Knob. The course selector knob on most flight directors may be used to select any of 360 courses. To select a desired course, rotate the head of the course arrow to the desired course on the compass card and check the course selector window for the precise setting. The TO-FROM indicator is a triangular-shaped pointer. When the indicator points to the head of the course arrow, it indicates that the course selected, if properly intercepted and flown, will take the aircraft to the selected facility.

5.3.2.3. Heading Set Knob. The heading set knob on most flight directors is used to set the heading marker to a desired heading. With the proper mode selected on the flight director control panel, the heading marker can be slaved to the flight director computer. Thus, when a heading is set, the command bars will command the bank attitude required to turn to and maintain the selected heading.

5.3.3. Flight Director Computer.

5.3.3.1. Flight Director Computer Information. The flight director computer receives navigation information from the navigation systems and attitude information from the attitude gyro. Depending on the modes available and selected, the computer supplies pitch or bank commands to the command bars of the ADI. The functions of the computer vary with systems, and a number of inputs (NAVAIDs, datalink, Doppler, etc.) may be electronically processed by the system.

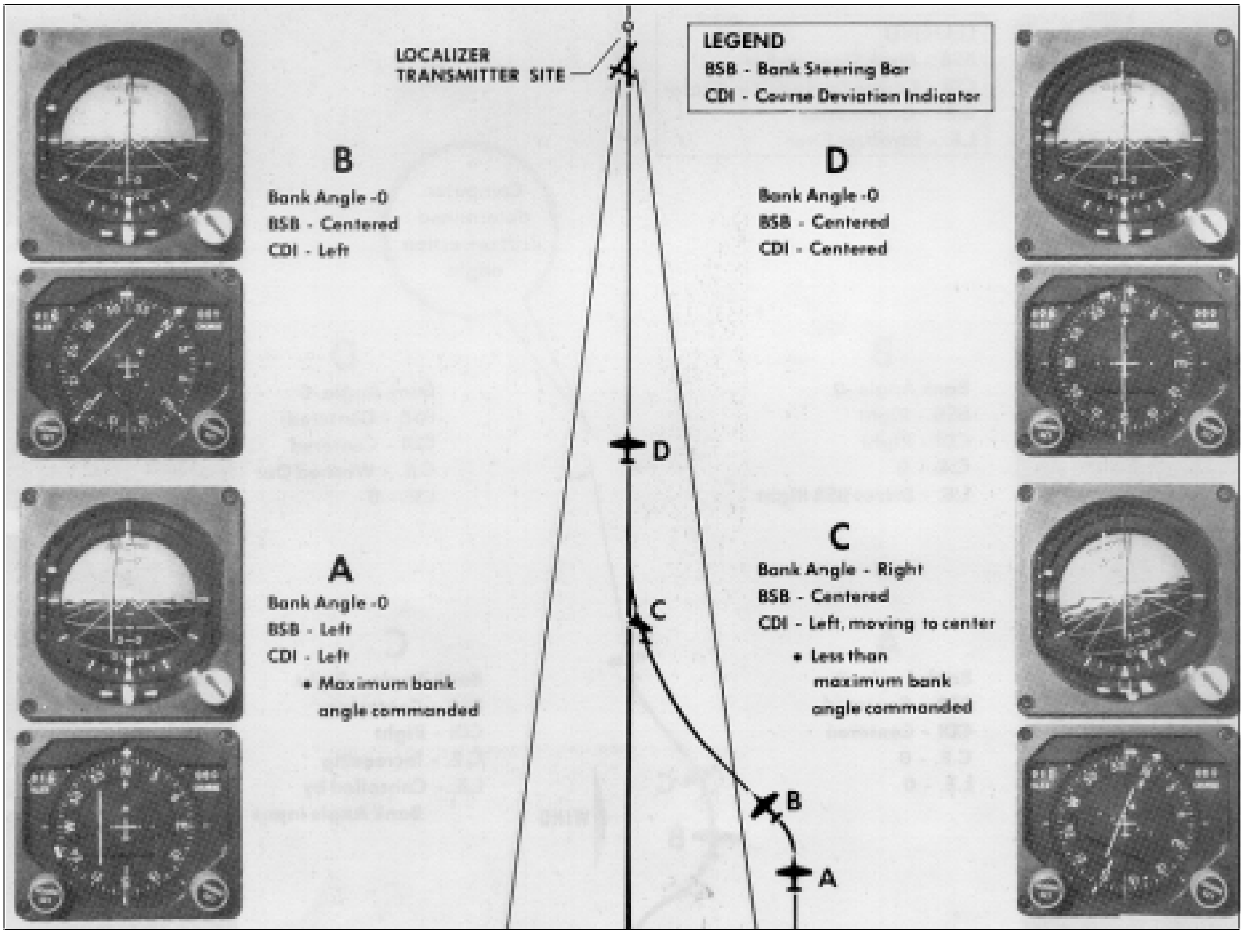
5.3.3.2. Flight Director Systems. In some flight director systems, the command bars can be used for other maneuvers such as intercepting VOR, TACAN, and Doppler courses or performing data link intercepts. Pitch command information can vary from terrain avoidance commands to commanding a selected altitude. In all cases, the command bars display command information and do not reflect actual aircraft position. This section is limited to command information pertaining to selected headings and ILS approaches and is common to most flight director systems. Refer to the appropriate flight manual for the specific capabilities of the system installed in your aircraft.

5.3.4. Flight Director Modes.

5.3.4.1 Heading Mode. The flight director usually has mode selectors that allow the pilot to select command steering to a heading or to various navigation systems.

5.3.4.2. ILS Intercept Mode (Figure 5.10). This mode is designed to direct the aircraft to, place it upon, and maintain it on the localizer course. This is accomplished by positioning the bank steering bar to command the pilot to fly flight director computed headings.

Figure 5.10. Flight Director Computer Inputs (ILS Intercept Mode) (para 5.3.4.2).

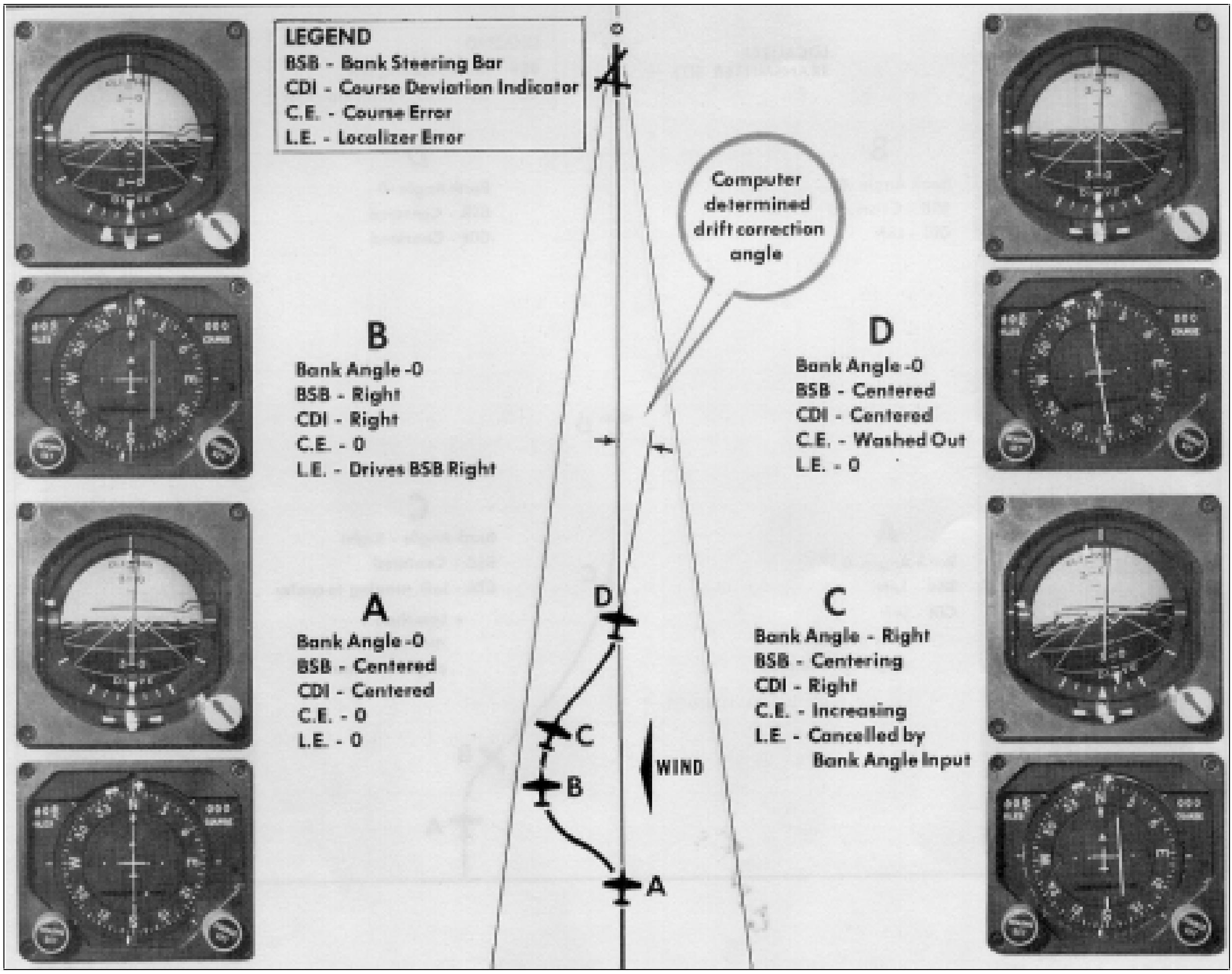


–**Wind drift.** Some computers supply wind drift compensation.
–**Bank angle.** Maximum bank angle commanded is usually 25° to 35°, depending on the system.
–**Intercept angle.** Maximum intercept angle commanded is normally about 45°.

5.3.4.3. ILS Final Approach Mode (Figure 5.11). This mode is designed to place and maintain the aircraft on the localizer course and glide slope. This is accomplished by positioning the pitch and bank steering bars to command the pilot to fly flight director computed headings and pitch attitudes.

–**Drift.** Wind drift compensation is provided to maintain the aircraft on the final approach course.
–**Bank Angle.** Bank angle commanded is a maximum of 15°.
–**Pitch.** Maximum pitch attitude commanded is 10° to 17°, depending on the system.

Figure 5.11. Flight Director Inputs (ILS Final Approach Mode) (para 5.3.4.3).



5.3.5. ILS Display. As in the CI, the course set knob and course selected have no effect on the CDI display. The CDI displays only if the aircraft is on course or in a 90- or 150-Hz zone of signals originating from the ILS localizer transmitter. When on course, the CDI will center regardless of the course selected; however, the CDI and course arrow will not necessarily be directional to the aircraft symbol. Set the published localizer front course in the course selector window in order to have the CDI and aircraft symbol directional.

Chapter 6

NAVIGATION AIDS (NAVAIDs)

6.1. Precautions. Various types of navigation aids are in use today, each serving a special purpose. Although operating principles and cockpit displays will vary among navigation systems, there are several precautionary actions that must be taken to prevent in-flight use of erroneous navigation signals:

6.1.1. Identification. Check the identification of any navigation aid and monitor it during flight. NAVAIDs are normally identified by listening to the Morse code identification of the tuned station; i.e., the TCL VORTAC would be identified by the Morse code for the letters "T-C-L." Some NAVAIDs can be identified by voice transmission. Additionally, some aircraft equipment interprets the Morse code identification and displays it in letter form for easy identification.

6.1.2. Crosscheck Information. Use all suitable navigation equipment aboard the aircraft and crosscheck heading and bearing information.

6.1.3. Estimated Time of Arrival. Never overfly an estimated time of arrival (ETA) without a careful crosscheck of navigation aids and ground checkpoints.

6.1.4. Notices to Airmen. Check notices to airmen (NOTAM) and flight information publication (FLIP) before flight for possible malfunctions or limitations to navigation aids.

6.1.5. Suspect Navigation Aid. Discontinue use of any suspect navigation aid and, if necessary, confirm aircraft position with radar (ground or airborne) or other equipment. Advise ATC of any problems receiving NAVAIDs--the problem may be the ground station and not your aircraft's equipment.

6.2. VHF Omni-Directional Range (VOR).

6.2.1. VOR Frequency. VORs operate within the 108.0 to 117.95 MHz (VHF) frequency band and have a power output necessary to provide coverage within their assigned operational service volume. The equipment is subject to line-of-sight restriction, and its range varies proportionally to the altitude of the receiving equipment.

6.2.2. Voice Transmission. Most VORs are equipped for voice transmission. VORs without voice capability are indicated on enroute and sectional charts by underlining the VOR frequency or by the designation "VORW" in the IFR Supplement. Since a large portion of the frequencies available on the VOR control panel may overlap the VHF communication frequency band, you may use the VOR receiver as a VHF communications receiver.

6.2.3. Accuracy. The accuracy of course alignment of the VOR is excellent, being generally plus or minus 1°, but no more than 2.5°.

6.2.4. Identification. The only method of identifying a VOR is by its Morse code identification or by the recorded automatic voice identification. Voice identification consists of a voice announcement, "COUSHATTA VOR," alternating with the usual Morse Code identification. During periods of maintenance, the facility may radiate a T-E-S-T code or the code may be removed.

6.3. Tactical Air Navigation (TACAN).

6.3.1. Principles of Operation. The theoretical and technical principles of operation of TACAN equipment are different from those of VOR; however, the end result, as far as the pilot is concerned, is the same.

6.3.2. TACAN Ground Equipment. TACAN ground equipment consists of either a fixed or mobile transmitting unit. The airborne unit in conjunction with the ground unit reduces the transmitted signal to a visual presentation of both azimuth and distance information. TACAN operates in the UHF band of frequencies. The system presently has a total of 252 channels available and is identified by two sets of channel numbers from 1 to 126, with suffixes ”X” or ”Y” for discrimination between the sets.

6.3.3. TACAN Malfunctions. Several forms of TACAN malfunctions can give false or erroneous information to the navigation display equipment:

6.3.3.1. Forty-Degree Azimuth Error Lock-On. Due to the nature of the TACAN signal, it is possible for the TACAN azimuth to lock on in multiples of 40° from the true bearing with no warning flag appearing. The pilot should crosscheck other navigation aids available to verify TACAN azimuth. Rechanneling the airborne receiver to deliberately cause unlock may correct the problem. Although some TACAN sets are designed to eliminate 40° lock-on error, the pilot should crosscheck the bearing with other available navigation aids.

6.3.3.2. Co-channel Interference. This occurs when the aircraft is in a position to receive TACAN signals from more than one ground station on the same channel, normally at high altitude. DME, azimuth, or identification from either ground station may be received.

6.3.3.3. False or Incorrect Lock-On. This is caused by misalignment or excessive wear of the airborne equipment channel selection mechanism. Rechanneling from the selected channel number and back preferably from the opposite direction than the original setting sometimes will correct this problem.

6.4. VHF Omni-Directional Range/Tactical Air Navigation (VORTAC).

6.4.1. VORTAC. A VORTAC is a facility consisting of two components, VOR and TACAN, which provides three individual services: VOR azimuth, TACAN azimuth, and TACAN distance (DME) at one site. Although consisting of more than one component, incorporating more than one operational frequency, and using more than one antenna system, a VORTAC is considered to be a unified navigation aid. Both components of a VORTAC operate simultaneously and provide the three services at all times.

6.4.2. Identification. Transmitted signals of VOR and TACAN are each identified by a three-letter code transmission and are interlocked so that pilots using VOR azimuth with TACAN distance can be assured that both signals being received are definitely from the same ground station. The frequencies of the VOR, TACAN, and DME at each VORTAC facility are "paired" in accordance with a national plan to simplify airborne operation. Frequency pairing information is published in the Flight Information Handbook.

6.5. Distance Measuring Equipment (DME).

6.5.1. Operation. In the operation of DME, paired pulses at a specific spacing are sent out from the aircraft and are received at the ground station. The ground station then transmits paired pulses back to the aircraft at the same pulse spacing but on a different frequency. The time required for the round trip of this signal exchange is measured in the airborne DME unit and is translated into distance in nautical miles from the aircraft to the ground station.

6.5.2. Line-of-sight principle. Operating on the line-of-sight principle, DME furnishes distance information with a very high degree of accuracy. Reliable signals may be received at distances up to 199 NM at line-of-sight altitude with an accuracy of better than ½ mile or 3 percent of the distance, whichever is greater. Distance information received from DME equipment is slant range distance and not actual horizontal distance.

6.5.3. DME Frequencies. DME operates on frequencies in the UHF spectrum between 962 MHz and 1213 MHz. Aircraft equipped with TACAN equipment will receive distance information from a VORTAC automatically, while aircraft equipped with only a VOR receiver must have a separate DME airborne unit.

6.5.4. Facilities. VOR/DME, VORTAC, ILS/DME, and LOC/DME navigation facilities provide course and distance information from collocated components under a frequency-pairing plan. Aircraft receiving equipment that provides for automatic DME selection ensures reception of azimuth and distance information from a common source when designated VOR/DME, VORTAC, ILS/DME, and LOC/DME are selected.

6.5.5. Identification. VOR/DME, VORTAC, ILS/DME, and LOC/DME facilities are identified by synchronized identifications which are transmitted on a time share basis. The DME or TACAN coded identification is transmitted one time for each three or four times that the VOR or localizer coded identification is transmitted. When either the VOR or the DME is inoperative, it is important to recognize which identifier is retained for the operative facility. A single coded identification with a repetition interval of approximately 30 seconds indicates that the DME is operative.

NOTE: DME unlocks can occur periodically due to ground station overload when more than 100 aircraft interrogations are received at the same time. This problem is most likely to occur at locations of heavy traffic (i.e. Chicago-O Hare).

6.6. Instrument Landing System (ILS).

6.6.1. Description.

6.6.1.1. Design. The ILS is designed to provide an approach path for exact alignment and descent of an aircraft on final approach to a runway.

6.6.1.2. Ground equipment. The ground equipment consists of two highly directional transmitting systems, and along the approach, three (or fewer) marker beacons. The directional transmitters are known as the localizer and glide slope transmitters.

6.6.1.3. Signals. Both localizer and glide slope signals are received and displayed according to the aircraft control panel or flight director configuration.

6.6.2. Localizer (Figure 6.1). The localizer transmitter, operating on one of the 40 ILS channels within the frequency range of 108.10 MHz to 111.95 MHz, emits a signal that provides the pilot with course guidance to the runway centerline. The localizer signal is usable and accurate to a range of 18 NM from the localizer antenna unless otherwise stated on the IAP.

6.6.3. Glide Slope (Figure 6.1). The ultra high frequency (UHF) glide slope transmitter, operating on one of the 40 ILS channels within the frequency range 329.15 MHz to 335.00 MHz radiates its signals primarily in the direction of the localizer front course. The glide slope signal is usable to a distance of 10 NM from the glide slope antenna (located near the approach end of the runway) unless otherwise stated on the IAP.

CAUTION*:* Spurious glide slope signals may exist in the area of the localizer back course that can cause the glide slope flag alarm to disappear and present unreliable glide slope information. Disregard all glide slope signal indications when flying a localizer back course approach unless a glide slope is specified on the instrument approach procedure.

6.6.4. Marker Beacons. A marker beacon light and (or) aural tone may be included in the cockpit display to indicate aircraft position along the localizer. The marker beacons are identified by continuous dashes for the outer marker, alternating dashes and dots for the middle marker, and continuous dots for the inner marker.

6.6.5. ILS System on Each End of Runway. Some locations have a complete ILS system installed on each end of a runway; on the approach end of Runway 04 and the approach end of Runway 22, for example. When this is the case, the ILS systems are not in service simultaneously and although the same frequency may be used for both systems, each runway will have its own unique coded identifier.

6.6.6. False Course Indications (Figure 6.2). False course indications may be received when the aircraft is not within the depicted area of coverage. Therefore, localizer course information received outside the area depicted in **Figure 6.2** should be considered invalid unless the procedure is published otherwise (for example, localizer type directional aid or back course localizer). There is also a remote chance electromagnetic interference may cause false course indications within the depicted area of coverage. For these reasons, it is essential to confirm the localizer on course indication by reference to aircraft heading and any other available navigation aids, such as an ADF bearing pointer, before commencing final descent. Any abnormal indications experienced within 35 degrees of the published front course or back course centerline of an ILS localizer should be reported immediately to the appropriate ATC facility.

6.6.7. ILS Facilities with Associated DME. ILS facilities sometimes have associated distance measuring equipment (DME). These facilities are usually found at civilian fields. Some instrument approach procedures require TACAN or VOR associated DME on the initial segment and the ILS associated DME during the final portion of the approach. Pilots must exercise extreme caution to ensure the proper DME channel is tuned to preclude premature descents.

NOTE*:* Due to angular dispersion of the localizer and glide slope signals, the corrective inputs to return to "on course, on glide slope" become smaller as the aircraft approaches the runway threshold (**Figure 6.2**).

Figure 6.1. Standard ILS Characteristics and Terminology (para 6.6.2).

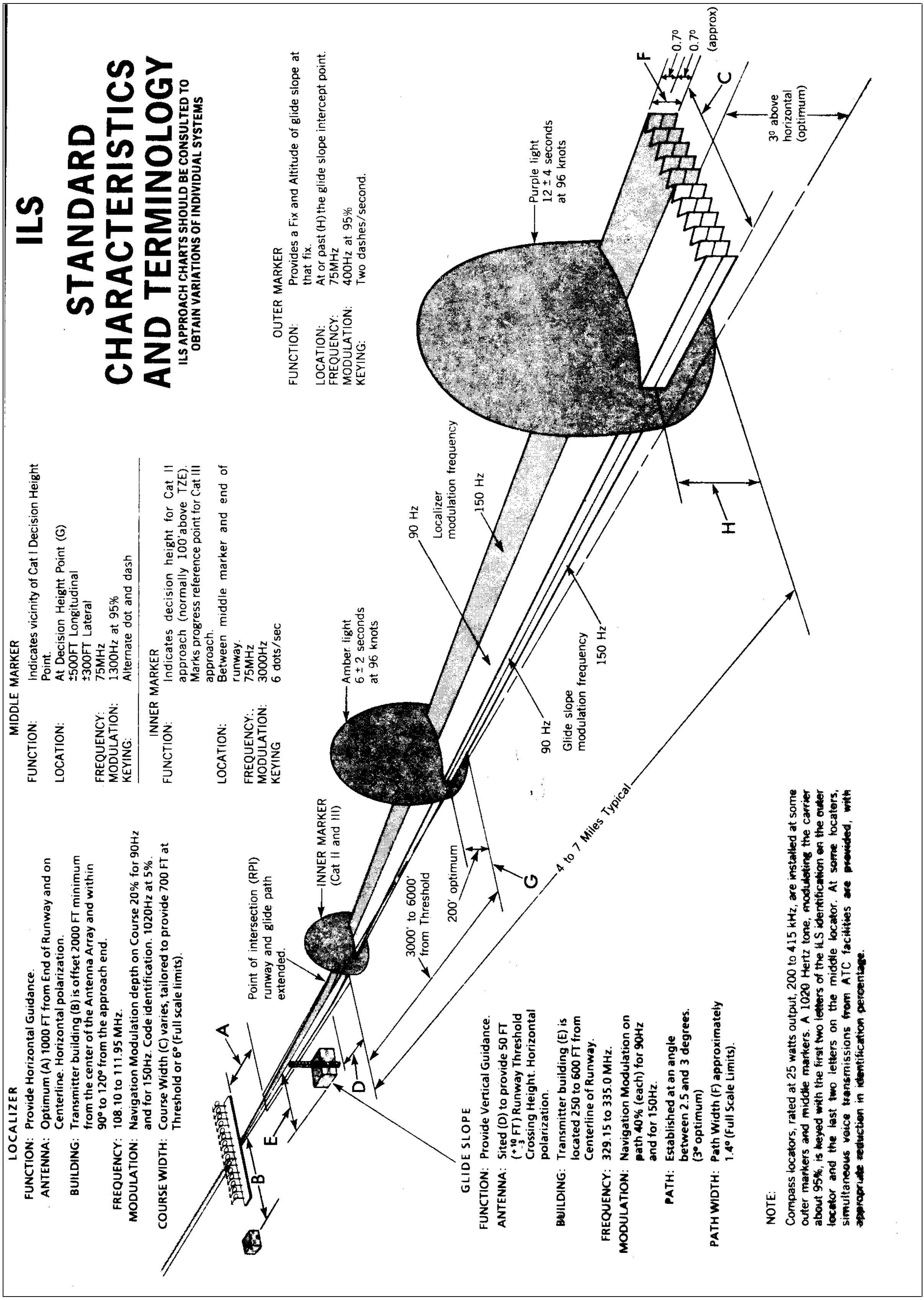
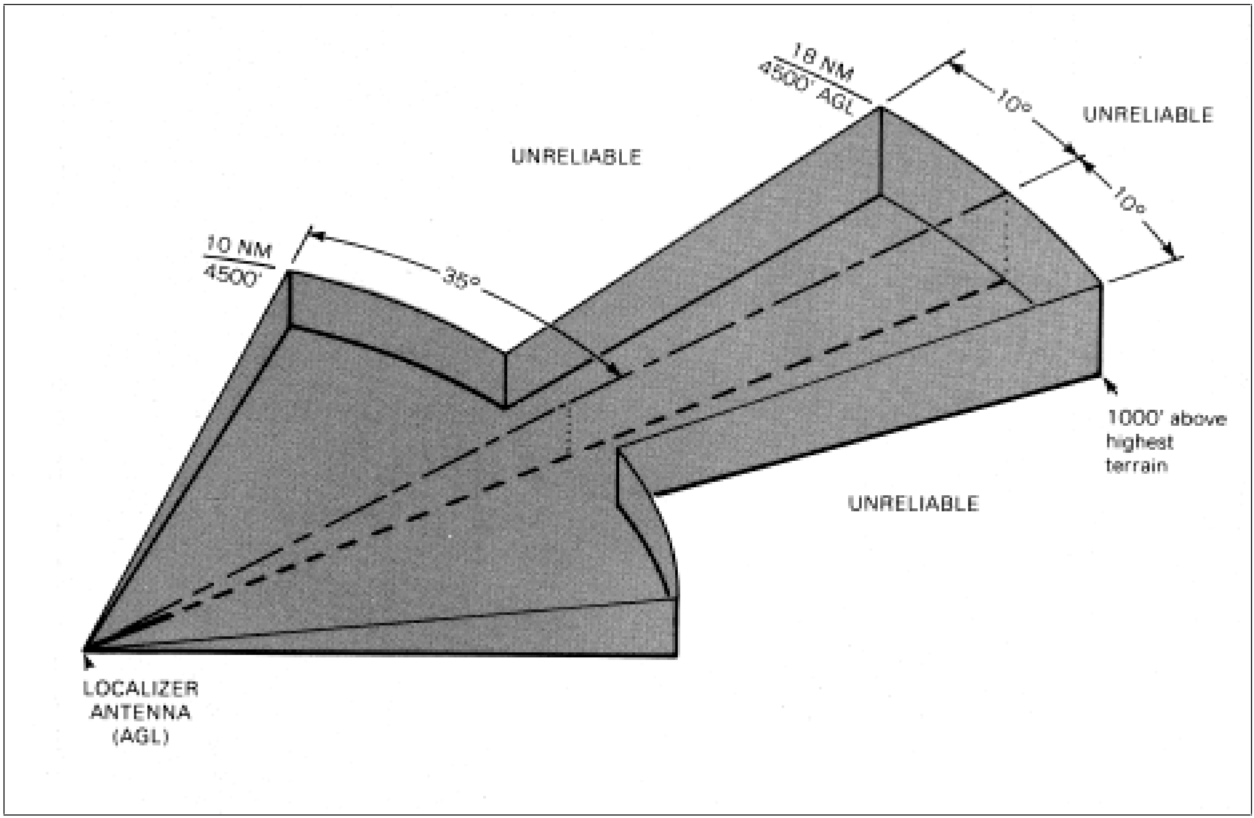


Figure 6.2. Normal Localizer Signal Coverage (para 6.6.6).



6.7. Microwave Landing System (MLS).

6.7.1. Description.

6.7.1.1. Guidance. The MLS provides precision navigation guidance for aircraft alignment to a runway. It integrates azimuth, elevation angle guidance, and range information to provide precise aircraft positioning. The MLS azimuth transmitter is usually located about 1,000 feet beyond the departure end of the runway and the elevation transmitter is located to the side of the runway near the approach threshold. The precision DME, which provides range information, is collocated with the azimuth transmitter.

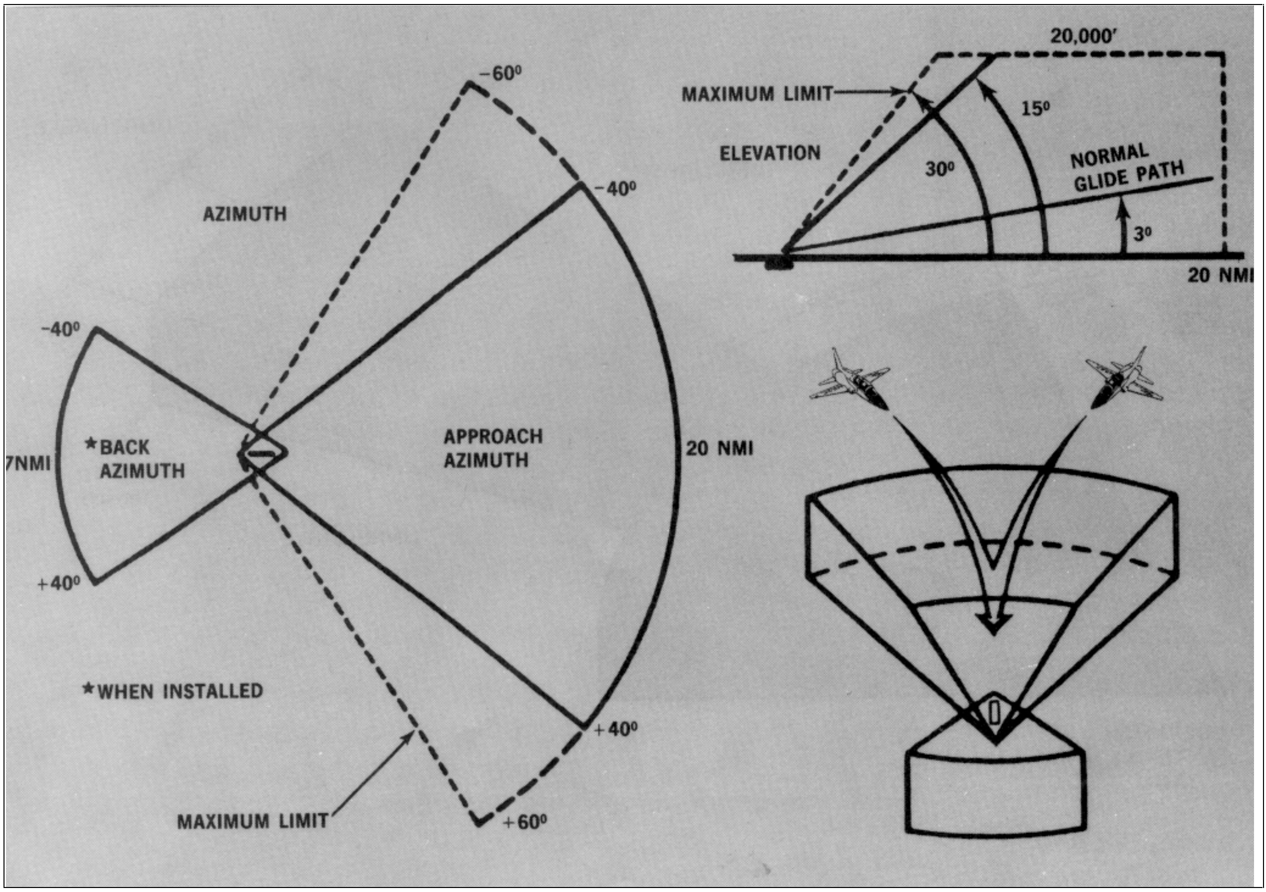
6.7.1.2. Displays. Both lateral and vertical MLS guidance may be displayed on conventional course deviation indicators or incorporated into multipurpose cockpit displays. Range information can be displayed by conventional DME indicator or incorporated into multipurpose displays.

6.7.2. Approach Azimuth Guidance.

6.7.2.1. Azimuth guidance. In addition to providing azimuth navigation guidance, the azimuth station also transmits basic data concerning the operation of the landing system and advisory data on the performance level of the ground equipment.

6.7.2.2. Ground equipment. Although the equipment is normally located about 1,000 feet beyond the departure end of the runway, there is considerable flexibility in selecting sites. For example, for heliport operations the azimuth transmitter can be collocated with the elevation transmitter.

Figure 6.3. MLS Coverage Volumes (para 6.7.2.3).



6.7.2.3. The Azimuth Coverage (Figure 6.3) Extends:

–Laterally. At least 40° on either side of the runway.

–In elevation. Up to an angle of 15° and to at least 20,000 feet.

–In range. To a distance of 20 NM.

6.7.3. Elevation Guidance (Figure 6.3).

–Elevation station. The elevation station transmits its guidance signals on the same carrier frequency as the azimuth station. The single frequency is time-shared between angle and data function.

–Elevation transmitter. The elevation transmitter is normally located about 400 feet to one side of the runway between the runway threshold and the touchdown zone.

–Coverage. Elevation coverage is the same as for azimuth coverage.

6.7.4. MLS precision distance measuring equipment. The MLS precision distance measuring equipment (DME/P) is the same in function as the DME described in the TACAN section of the manual. DME/P accuracy has been improved to be consistent with the accuracy provided by the MLS azimuth and elevation stations. The DME/P is an integral part of the MLS.

6.7.5. MLS Expansion Capabilities. The standard MLS configuration can be expanded by addition of one or more of the following functions:

–**Back Azimuth.** To provide lateral guidance for missed approach and departure navigation.

–**Auxiliary Data Transmissions.** To provide additional data, including meteorological information, runway condition, and other supplementary information. This digitally transmitted data may be displayed on appropriately equipped aircraft.

–**Larger Coverage Area.**

6.7.6. MLS Characteristics.

6.7.6.1. Accuracy. The MLS provides precision three-dimensional navigation guidance that is accurate enough for all approach and landing maneuvers.

6.7.6.2. Coverage. Precise navigation accuracy is provided throughout the coverage volumes shown in **Figure 6.3**.

6.7.6.3. Environment. The system has low susceptibility to interference from weather conditions and airport ground traffic.

6.7.6.4. Channels. MLS has 200 discrete channels.

6.7.6.5. Data. The MLS transmits ground-air data messages associated with system operation.

6.7.6.6. Range Information. Continuous range information is provided to an accuracy of about 100 feet if the aircraft avionics includes a DME/P capability.

6.7.6.7. Operational Flexibility. The MLS has the capability to fulfill a variety of needs in the transition, approach, landing, missed approach and departure phases of flight. For example: Curved and segmented approaches, selectable glide path angles, accurate three-dimensional positioning of the aircraft in space, and the establishment of boundaries to ensure clearance from obstructions in the terminal area. While many of these capabilities are available to any MLS equipped aircraft, the more sophisticated capabilities, such as curved and segmented approaches, are dependent upon the display capabilities of the aircraft equipment.

6.8. Marker Beacon (Figure 6.1). Marker beacons serve to identify a particular location in space on the approach to an instrument runway. This is done by means of a 75-MHz transmitter that transmits a directional signal to be received by aircraft flying overhead. These markers are generally used in conjunction with en route NAVAIDs and ILS as point designators.

6.9. Localizer Type Directional Aid (LDA). The LDA is of comparable utility and accuracy to a localizer but is not always aligned with the centerline of the runway. Straight-in minima can be published only where alignment conforms to the straight-in criteria specified in AFJM 11-226 (TERPs). Circling minima are published where this alignment exceeds straight-in criteria. The LDA is usually considered a non-precision approach; however, in some installations with a glide slope, a decision height will be published. If a decision height is published, it can be flown just like an ILS approach.

6.10. Simplified Directional Facility (SDF).

6.10.1. SDF. The SDF provides a final approach course that is similar to that of the ILS localizer and LDA. However, the SDF may have a wider course width of 6° or 12°. It does not provide glide slope information. A clear understanding of the ILS localizer and the additional factors listed below completely describe the operational characteristics and use of the SDF.

6.10.2. Frequencies. The SDF transmits signals within the range of 108.10 MHz to 111.95 MHz.

6.10.3. Procedures. For the pilot, the approach techniques and procedures used in the performance of an SDF instrument approach are essentially identical to those used in executing a standard no glide slope localizer approach except that the SDF course may not be aligned with the runway and the course may be wider, resulting in less precision.

6.11. Nondirectional Radio Beacon (NDB).

6.11.1. Frequencies. NDB is a low, or medium, or ultra high frequency radio beacon that transmits nondirectional signals whereby an aircraft properly equipped can automatically determine and display bearing to any radio station within its frequency and sensitivity range. These facilities normally operate on frequencies between 190 and 1750 kHz or 275-287 MHz and transmit a continuous carrier keyed to provide identification except during voice transmission.

6.11.2. Compass locator. When a radio beacon is used in conjunction with the ILS markers, it is called a "compass locator."

6.11.3. Identification. Most radio beacons within the U.S. transmit a continuous three-letter identifier. A two-letter identifier is normally used in conjunction with an ILS. Some NDBs have only a one-letter identifier. Outside of the contiguous U.S., one, two, or three-letter identifiers are transmitted; for example, BB.

6.11.4. Voice Transmissions. Voice transmissions can be made on radio beacons unless the letter "W" (without voice) is included in the class designator (HW).

6.11.5. Disturbances. Radio beacons are subject to disturbances that may result in erroneous bearing information. Such disturbances result from intermittent or unpredictable signal propagation due to such factors as lightning, precipitation, static, etc. At night, radio beacons are vulnerable to interference from distant stations. Nearly all disturbances that affect the ADF bearing also affect the facility's identification. Noisy identification usually occurs when the ADF needle is erratic. Voice, music, or erroneous identification will usually be heard when a steady false bearing is being displayed.

WARNING: Since ADF receivers do not have a "flag" to warn the pilot when erroneous bearing information is being displayed, the pilot must continuously monitor the NDB's identification.

6.11.6. Control panels. There are several different types of control panels currently installed in our operational aircraft. Refer to your aircraft technical manual for specific guidance pertaining to equipment operation and its limitations.

NOTE*:* ADF course intercept procedures are basically the same as those used in VOR/RMI-only procedures.

6.12. Global Positioning System (GPS).

NOTE: USAF aircraft may be equipped with either Technical Standard Order (TSO) compliant GPS systems for IFR navigation or mission enhancement GPS systems that are not authorized for IFR use. More detailed information on the IFR use of TSO compliant GPS systems is located in Volume II of this manual.

6.12.1. GPS Capabilities.

6.12.1.1. Spaced based system. The global positioning system (GPS) is a space based navigation system that has the capability to provide highly accurate three dimensional position, velocity, and time to an infinite number of equipped users anywhere on or near the Earth (**Figure 6.4**). The Air Force is currently making provisions to equip new aircraft with GPS receivers and retrofit aircraft already in service. The typical GPS integrated system will provide: position, velocity, time, altitude, steering information, groundspeed and ground track error, heading, and variation. GPS also provides a constant monitor of system status and accuracy, and the built-in test circuitry provides self-tests that diagnose most system failures. The airborne GPS receiver may accept inputs from other aircraft systems, such as inertial navigation system (INS), altimeter, central air data computer (CADC), attitude gyro, and compass systems that improve GPS accuracy and reliability.

6.12.1.2. Positioning. The GPS measures distance, which it uses to fix position, by timing a radio signal that starts at the satellite and ends at the GPS receiver. The signal carries with it data that discloses satellite position and time of transmission, and synchronizes the aircraft GPS system with satellite clocks. There are two levels of accuracy available: Coarse acquisition (C/A) data will provide position accurate to within 100 meters and can be received by anyone with a GPS receiver; precision (P) data can be received only by authorized users in possession of the proper codes, and the data is accurate to within 16 meters.

6.12.2. Description. The GPS is composed of three major segments: space, control, and user.

6.12.2.1. Space Segment. The GPS space segment is composed of 24. Satellite spacing is arranged such that a minimum of six satellites will normally be in view to the user, thereby, ensuring worldwide coverage.

6.12.2.2. Control Segment. The control segment includes a number of monitor stations and ground antennas located throughout the world. The monitor stations use a GPS receiver to passively track all satellites in view and thus accumulate ranging data from the satellite signals. The information from the monitor stations is processed at the master control station (MCS) to determine satellite orbits and to update the navigation message of each satellite. This updated information is transmitted to the satellites via the ground antennas, which arealso used for transmitting satellite control information.

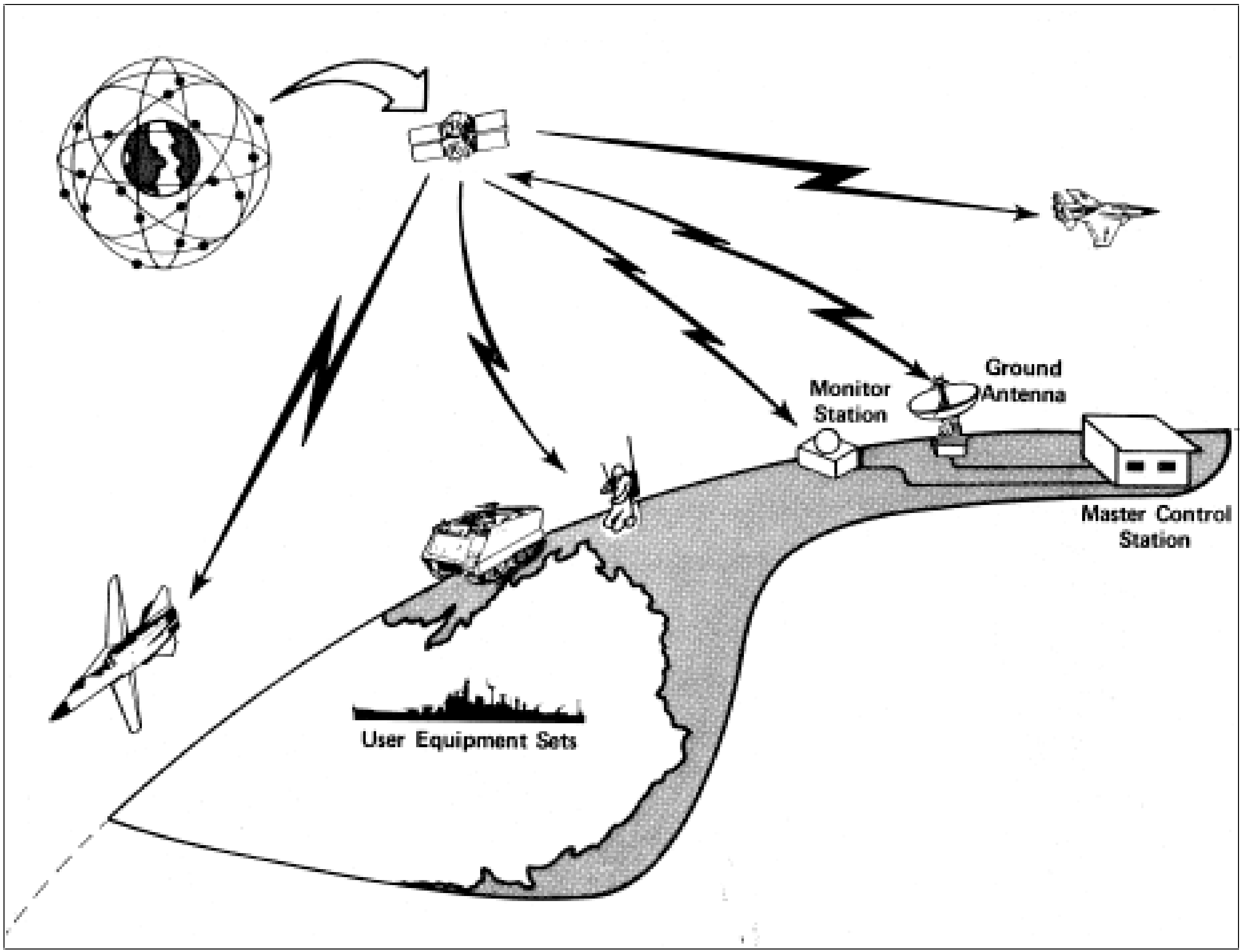
6.12.2.3. User Segment. The user segment consists of user equipment (UE) sets, test instrumentation, and user specific support equipment. The UE sets use data transmitted by the satellites to provide instantaneous navigation and time data. Additionally, the GPS UE set can be easily integrated with other navigation equipment/systems such as VOR or DME or an inertial platform. Three types of GPS sets have been developed and the choice of sets will depend on the user's operating environment.

6.12.2.3.1. Low Dynamic (One Channel) Set. Tracks and monitors four satellites sequentially. This type set will be used where rapid maneuvers are not a problem. One channel sets will typically be used by ground personnel and vehicles.

6.12.2.3.2. Medium Dynamic (Two Channel) Set. The two channel set provides expanded dynamic capabilities. One channel sequentially tracks four satellites while the second channel performs background functions including the search for a rising satellite. Medium dynamic sets will be used primarily by Army helicopters.

6.12.2.3.3. High dynamic (Five Channel) Set. This set will be used where the host vehicle will be subject to high dynamic maneuvers or jamming. It will continuously track and monitor four satellites. The fifth channel will be used to improve set performance. This model will be used by most fixed wing aircraft and ships.

Figure 6.4. Global Positioning System (GPS) (para 6.12.1.1).



6.12.3. Integrated Systems. Although GPS is meant to replace some navigation equipment, the way it is integrated into the navigation system will depend on the mission of the aircraft. GPS can greatly enhance the performance of an INS. The INS in turn increases the usefulness of GPS equipment. INS has the ability to accurately measure changes in position and velocity over short periods of time using no external signal; however, errors are cumulative and increase with time. GPS can provide a continual position update that allows the INS to calculate error trends and improve its accuracy as time increases. The INS aids the GPS receiver by improving GPS anti-jam performance. When GPS is not available (due to mountain shadowing of satellites, jamming, or high dynamic maneuvers), this improved INS will provide the integrated navigation system with accurate position information until the satellites are in view or the jamming is over. An added advantage is that GPS provides an in-flight alignment capability for the INS.

6.13. Inertial Navigation System (INS).

6.13.1. Description. The INS is a primary source of groundspeed, attitude, heading, and navigation information. A basic system consists of acceleration sensors mounted on a gyro stabilized, gimbaled platform, a computer unit to process raw data and maintain present position, and a control display unit (CDU) for data input and monitoring. It allows the aircrew to selectively monitor a wide range of data, define a series of courses, and update present position. The INS operates solely by sensing the movement of the aircraft. Its accuracy is theoretically unlimited and affected only by technology and manufacturing precision. Since it neither transmits nor receives any signal, it is unaffected by electronic countermeasures or weather conditions. The INS can also supply data to many other aircraft systems.

6.13.2. Operation. Before an INS can be used, it must be aligned. During alignment, present position coordinates are inserted manually while local level and true north are derived by the INS. This operation must be completed before moving the aircraft. If alignment is lost in flight, navigation data may be lost, but, in some cases, attitude and heading information may still be used. Coordinate or radial and distance information describing points that define the route of flight are inserted as needed through the CDU. For complete operation procedures of any specific INS, consult the appropriate aircraft technical order.

Chapter 7

NAVIGATION TECHNIQUES PROCEDURES

7.1. Application. Instrument procedures are flown using a combination of the techniques described in this chapter (arc to radial, radial to arc, course intercepts, etc.). Individual aircraft flight manuals should provide proper procedures for using the navigation equipment installed.

NOTE: Where procedures depict a ground track, the pilot is expected to correct for known wind conditions. In general, the only time wind correction should not be applied is during radar vectors. The following general procedures apply to all aircraft.

NOTE: ***Unless otherwise authorized by ATC, no person may operate an aircraft within controlled airspace under IFR except as follows:***
(a) On a Federal airway, along the centerline of that airway.
(b) On any other route, along the direct course between the navigational aids or fixes defining that route. However, this section does not prohibit maneuvering the aircraft to pass well clear of other air traffic or the maneuvering of the aircraft in VFR conditions to clear the intended flight path both before and during climb or descent.

7.1.1. ***Tune. Tune to or select the desired frequency or channel***.

7.1.2. ***Identify. Identify the station***.

7.1.2.1. VOR. The station identification may be a repeated three-letter Morse code group, or a three-letter Morse code group alternating with a recorded voice identifier.

7.1.2.2. TACAN. The TACAN station transmits an aural three-letter Morse code identifier approximately every 35 seconds.

7.1.2.3. ADF. The nondirectional radio beacon transmits a repeated two or three-letter Morse code group depending on power output.

NOTE: When possible, use a nondirectional radio beacon. Commercial broadcasting stations should be used with caution because some have highly directional radiation patterns. Additionally, they are not flight-checked for use in navigation. Positive identification of the commercial station being used is imperative.

7.1.2.4. ILS. The ILS localizer transmitter puts out a repeated four-letter Morse code group. The first letter of the identifier is always "I" to denote the facility as an ILS.

NOTE: ***Positively identify the selected station.*** Through human error or equipment malfunction, it is possible that the station intended to be selected is not the one being received. This may occur as the result of failing to select the correct frequency or failure of the receiver to channelize to the new frequency.

7.1.3. ***Monitor. Monitor station identification while using it for navigation***. Removal of identification serves as a warning to pilots that the facility is officially off the air for tune-up or repairs and may be unreliable even though intermittent or constant signals are received. The navigation signal is considered to be unreliable when the station identifier is not being received.

NOTE*:* Voice communication is possible on VOR, ILS, and ADF frequencies. Consult FLIP documents to determine the availability of specific stations.

7.1.4. Select. Select proper position for the navigation system switches.

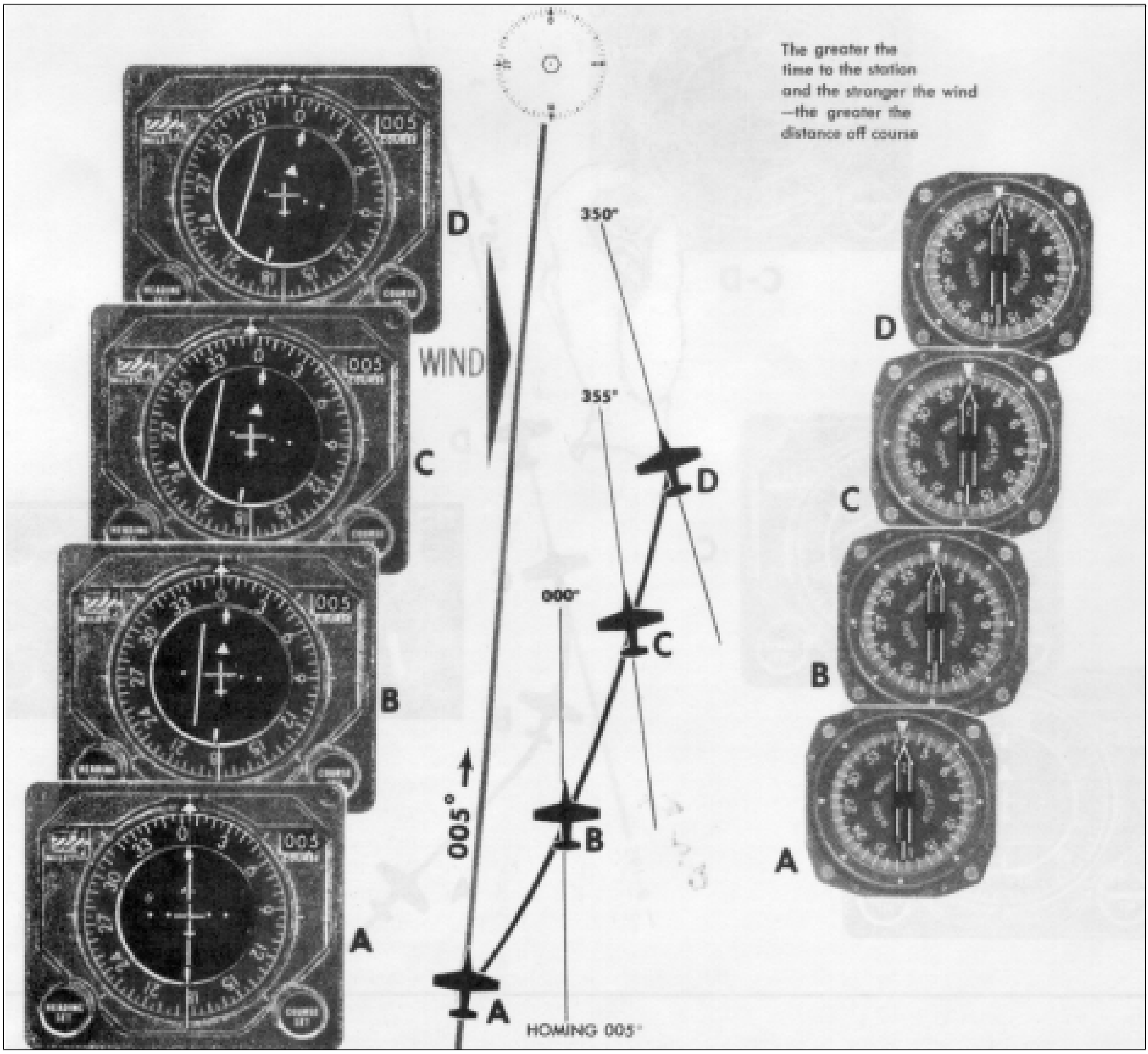
7.1.5. Set. Set the selector switches to display the desired information on the navigation instruments.

7.1.5.1. Monitor. Monitor the course warning flag (if installed) continuously to ensure adequate signal reception strength.

7.1.5.2. Check. Check the appropriate instrument indicators for proper operation.

7.2. Homing to a Station. Tune and identify the station. Turn the aircraft in the shorter direction to place the head of the bearing pointer under the top index of the RMI/BDHI or upper lubber line of the HSI. Adjust aircraft heading, as necessary, to keep the bearing pointer under the top index or upper lubber line. Since homing does not incorporate wind drift correction, in a crosswind the aircraft follows a curved path to the station (**Figure 7.1**). Therefore, homing should be used only in the event maintaining course is not required.

Figure 7.1. Curved Flight Path as a Result of Homing with a Crosswind (para 7.2).



7.3. Proceeding Direct to a Station (Figure 7.2).

7.3.1. Proceeding Direct. When proceeding direct to a station, the following applies:

7.3.1.1. Tune and Identify the Station.

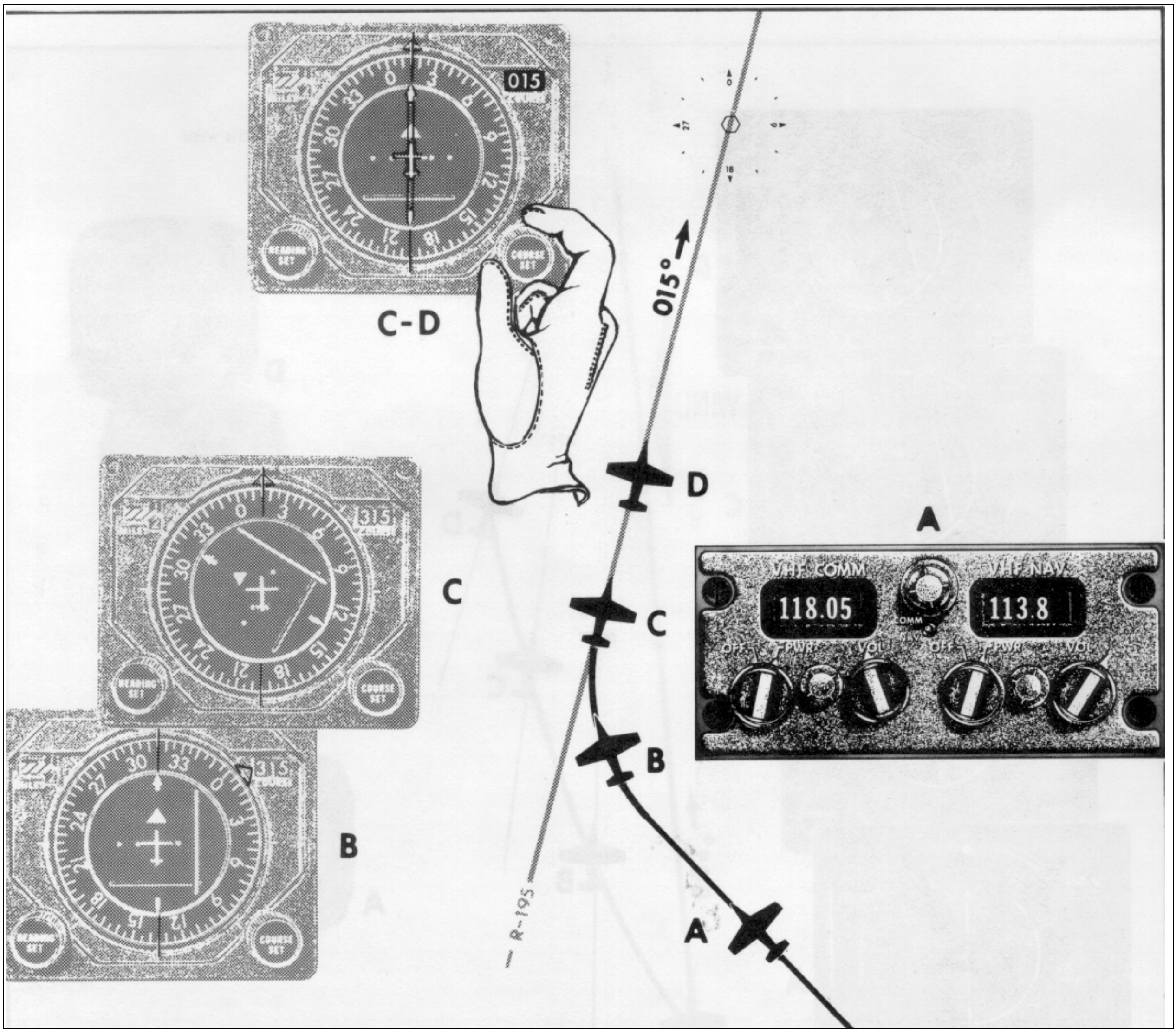
7.3.1.2. Turn. Turn the aircraft in the shorter direction to place the head of the bearing pointer under the top index or upper lubber line.

7.3.1.3. Center the CDI. Center the CDI with a TO indication (does not apply to RMI only).

7.3.1.4. Maintain Course. Maintain the selected course to the station. (Correct for winds.)

7.3.1.5. Inoperative Procedures. If either the compass card or the bearing pointer is inoperative, a course indicator or HSI may be used to determine the bearing to the station by rotating the course set knob until the CDI centers and TO is read in the TO-FROM indicator. The magnetic bearing from the aircraft to the station then appears in the course selector window. Until verified by radar or other navigation equipment, consider this bearing information unreliable.

Figure 7.2. Proceeding Direct to Station (para 7.3).



7.4. Course Intercepts.

7.4.1. Successful Course Interception. Course interceptions are performed in many phases of instrument navigation. ***To ensure successful course interception, an intercept heading must be used that results in an angle or rate of intercept sufficient to complete a particular intercept problem.***

7.4.1.1. Intercept Heading. The intercept heading (aircraft heading) is the heading determined to solve an intercept problem. When selecting an intercept heading, the essential factor is the relationship between distance from the station and the number of degrees the aircraft is displaced from course. Adjustments to the intercept heading may be necessary to achieve a more desirable rate of intercept.

7.4.1.2. Angle of Intercept. The angle of intercept is the angular difference between the heading of the aircraft (intercept heading) and the desired course. The minimum acceptable angle of intercept for an inbound course interception must be greater than the number of degrees the aircraft is displaced from the desired course. The angle of intercept should not exceed 90°.

7.4.1.3. Rate of Intercept. The rate of intercept is determined by observing bearing pointer and CDI movement. The rate of intercept is a result of intercept angle, groundspeed, distance from the station, and if you are proceeding to or from the station.

7.4.1.4. Completing the Intercept.

7.4.1.4.1. Lead point. A lead point to roll out on the course must be determined because of turn radius of the aircraft. The lead point is determined by comparing bearing pointer or CDI movement with the time required to turn to course.

7.4.1.4.2. Rate of intercept. To determine the rate of intercept, monitor the bearing pointer or CDI movement.

7.4.1.4.3. Turn. The time required to make the turn to course is determined by the intercept angle and the aircraft turn rate.

7.4.1.4.4. Complete the intercept. Use the CDI, when available, for completing the course intercept.

7.4.1.4.5. Undershoot or Overshoot. If it is obvious that the selected lead point will result in undershooting the desired course, either reduce the angle of bank or roll out of the turn and resume the intercept. If the selected lead point results in an overshoot, continue the turn and roll out with a correction back to the course.

7.4.1.4.6. Maintain course. The aircraft is considered to be maintaining the course centerline when the CDI is centered or the bearing pointer points to the desired course. A correction for known winds should be applied when completing the turn to a course.

NOTE: ***Pilots should always attempt to fly as close to the course centerline as possible.*** TERPs design criteria will provide maximum obstacle clearance protection when the course centerline is maintained.

7.4.2. In-bound (CI and HSI) (Figure 7.3).

7.4.2.1. Tune and identify the station.

7.4.2.2. Set inbound course. Set the desired inbound course in the course selector window and check for a TO indication.

7.4.2.3. Turn. Turn to an intercept heading.

7.4.2.3.1. CI. Turn in the shorter direction to place the heading pointer toward the CDI. Continue the turn to place the heading pointer in the top half of the instrument case. This precludes an intercept angle in excess of 90°. Roll out with the RMI/BDHI bearing pointer between the desired inbound course and top index. The angle of intercept must be greater than the number of degrees off course, not to exceed 90°. The intercept heading may be adjusted within these limits to achieve the most desirable rate of intercept. Displacing the bearing pointer approximately 30° from the top index will normally ensure a moderate rate of intercept.

Figure 7.3. Inbound Course Interceptions (Course Indicator and RMI; HSI) (para 7.4.2).

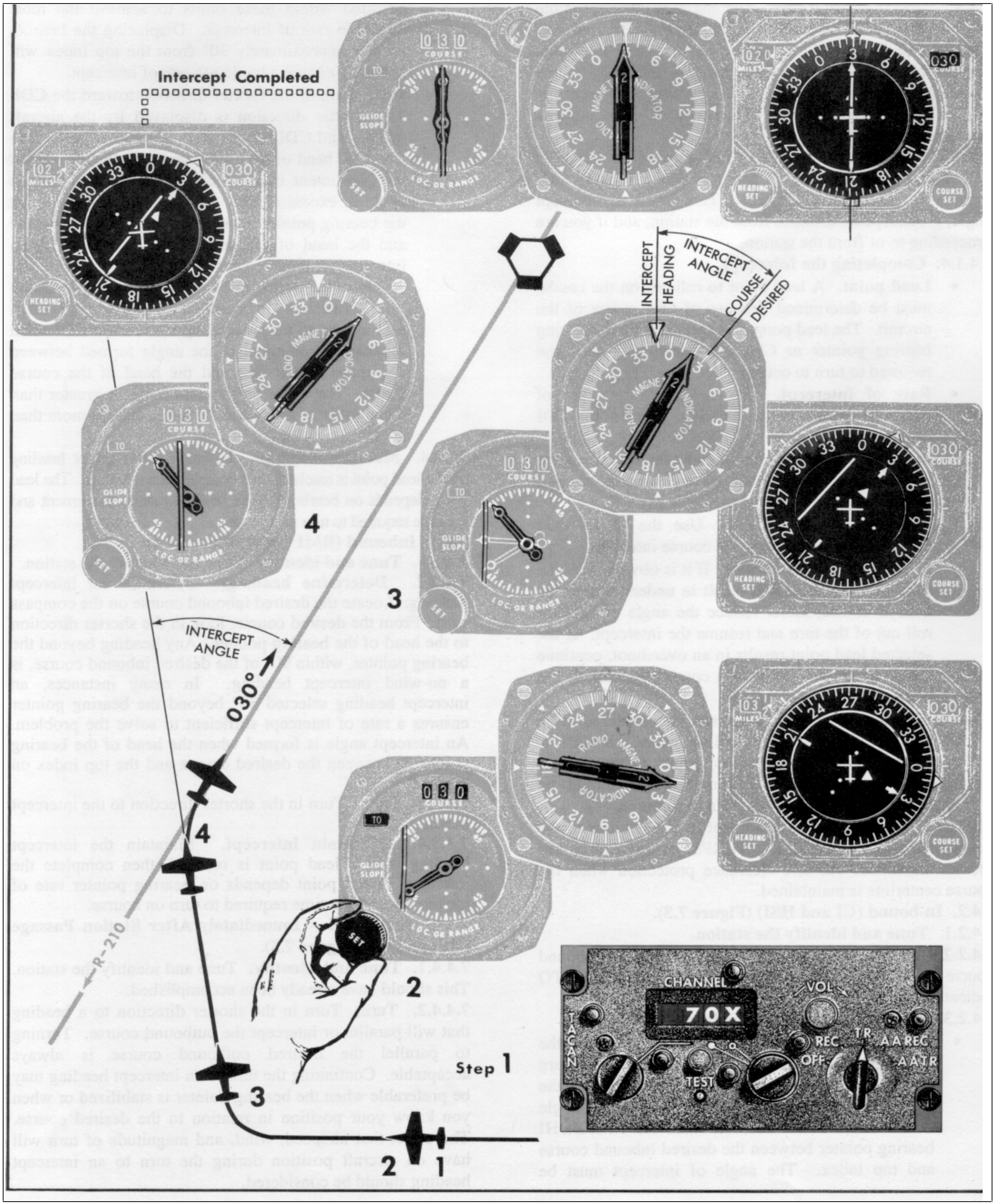
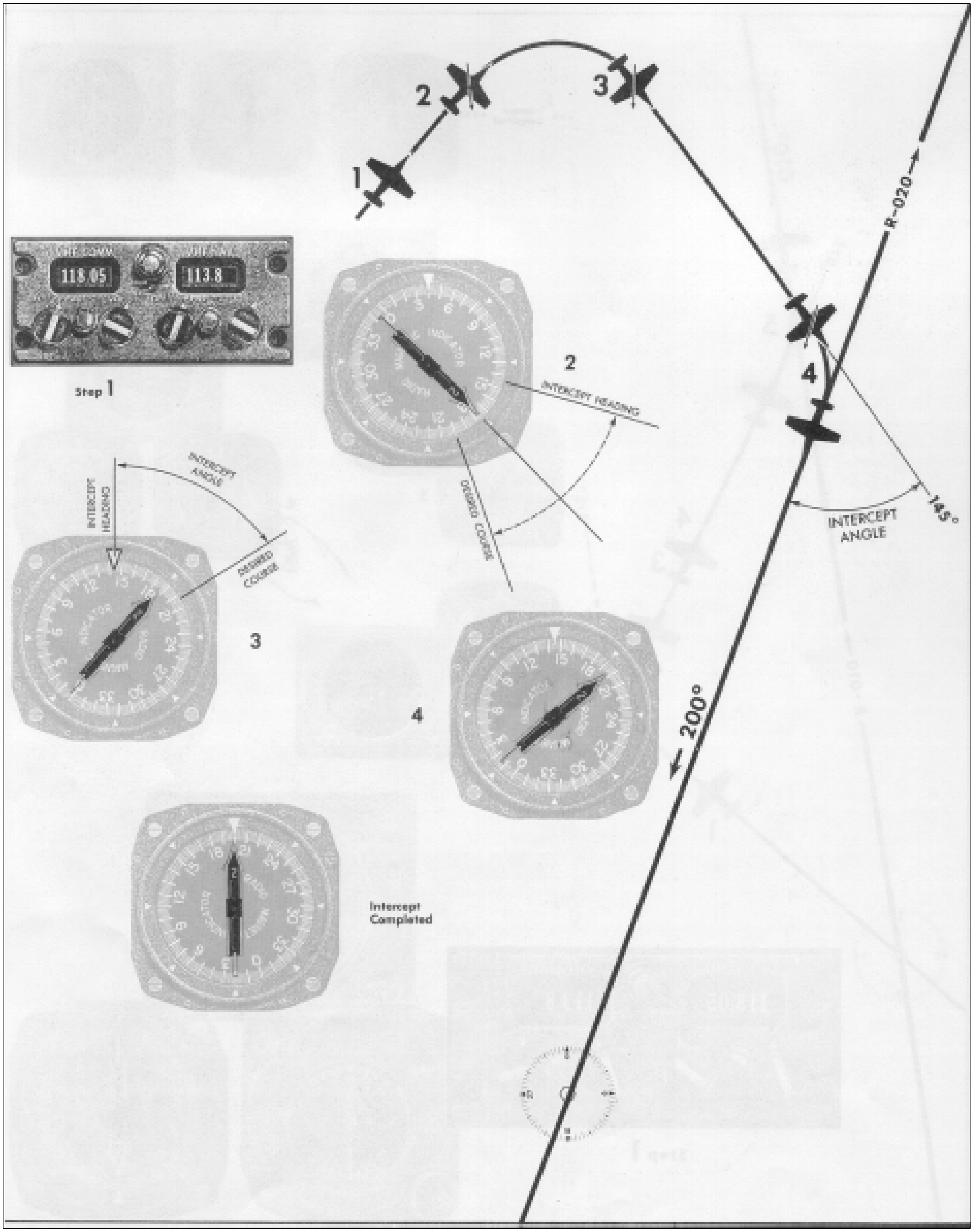


Figure 7.4. Inbound Course Interceptions (RMI Only) (para 7.4.3).



7.4.2.3.2. HSI. Turn in the shorter direction toward the CDI. The shorter direction is displayed by the aircraft symbol and CDI relationship. Continue the turn to place the head of the course arrow in the top half of the instrument case. This precludes an intercept angle in excess of 90°. Roll out of the turn when the bearing pointer is between the upper lubber line and the head of the course arrow to establish an intercept heading. Displacing the bearing pointer 30° from the upper lubber line will normally ensure a moderate rate of intercept. The aircraft symbol will appear to be proceeding toward the CDI at an intercept angle equal to the angle formed between the upper lubber line and the head of the course arrow. The angle of intercept must be greater than the number of degrees off course, but not more than 90°.

7.4.2.4. Maintain intercept. Maintain the intercept heading until a lead point is reached, then complete the intercept. The lead point depends on bearing pointer or CDI rate of movement and the time required to turn on course.

7.4.3. Inbound (RMI Only) (Figure 7.4).

7.4.3.1. Tune and identify. Tune and identify the station.

7.4.3.2. Determine heading. Determine an intercept heading. Locate the desired inbound course on the compass card. From the desired course, look in the shorter direction to the head of the bearing pointer. Any heading beyond the bearing pointer, within 90° of the desired inbound course, is a no-wind intercept heading. In many instances, an intercept heading selected 30° beyond the bearing pointer ensures a rate of intercept sufficient to solve the problem. An intercept angle is formed when the head of the bearing pointer is between the desired course and the top index on the RMI.

7.4.3.3. Turn. Turn in the shorter direction to the intercept heading.

7.4.3.4. Maintain intercept. Maintain the intercept heading until a lead point is reached, then complete the intercept. Lead point depends on bearing pointer rate of movement and the time required to turn on course.

7.4.4. Outbound -- Immediately After Station Passage (HSI and CI) (Figure 7.5).

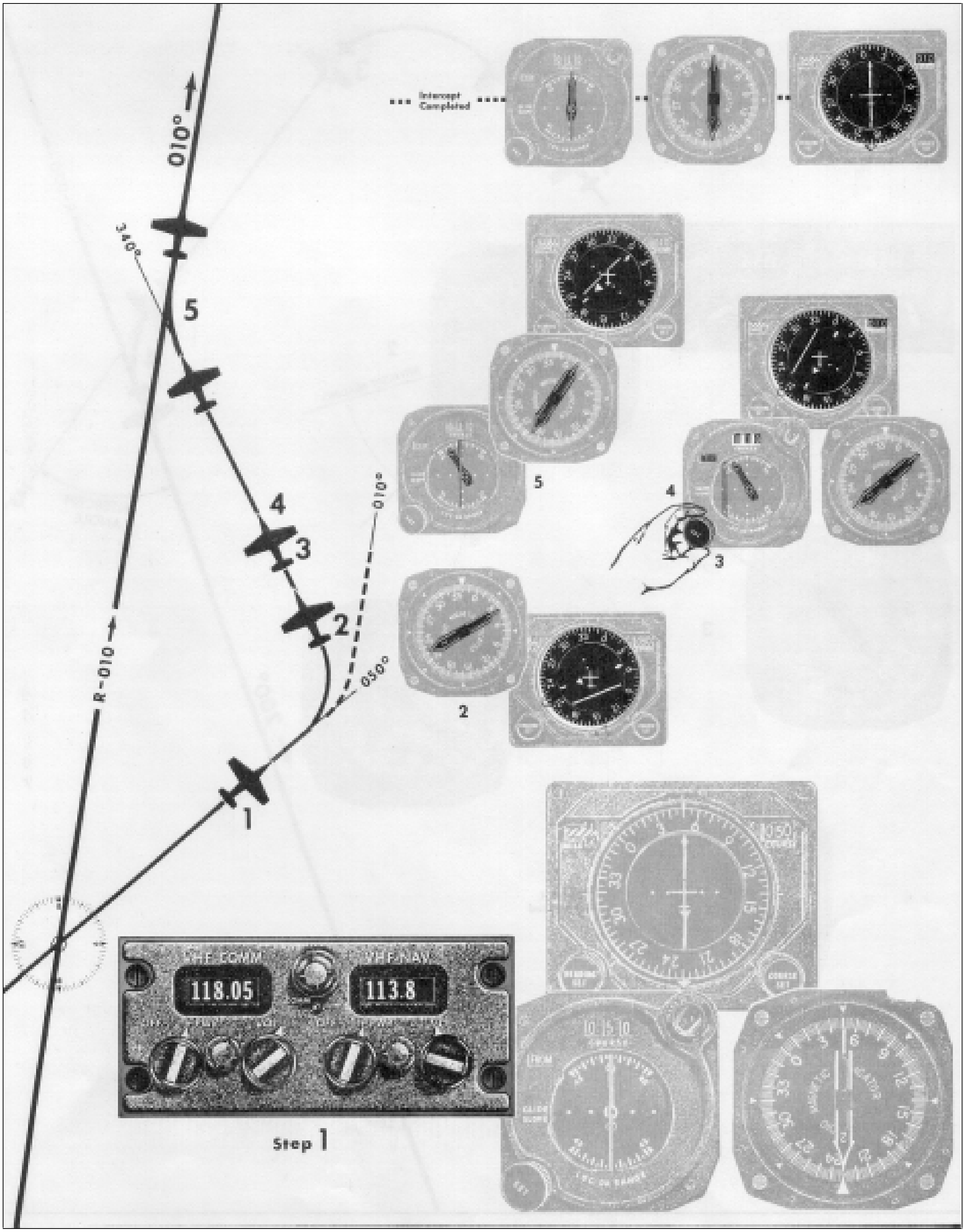
7.4.4.1. Tune and Identify. Tune and identify the station. This should have already been accomplished.

7.4.4.2. Turn. Turn in the shorter direction to a heading that will parallel or intercept the outbound course. Turning to parallel the desired outbound course is always acceptable. Continuing the turn to an intercept heading may be preferable when the bearing pointer is stabilized or when you know your position in relation to the desired course. The effect that airspeed, wind, and magnitude of turn will have on aircraft position during the turn to an intercept heading should be considered.

7.4.4.3. Set course. Set the desired course in the course selector window and check for FROM indication.

7.4.4.4. Turn to Intercept. Turn to an intercept heading if not previously accomplished. Determine the number of degrees off course as indicated by CDI displacement or angular difference between the tail of the bearing pointer and the desired course. If the initial turn was to parallel the desired course, turn toward the CDI to establish an intercept angle approximately equal to the number of degrees off course. Normally, to avoid overshooting, an intercept angle greater than 45° should not be used.

Figure 7.5. Outbound Course Interceptions-Immediately After Station Passage (Course Indicator and RMI: HSI) (para 7.4.4).



7.4.4.5. Maintain. Maintain the intercept heading until a lead point is reached, then complete the intercept. The lead point depends on bearing pointer or CDI rate of movement and the time required to turn on course.

7.4.5. Outbound -- Immediately After Station Passage (RMI Only) (Figure 7.6).

7.4.5.1. Tune and Identify. Tune and identify the station. This should have already been accomplished.

7.4.5.2. Turn. Turn in the shorter direction to a heading that will parallel or intercept the outbound course. Refer to paragraph 7.4.4 above (Outbound - Immediately After Station Passage (HSI and CI)).

7.4.5.3. Degrees Off Course. Determine the number of degrees off course. Note the angular difference between the tail of the bearing pointer and the desired course.

7.4.5.4. Intercept Heading. Determine an intercept heading. If a suitable intercept angle was not established during the initial turn, look from the tail of the bearing pointer to the desired course. Any heading beyond the desired course is a no-wind intercept heading. Turn in this direction an amount approximately equal to the number of degrees off course. Normally, to avoid overshooting the course, do not use an intercept angle greater than 45°.

NOTE: On some aircraft, the RMI/BDHI bearing pointer does not have a tail. In this case, turn to the magnetic heading of the desired course. Continue on the outbound magnetic heading of the desired course until the bearing pointer stabilizes. Note the number of degrees the bearing pointer is off the tail of the aircraft. This is the number of degrees off course. Any heading change in the direction toward the head of the bearing pointer is a no-wind intercept heading. Turn in the direction of the head of the bearing pointer an amount approximately equal to the number of degrees off course. Normally, to avoid overshooting the course, do not use an intercept angle greater than 45°.

7.4.5.5. Adjust intercept. Turn to an intercept heading if not previously accomplished.

7.4.5.6. Maintain. Maintain the intercept heading until a lead point is reached, then complete the intercept. The lead point depends on the bearing pointer rate of movement and the time required to turn on course.

7.4.6. Outbound-Away from the Station (HSI and CI) (Figure 7.7).

7.4.6.1. Tune and identify. Tune and identify the station.

7.4.6.2. Set. Set the desired outbound course in the course selector window.

7.4.6.3. Turn. Turn to an intercept heading:

Figure 7.6. Outbound Course Interceptions-Immediately After Station Passage (RMI Only) (para 7.4.5).

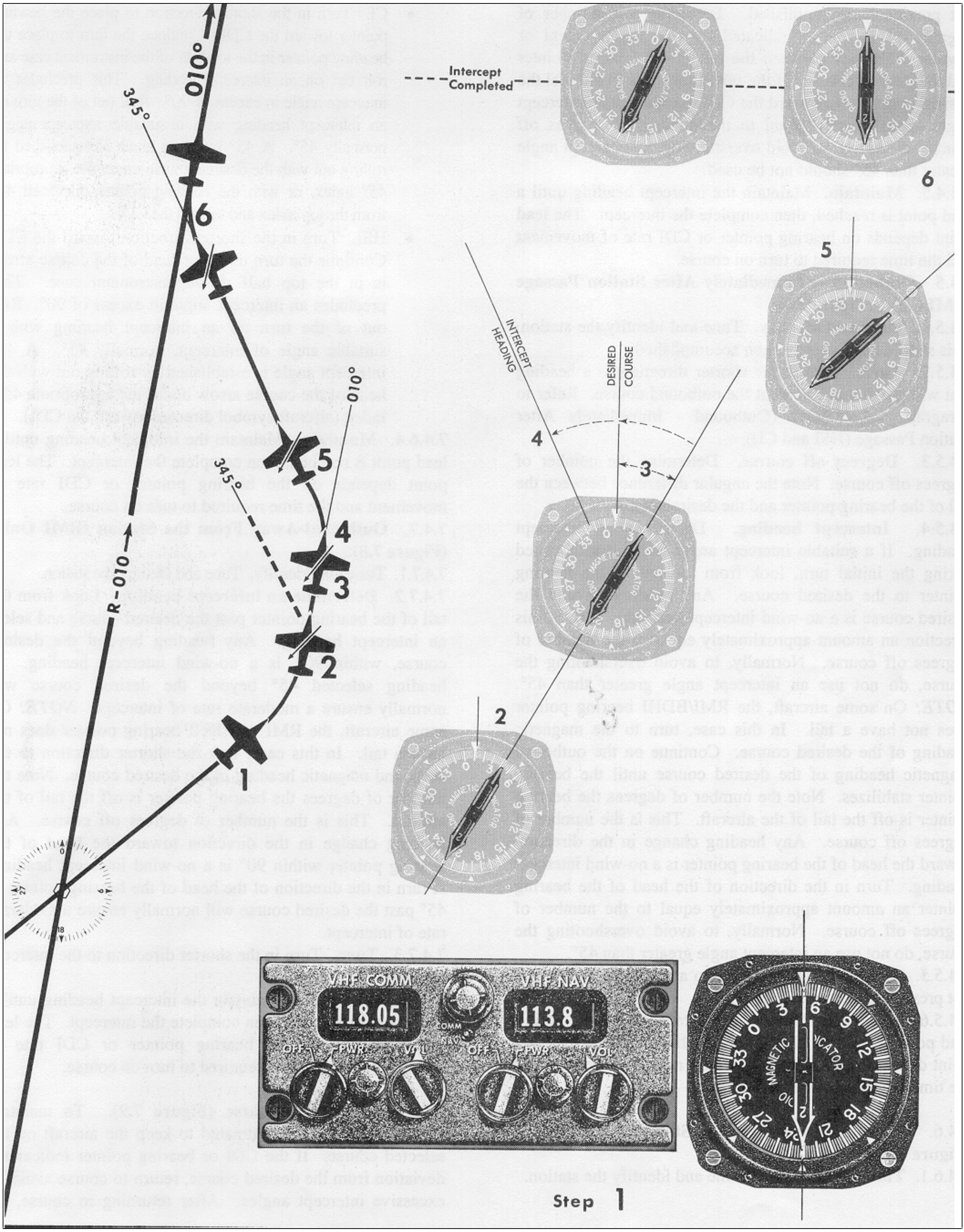
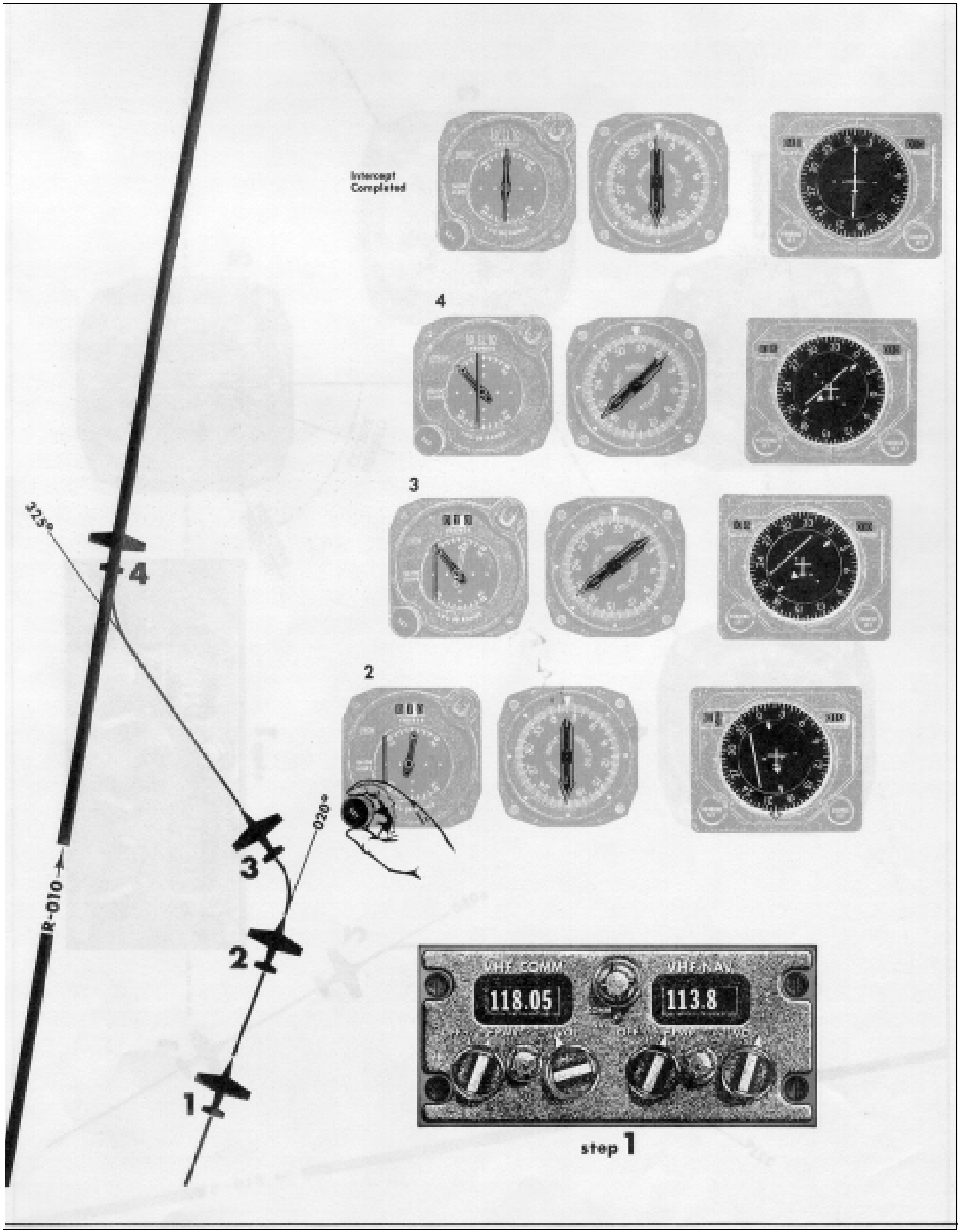


Figure 7.7. Outbound Course Interceptions-Away From the Station (Course Indicator and RMI; HSI) (para 7.4.6).



CI. Turn in the shorter direction to place the heading pointer toward the CDI. Continue the turn to place the heading pointer in the top half of the instrument case and roll out on an intercept heading. This precludes an intercept angle in excess of 90°. Roll out of the turn on an intercept heading with a suitable intercept angle, normally 45°. A 45° intercept angle is established by rolling out with the desired course under the appropriate 45° index, or with the heading pointer displaced 45° from the top index and toward the CDI.

HSI. Turn in the shorter direction toward the CDI. Continue the turn until the head of the course arrow is in the top half of the instrument case. This precludes an intercept angle in excess of 90°. Roll out of the turn on an intercept heading with a suitable angle of intercept, normally 45°. A 45° intercept angle is established by rolling out with the head of the course arrow under the appropriate 45 ° index (aircraft symbol directed toward the CDI).

7.4.6.4. Maintain. Maintain the intercept heading until a lead point is reached, then complete the intercept. The lead point depends on the bearing pointer or CDI rate of movement and the time required to turn on course.

7.4.7. Outbound-Away From the Station (RMI Only) (Figure 7.8).

7.4.7.1. Tune and identify. Tune and identify the station.

7.4.7.2. Determine an intercept heading. Look from the tail of the bearing pointer past the desired course and select an intercept heading. Any heading beyond the desired course, within 90°, is a no-wind intercept heading. A heading selected 45° beyond the desired course will normally ensure a moderate rate of intercept.

NOTE: On some aircraft, the RMI or BDHI bearing pointer does not have a tail. In this case, turn the shorter direction to the outbound magnetic heading of the desired course. Note the number of degrees the bearing pointer is off the tail of the aircraft. This is the number of degrees off course. Any heading change in the direction toward the head of the bearing pointer within 90° is a no-wind intercept heading. A turn in the direction of the head of the bearing pointer of 45° past the desired course will normally ensure a moderate rate of intercept.

7.4.7.3. Turn. Turn in the shorter direction to the intercept heading.

7.4.7.4. Maintain. Maintain the intercept heading until a lead point is reached, then complete the intercept. The lead point depends on the bearing pointer or CDI rate of movement and the time required to turn on course.

7.5. Maintaining Course (Figure 7.9). To maintain course, fly a heading estimated to keep the aircraft on the selected course. If the CDI or bearing pointer indicates a deviation from the desired course, return to course avoiding excessive intercept angles. After returning to course, re-estimate the drift correction required to keep the CDI centered or the bearing pointer pointing to the desired course. (The CDI and bearing pointer may show a rapid movement from the on-course indication when close to the station. In this situation, avoid making large heading changes because actual course deviation is probably small due to proximity to the station).

Figure 7.8. Outbound Course Interceptions-Away From the Station (RMI Only) (para 7.4.7).

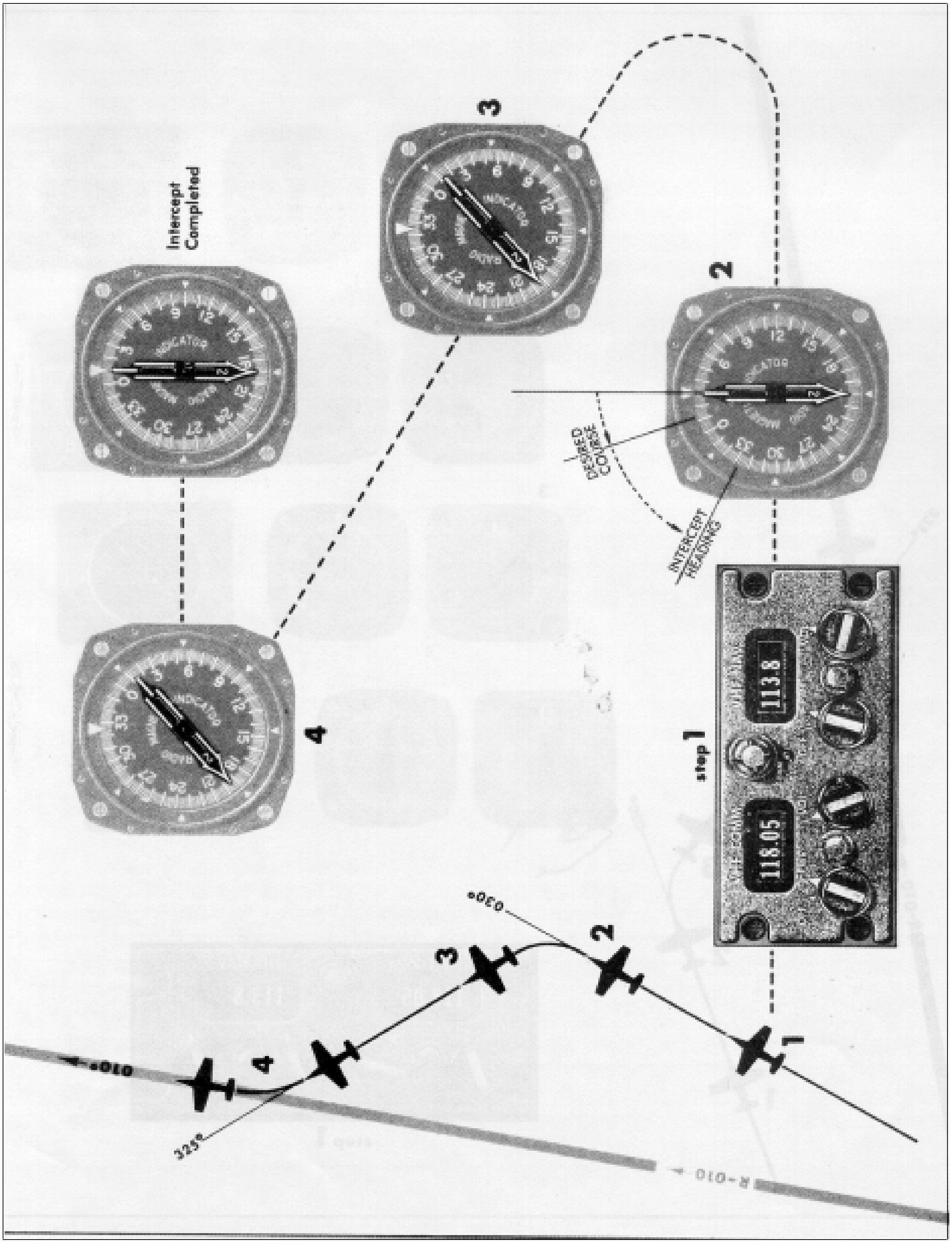
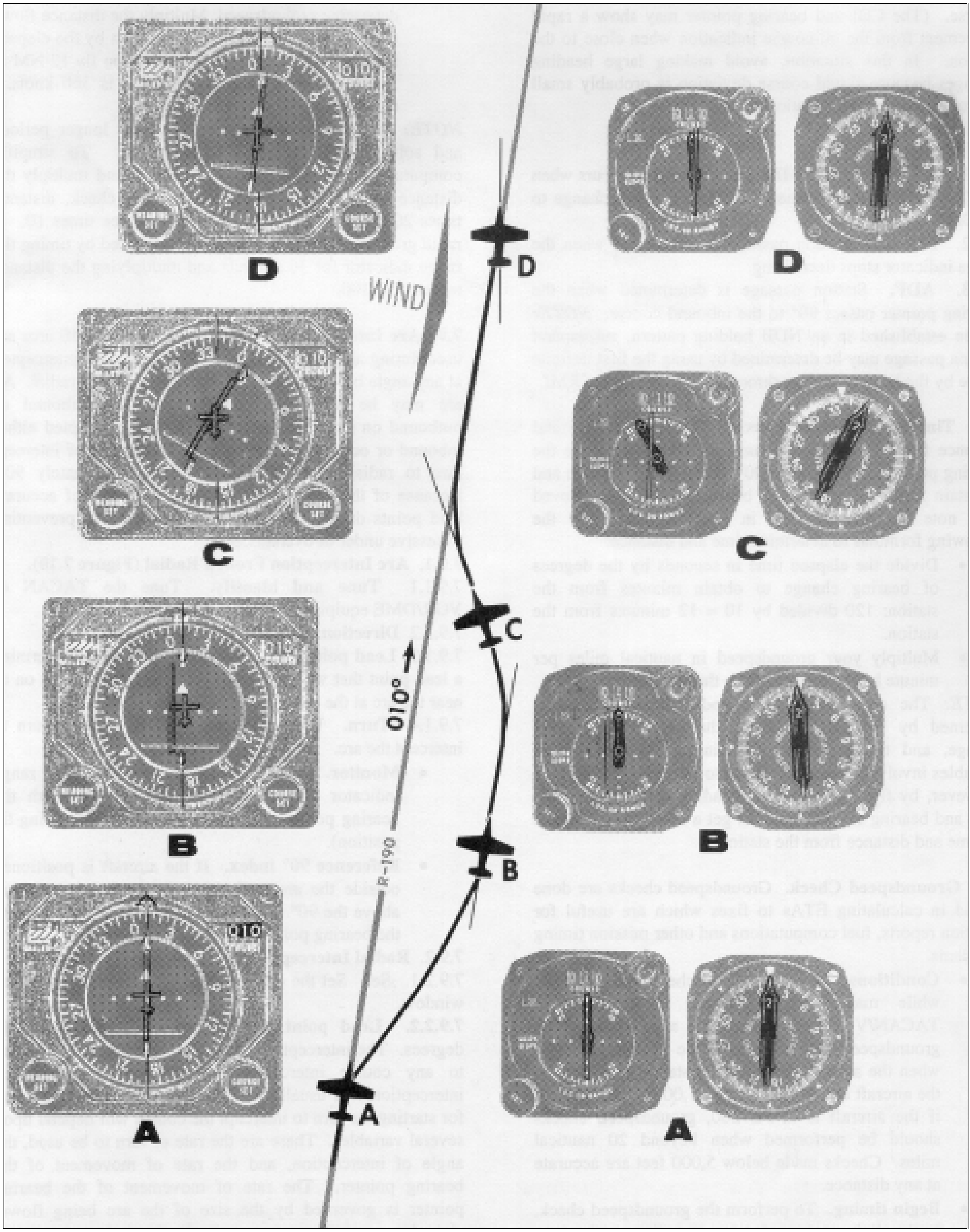


Figure 7.9. Maintaining Course (para 7.5).



7.6. Station Passage.

7.6.1. VOR and VOR/DME. Station passage occurs when the TO-FROM indicator makes the first positive change to FROM.

7.6.2. TACAN. Station passage is determined when the range indicator stops decreasing.

7.6.3. ADF. Station passage is determined when the bearing pointer passes 90° to the inbound course.

NOTE: When established in an NDB holding pattern, subsequent station passage may be determined by using the first definite move by the bearing pointer through 45° index on the RMI.

7.7. Time and Distance Check. To compute time and distance from a station, first turn the aircraft to place the bearing pointer on the nearest 90° index. Note the time and maintain heading. When the bearing pointer has moved 10°, note the elapsed time in seconds and apply the following formulas to determine time and distance:

–Divide the elapsed time in seconds by the degrees of bearing change to obtain minutes from the station: 120 divided by 10 = 12 minutes from the station.
–Multiply your groundspeed in nautical miles per minute by the minutes from the station.

NOTE: The accuracy of time and distance checks is governed by the existing wind, the degree of bearing change, and the accuracy of timing. The number of variables involved causes the result to be an approximation. However, by flying an accurate heading and checking the time and bearing closely, you can get a reasonable estimate of time and distance from the station.

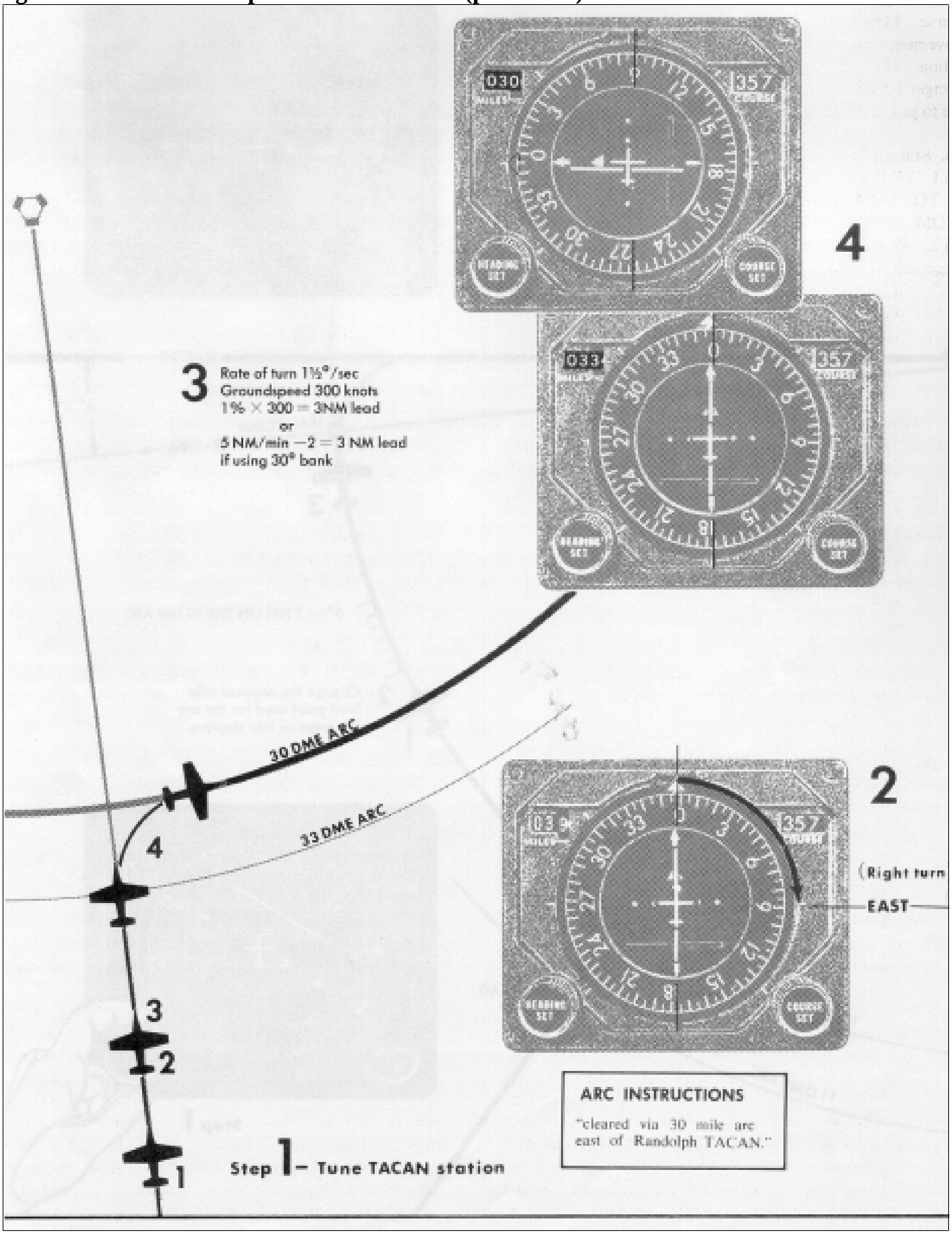
7.8. Groundspeed Check. Groundspeed checks are done to aid in calculating ETAs to fixes which are useful for position reports, fuel computations and other mission timing problems.

7.8.1. Conditions. A groundspeed check can be made while maintaining a course to or from a TACAN/VORTAC station. As a guide, however, groundspeed checks should be performed only when the aircraft slant range distance is more than the aircraft altitude divided by 1,000. For example, if the aircraft is at FL 200, groundspeed checks should be performed when beyond 20 nautical miles. Checks made below 5,000 feet are accurate at any distance.

7.8.2. Begin timing. To perform the groundspeed check, begin timing when the range indicator shows a whole number. After the predetermined time has elapsed, check the range indicator and note the distance flown. Apply the following formula to determine groundspeed: Multiply the distance flown times 60 and then divide the product by the elapsed time in minutes. For example, if you fly 12 NM in 2 minutes, then your groundspeed is 360 knots. ((12 NM x 60)/2 min = 360 knots)

NOTE: For precise computation, time for longer periods and solve the problems on a computer. To simplify computations, use a 2-minute time check and multiply the distance traveled by 30, a 3-minute time check, distance times 20; or a 6-minute time check, distance times 10. A rapid groundspeed check can be accomplished by timing the range indicator for 36 seconds and multiplying the distance traveled by 100.

Figure 7.10. Arc Interception From a Radial (para 7.9.1).



7.9. Arc Interceptions. TACAN and VOR/DME arcs are used during all phases of flight. An arc may be intercepted at any angle but it is normally intercepted from a radial. An arc may be intercepted when proceeding inbound or outbound on a radial. A radial may be intercepted either inbound or outbound from an arc. The angles of intercept (arc to radial or radial to arc) are approximately 90°. Because of the large intercept angles, the use of accurate lead points during the interception will aid in preventing excessive under or overshoots.

7.9.1. Arc Interception from a Radial (Figure 7.10).

7.9.1.1. Tune and Identify. Tune the TACAN or VOR/DME equipment.

7.9.1.2. Direction. Determine the direction of turn.

7.9.1.3. Lead Point. Determine the lead point. Determine a lead point that will result in positioning the aircraft on or near the arc at the completion of the initial turn.

7.9.1.4. Turn. When the lead point is reached, turn to intercept the arc.

7.9.1.4.1. Monitor. Monitor the bearing pointer and range indicator during the turn, and roll out with the bearing pointer on or near the 90° index (wing-tip position).

7.9.1.4.2. Reference 90° index. If the aircraft is positioned outside the arc, roll out with the bearing pointer above the 90° index; if inside the arc, roll out with the bearing pointer below the 90° index.

7.9.2. Radial Interception From an Arc (Figure 7.11).

7.9.2.1. Set. Set the desired course in the course selector window.

7.9.2.2. Lead Point. Determine the lead required in degrees. The interception of a radial from an arc is similar to any course interception except that the angle of interception will usually approximate 90°. The lead point for starting the turn to intercept the course will depend upon several variables. These are the rate of turn to be used, the angle of interception, and the rate of movement of the bearing pointer. The rate of movement of the bearing pointer is governed by the size of the arc being flown, aircraft true airspeed, wind direction and velocity.

7.9.2.3. Turn. When the lead point is reached, turn to intercept the selected course. Monitor the course deviation indicator or bearing pointer during the turn and roll out on course or with a suitable correction to course.

7.9.3. Maintaining an Arc. Control aircraft heading to keep the bearing pointer on or near the 90° index (reference point) and the desired range in the range indicator. Some techniques for accomplishing this are:

7.9.3.1. Bank Angle. Establish a small bank angle that will result in a rate of turn that will keep the bearing pointer on the selected reference point. A reference point other than the 90° index must be used when operating in a crosswind. If the aircraft drifts toward the station, select a reference point below the 90° index. If the drift is away from the station, select a reference point above the 90° index. The selected reference point should be displaced from the 90° index an amount equal to the required drift correction. Monitor the range indicator to ensure the range remains constant. The angle of bank will depend upon the size of the arc, wind, and true airspeed (TAS). This technique is more suitable when flying a relatively small arc at a high airspeed.

7.9.3.2. Short Legs. Fly a series of short, straight legs to maintain the arc. To fly an arc in this manner, adjust the aircraft heading to place the bearing pointer 5° to 10° above the selected reference point. Maintain heading until the bearing pointer moves 5° to 10° below the reference point. The range should decrease slightly while the bearing pointer is above the reference point, and increase slightly when below the reference point. The arc is more closely maintained by flying shorter legs-controlling the heading to keep the bearing pointer nearer to the reference point. Adjust heading and reference point as necessary.

Figure 7.11. Radial Interception From an Arc (para 7.9.2).

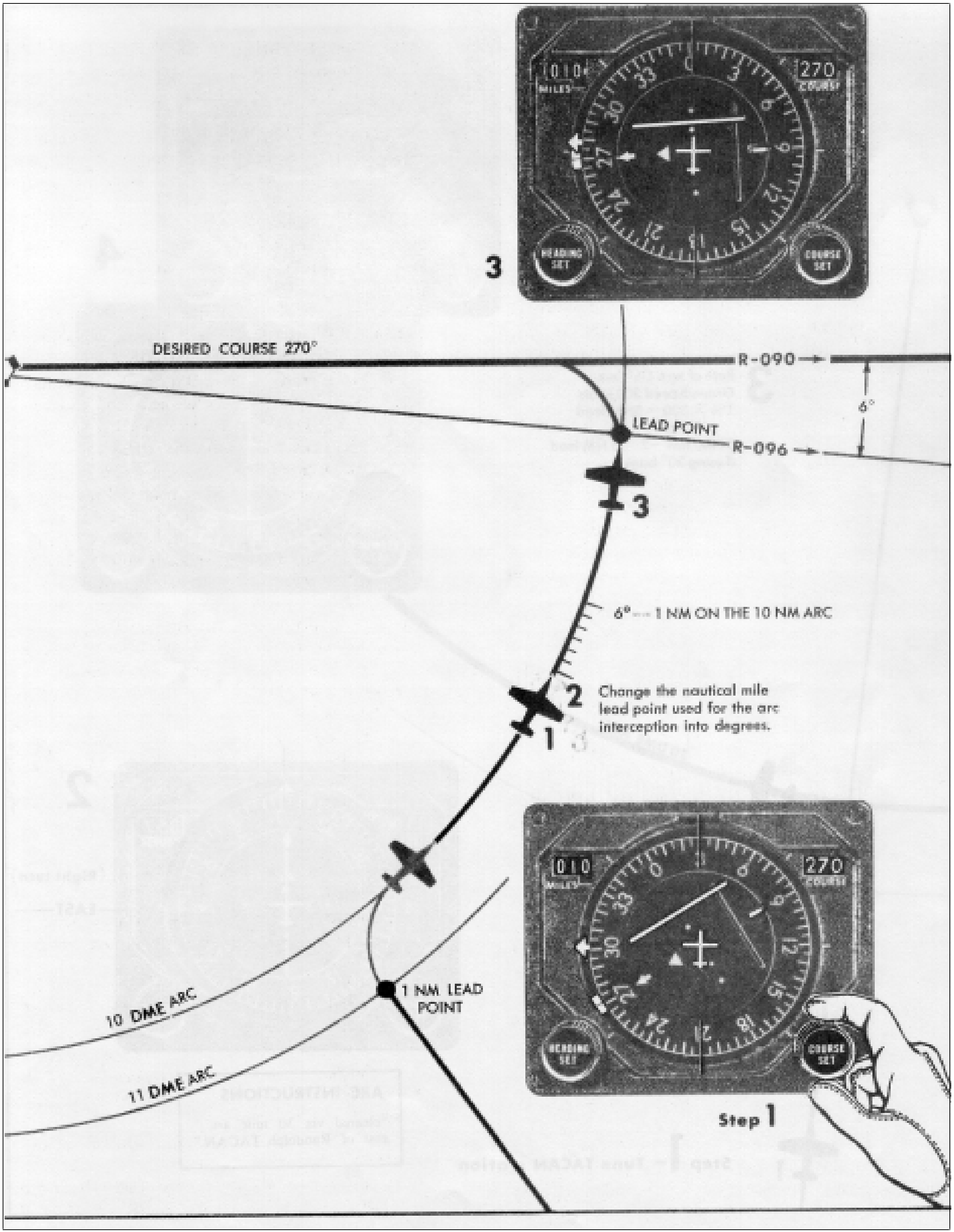


Figure 7.12. Correcting to Maintain an Arc (para 7.9.3.3).

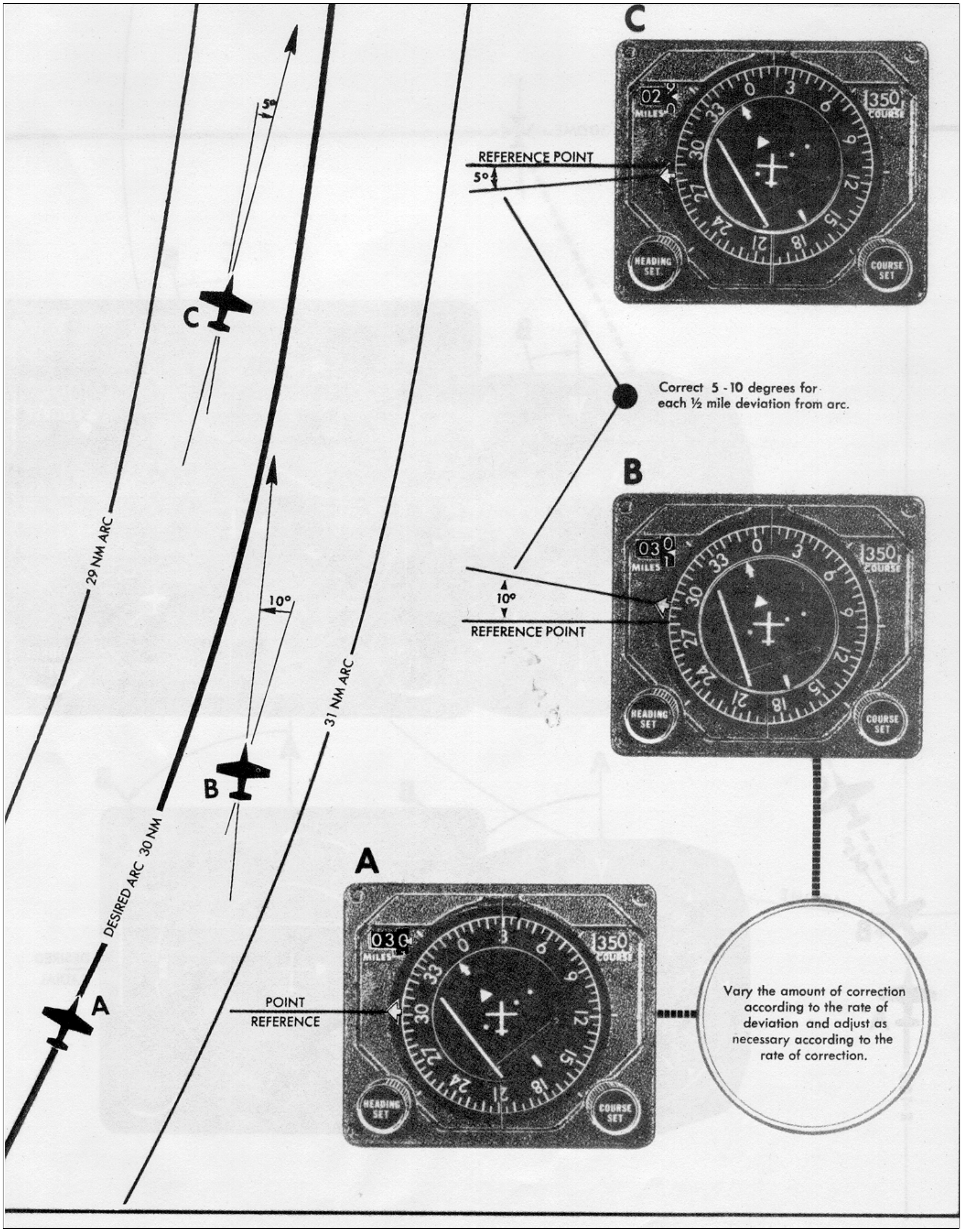
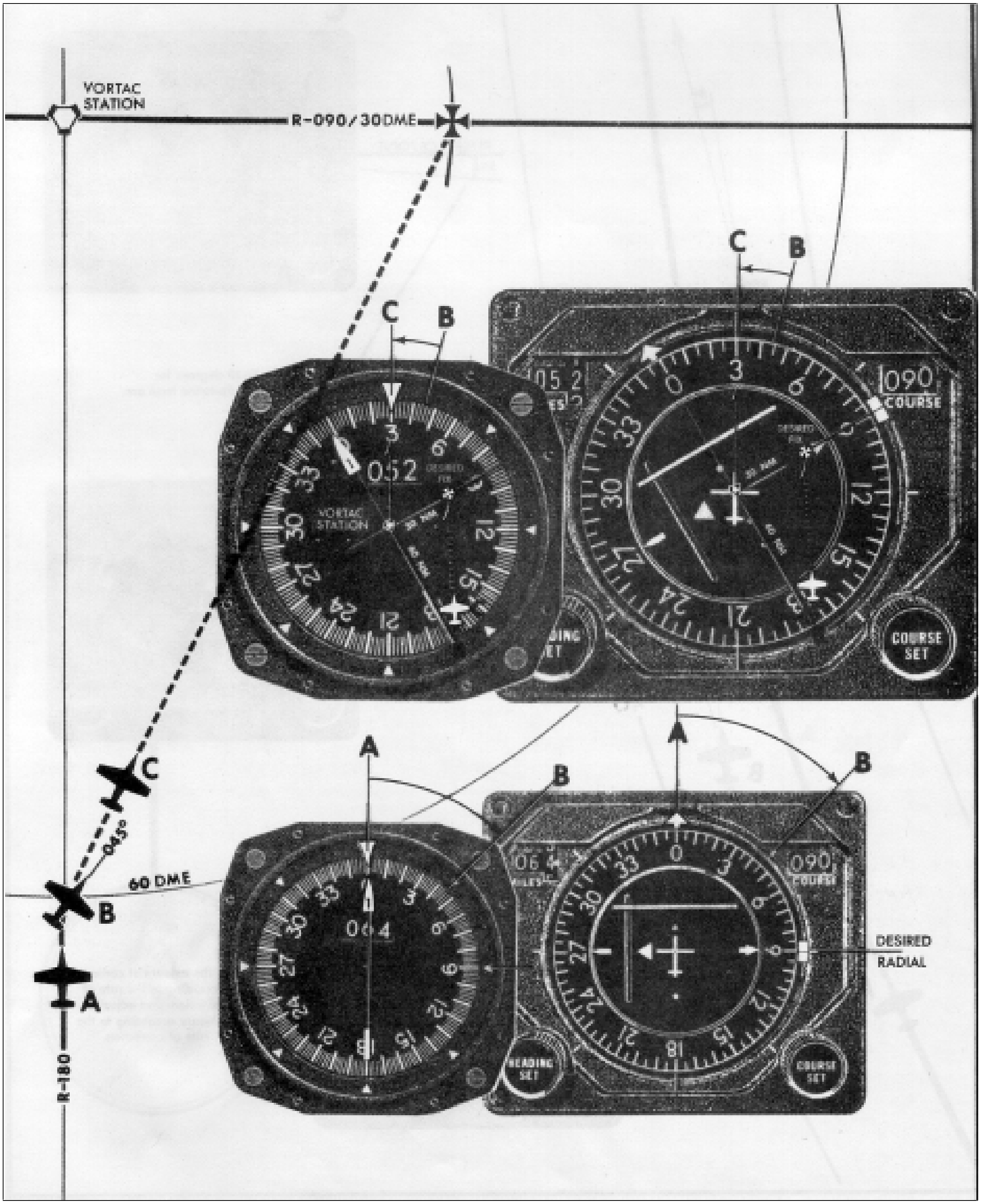


Figure 7.13. Proceeding Direct to a DME Fix (para 7.10).



7.9.3.3. Adjust. To correct to the arc, change aircraft heading to displace the bearing pointer as desired about the reference point (**Figure 7.12**). The size of the correction must be adequate to return the aircraft to the arc, and is dependent upon the magnitude and rate of deviation from the arc. The rate of deviation from or correction to an arc will vary with the size of the arc, whether the aircraft is inside or outside the arc, TAS of the aircraft, wind direction and velocity. A small arc has a relatively sharp curvature, and deviation to or from the arc can occur rapidly. Corrections from inside an arc are assisted by the curvature of the arc. Conversely, corrections from outside the arc for a like amount of deviation must necessarily be larger to offset the effect of arc curvature. The effects of aircraft TAS and wind are self-evident. These many variables make it impossible to use a consistent correction for a given deviation. The following technique may be used for determining the size correction to use:

7.9.3.3.1. Displace. Displace the bearing pointer 5° from the reference point for each one-half mile deviation to the inside of the arc, and 10° for each one-half mile outside the arc.

7.9.3.3.2. Deviation. If the deviation is greater than the normal lead required for a 90° interception, consider using "arc interception" procedures rather than "correcting to the arc."

7.10. Proceeding Direct to a VOR/DME or TACAN Fix. To proceed direct from one fix to another is often required during departures, approaches, or when maneuvering in a terminal area. Bearing and range information from a VOR/DME or TACAN facility is sufficient for navigating direct to any fix within reception range. The following are some techniques to accomplish a fix-to-fix (**Figure 7.13**):

7.10.1. Tune. Tune the TACAN or VOR/DME equipment and, if not proceeding in the general direction of the desired fix, turn to a heading approximately halfway between the head of the bearing pointer and radial on which the desired fix is located.

7.10.2. Turn. The objective is to turn in the general direction of the desired fix rather than fly away from the fix while attempting to determine a precise heading.

7.10.2.1. HSI. When using an HSI, the desired radial should be set in the course selector window and the aircraft turned to a heading between the head of the bearing pointer and the head of the course arrow.

7.10.2.2. Initial Turn. The initial turn may be adjusted to roll out on a heading other than halfway between the bearing pointer and the desired fix and present location. If the range must be decreased, roll out on a heading closer to the bearing pointer. To increase the range, roll out on a heading closer to the desired radial.

7.10.3. Visualize. Visualize the aircraft position and the desired fix on the compass card of an RMI or similar instrument. The following factors must be understood when visually establishing the aircraft position and the desired fix on the compass card.

7.10.3.1. Station Location. The station is located at the center of the compass card, and the compass rose simulates the radials around the station.

7.10.3.2. Aircraft Position. The aircraft position is visualized along the reciprocal (radial) of the bearing pointer.

7.10.3.3. Fix. The fix with the greater range is established at the outer edge of the compass card. The fix with the lesser range is visualized at a point that is proportional to the distance represented by the outer edge of the compass card.

7.10.4. Determine Heading. Determine a precise heading from the aircraft position to the desired fix. Determine the heading to the fix by connecting the aircraft position to desired fix with an imaginary line. Establish another line in the same direction, parallel to the original line through the center of the compass card. This will establish a no-wind heading to the desired fix.

7.10.5. Adjust Heading. Adjust aircraft heading as necessary and proceed to the fix.

7.10.5.1. Drift. Apply any known wind drift correction. The effect of wind drift and any inaccuracy of the initial solution may be compensated for by repeating the previous steps while en route. As the aircraft approaches the desired fix, adjust the heading as necessary to intercept the arc or radial or to comply with route clearance beyond the fix.

7.10.5.2. Distance. The distance to the desired fix can be estimated since the distance between the aircraft position and the desired fix is proportionate to the distance established from the center to outer edge of the compass card.

7.10.6. Update. Update heading continuously enroute to refine your solution and correct for winds.

NOTE: The same problem can be easily and more accurately solved on the CPU/26A computer. This is done on the wind face by imagining that the center grommet is the station and applying the same basic techniques as in b, c, and d above.

7.11. Area Navigation (RNAV).

7.11.1. Definitions.

7.11.1.1. Area Navigation (RNAV). A method of navigation permitting aircraft operations on any desired course within the coverage and capabilities of the aircraft onboard navigation equipment.

7.11.1.2. Aircraft RNAV Equipment. Any of the various types and (or) combinations of onboard equipment required to file and fly RNAV. These include INS, TACAN/VOR/DME-based FMS, Integrated/Embedded GPS, or Loran-C.

7.11.1.3. RNAV Waypoint. A predetermined geographical position used for route or instrument procedure definition normally defined in terms of latitude and longitude coordinates or radial/distance relative to a ground based navigation facility.

7.11.1.4. Designated RNAV Route. Permanent, published and charted airway routes based on area navigation equipment, they are available for use by aircraft with RNAV capability..

7.11.1.5. Random RNAV Routes. A direct route flown between any two points using RNAV equipment without reference to airways or jet routes.

7.11.1.6. Required Navigation Performance. A statement of the aircraft navigation performance necessary for operation within a defined airspace.

7.11.1.7. Required Navigation Performance Type (RNP Type). A value stating the actual position of the aircraft for at least 95 percent of the total flying time from the intended position of that aircraft. The value is a must remain within value and is typically expressed as a distance in (longitudinal and lateral) nautical miles (e.g., RNP-5 airspace requires an aircraft to be within 5 miles of its intended position 95 percent of the time).

7.11.2. RNAV Capability. An aircraft must have equipment capable of displaying a course from a given point (waypoint) to a clearance limit while also providing a continuously updated aircraft position with reference to that course line. An aircraft FMS, INS, LORAN, or integrated GPS navigation system providing course guidance to the aircrew meets this requirement.

7.11.3. RNAV Restrictions.

7.11.3.1. En route. RNAV aircraft must be able to navigate on the intended RNP Type route or within the RNP Type airspace using their onboard navigation equipment. Major Commands certify the accuracy of the RNAV equipment installed in their aircraft and must ensure that backup equipment (VOR/DME, TACAN, etc.) is installed to allow reversion to an alternate means of navigation should RNAV equipment fail.

7.11.3.2. Terminal. RNAV in the terminal area consists of both approach and departure procedures. RNAV equipment may be used as the sole source of navigation information for instrument approaches in suitably equipped and certified aircraft. RNAV approaches must only be retrieved from an aircraft database and not be manually entered. RNAV instrument approach procedure charts incorporate all types of approaches using Area Navigation systems, both ground and satellite based. The approach charts may contain as many as four lines of approach minimums: GLS; LNAV/VNAV; LNAV; and Circling. The minima are dependent on the navigational equipment capability as outlined in General Planning. Typically, the approach chart will indicate the equipment required for the approach, i.e. GPS or RNP-.03 Required. MAJCOMs will certify the capabilities of their aircraft in accordance with civil standards as outlined in the various TSOs and ACs. RNAV equipment may be used as the sole source of navigation information for departures, in suitably certified aircraft, as long as the DP is a RNAV departure (like the WYLYY THREE at KBOS) and can be retrieved from an aircraft database. For both approaches and departures, underlying NAVAIDs (if available) must be tuned and monitored.

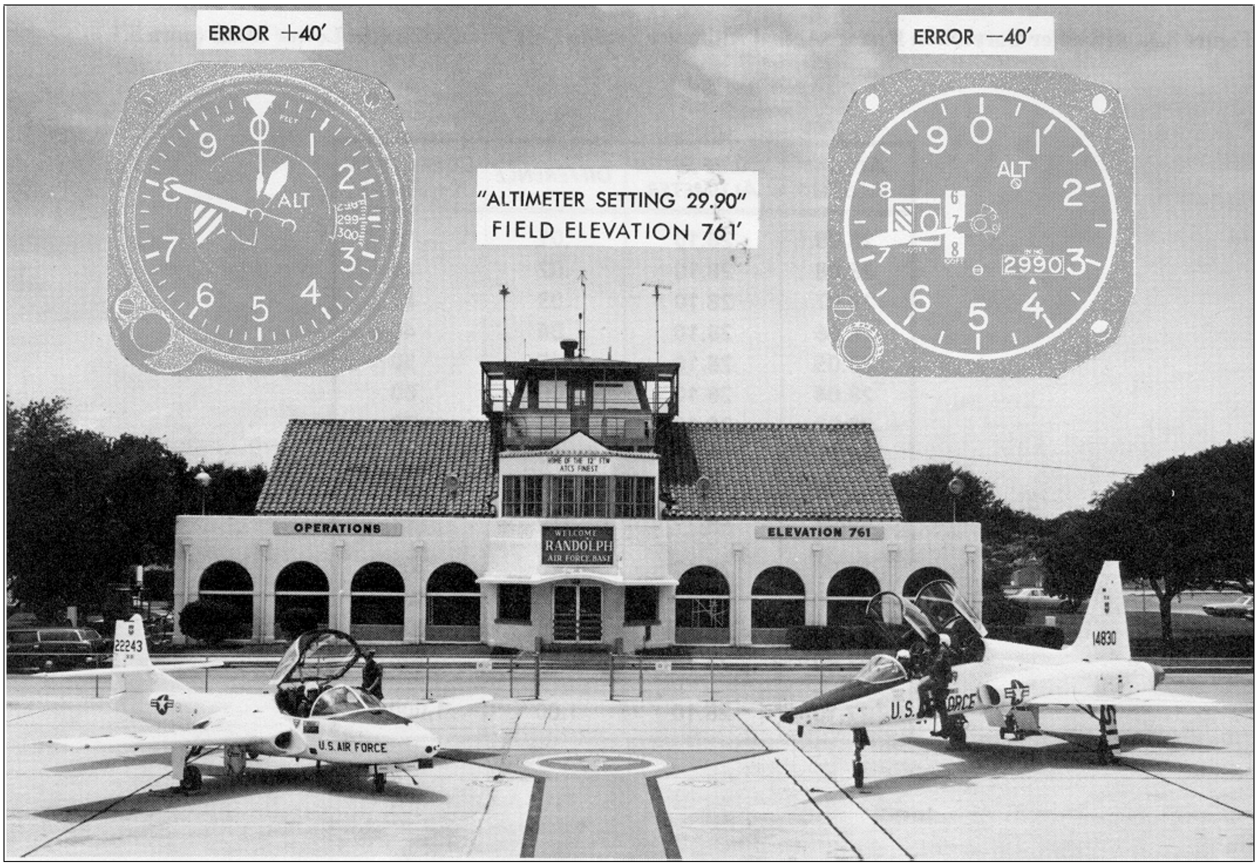
7.11.4. Aircrew Responsibilities. Although RNAV routes (including random routes) may be filed at any time, air traffic control (ATC) will only approve them on an individual basis. Aircrews should have alternate routing and contingency actions planned. ATC considers radar coverage capability and compatibility with traffic flow and volume prior to assigning random RNAV routes. Although ATC provides radar separation on RNAV routes in the national airspace (NAS), navigation and collision avoidance on any RNAV route remains the responsibility of the aircrew. Aircrews must consider the limits of RNAV equipment certification prior to accepting clearance for RNAV routes or RNP airspace. Aircrews should also take advantage of opportunities to update the navigation system while en route. In addition, crews should monitor RNAV equipment performance and be prepared to return to an alternate means of navigation should equipment malfunction require.

Chapter 8

PLANNING AN INSTRUMENT FLIGHT

8.1. Altimeter Setting Procedures (Figure 8.1). ***Accomplish the following procedures at an altimeter checkpoint if practical:*** (Altimeter checkpoints are required at all USAF bases if the takeoff end of the runway varies more than 25 feet from the official field elevation.)

Figure 8.1. Setting the Altimeter (para 8.1).



8.1.1. Procedure. ***Set the reported altimeter setting on the barometric scale. Compare the indicated altitude to the elevation of a known checkpoint. The maximum allowable error is 75 feet. If the altimeter error exceeds 75 feet, the instrument is out of tolerance for flight.*** No further corrections are necessary if the altimeter is within tolerance.

8.1.2. Off-Scale Altimeter Settings. **Figures 8.2** and **8.3** give a sampling of possible altimeter settings and their resulting correction factors.

WARNING: Most altimeters will only accommodate altimeter settings from 28.10 inches to 31.00 inches. Attempting to adjust an altimeter outside this range may cause internal damage to the instrument. At some northern latitude locations, extremely high and low pressures occasionally occur outside this range. When this occurs, a correction may be made to all depicted approach altitudes (DH, MDA, FAF, intermediate altitudes) using a ratio of 10 feet for every .01-inch difference between the actual altimeter setting and the lower or upper limit set in the altimeter. ***If the actual altimeter setting is greater than 31.00 inches, the correction factor will be subtracted from all depicted approach altitudes. If the actual altimeter setting is less than 28.10 inches, the correction factor will be added to all depicted approach altitudes.***

Figure 8.2. Altimeter Correction Factor: Actual Altimeter Setting Exceeds Altimeter Upper Limit (para 8.1.1).

ACTUAL ALSTG	VALUE SET IN ALTIMETER	DIFFERENCE	CORRECTION (- Feet)
31.01	31.00	.01	10
31.02	31.00	.02	20
31.03	31.00	.03	30
31.04	31.00	.04	40
31.05	31.00	.05	50
31.06	31.00	.06	60
31.07	31.00	.07	70
31.08	31.00	.08	80
31.09	31.00	.09	90
31.10	31.00	.10	100
31.20	31.00	.20	200
31.30	31.00	.30	300
31.40	31.00	.40	400
31.50	31.00	.50	500
32.00	31.00	1.00	1,000

Figure 8.3. Altimeter Correction Factor: Actual Altimeter Setting Less than Altimeter Lower Limit (para 8.1.1).

ACTUAL ALSTG	VALUE SET IN ALTIMETER	DIFFERENCE	CORRECTION (+ Feet)
28.09	28.10	.01	10
28.08	28.10	.02	20
28.07	28.10	.03	30
28.06	28.10	.04	40
28.05	28.10	.05	50
28.04	28.10	.06	60
28.03	28.10	.07	70
28.02	28.10	.08	80
28.01	28.10	.09	90
28.00	28.10	.10	100
27.90	28.10	.20	200
27.80	28.10	.30	300
27.70	28.10	.40	400
27.60	28.10	.50	500
27.10	28.10	1.00	1,000

8.1.3. Corrections to Approach Altitudes. To illustrate how these corrections are applied, consider the two approach plate excerpts (**Figures 8.4 and 8.5**).

Figure 8.4. Example 1-Off-Scale Altimeter (para 8.1.3).

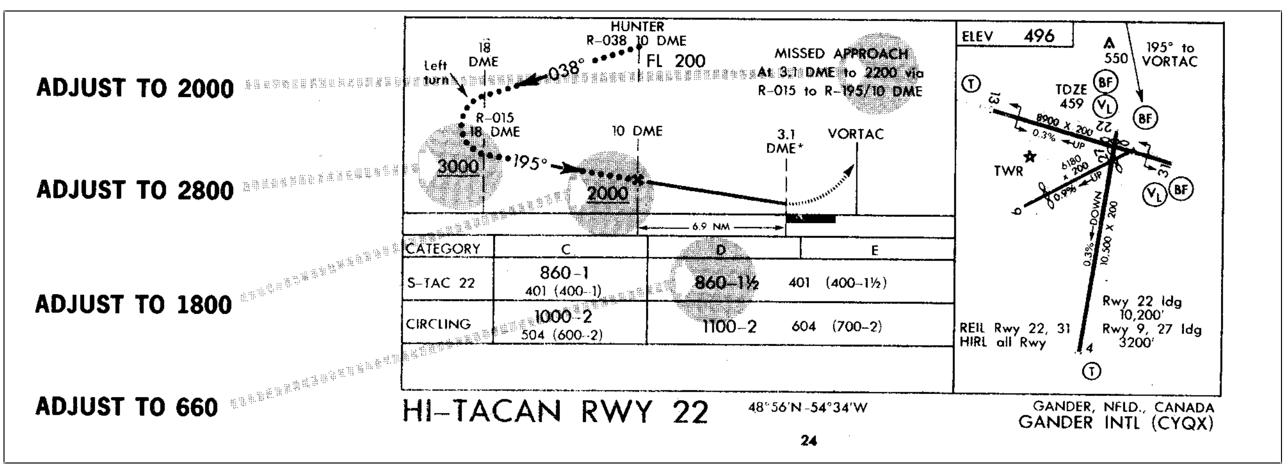
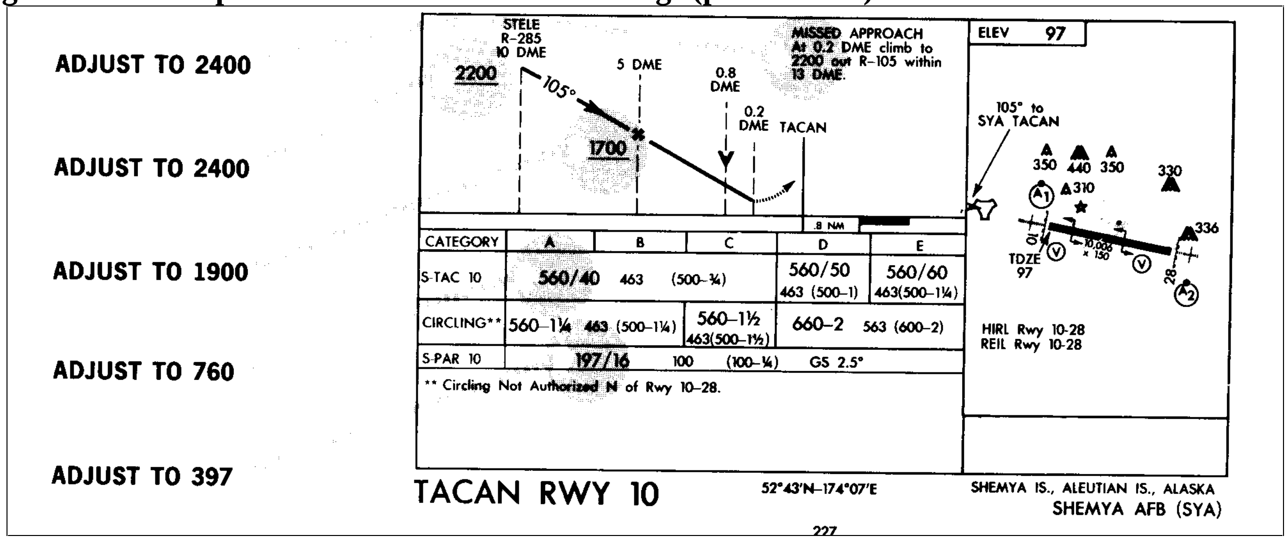


Figure 8.5. Example 2 - Off-scale Altimeter Settings (para 8.1.3.2).



8.1.3.1. Subtracting Corrections. In example one (**Figure 8.4**), you have been cleared to fly the HI-TACAN RWY 22 at Gander INTL. The local altimeter setting is 31.20 inches. Your altimeter's maximum range is 31.00 inches. First, determine the difference between the actual ALSTG (31.20) and the value set in your altimeter (31.00). Take this result (.20) and multiply by 1,000. This will give you your correction factor 200 ft). Because the altimeter setting exceeds the altimeter's maximum range, the correction (200 ft) will be subtracted from all approach altitudes. These corrections are indicated on the approach.

8.1.3.2. Adding Corrections. In example two (**Figure 8.5**), you have been cleared to fly the TACAN RWY 10 at Shemya AFB. The local altimeter setting is 27.90 inches. Your altimeter's minimum range is 28.10 inches. First, determine the difference between the actual ALSTG (27.90) and the value set in your altimeter (28.10). Take this result (.20) and multiply by 1,000. This will give you your correction factor (200 ft). Because the altimeter setting is less than the altimeter's minimum range, the correction (200 ft) will be added to all approach altitudes. These corrections are indicated on the approach.

NOTE: Because high pressure is usually associated with fair weather (VMC), the use of correction factors where the actual altimeter setting exceeds the altimeter upper limit does not present a serious problem. On the other hand, low ceilings and visibilities are often associated with extremely low pressure (low altimeter settings). Aircraft that must execute an actual instrument approach (IMC) under these conditions should consider this situation an emergency. It is further recommended that all available approach and navigation aids (radar altimeters, GCA monitored approach, etc.) be used to determine aircraft position and altitude.

8.1.4. Cold Weather Altimeter Corrections. Pressure altimeters are calibrated to indicate true altitude under International Standard Atmospheric (ISA) conditions. Any deviation from these standard conditions will result in an erroneous reading on the altimeter. This error becomes important when considering obstacle clearances in temperatures lower than standard since the aircraft's altitude is below the figure indicated by the altimeter. The error is proportional to the difference between actual and ISA temperature and the height of the aircraft above the altimeter setting source. The amount of error is approximately 4 feet per thousand feet for each degree Celsius of difference. Corrections will only be made for Decision Heights (DHs), Minimum Descent

Altitudes (MDAs), and other altitudes inside, but not including, the Final Approach Fix (FAF). The same correction made to DHs and MDAs can be applied to other altitudes inside the FAF. ***For the current cold weather altimeter correction procedure, you must refer to the Flight Information Handbook (FIH).*** The guidance found in paragraph 8.1.4.1 is provided as an example of how to accomplish the procedure found in the FIH.

8.1.4.1. To ensure adequate obstacle clearance the values derived from the chart below will be:

–Added to the published DH or MDA and step-down fixes inside the FAF whenever the outside air temperature is less than 0° Celsius

–Added to ALL altitudes in the procedure in Designated Mountainous Regions whenever the outside air temperature is 0° Celsius or less

–Added to ALL altitudes in the procedure whenever the outside air temperature is -30° Celsius or less, and/or procedure turn, intermediate approach altitude HATs/HAA are 3000 feet or more above the altimeter setting source

–ATC will continue to apply correction to Minimum Vectoring Altitudes

TEMPERATURE CORRECTION CHART

(Feet)

(This chart is not authorized for use in flight – for the current chart and procedure, see the FIH)

TEMP °C														
0	0	20	20	20	20	40	40	40	40	60	80	140	180	220
-10	20	20	40	40	40	60	80	80	80	120	160	260	340	420
-20	20	40	40	60	80	80	100	120	120	180	240	380	500	620
-30	40	40	60	80	100	120	140	140	160	240	320	500	660	820
-40	40	60	80	100	120	140	160	180	200	300	400	620	820	1020
-50	40	80	100	120	140	180	200	220	240	360	480	740	980	1220
	200	300	400	500	600	700	800	900	1000	1500	2000	3000	4000	5000

HAT or HAA

Example: Published MDA 1180’ MSL
HAT 402
Temp -30° C
Correction 60’
MDA to use: 1180 + 60 = 1240’ MSL

NOTE: Pilots should advise ATC of corrections in excess of 80 feet.

8.2. U.S. NOTAM System (USNS). ***You must check applicable NOTAMs for each flight.*** Thorough preflight planning is the key to successful flight operations. For flight planning purposes, Notice to Airmen (NOTAM) information is available from the U.S. NOTAM System (USNS) via the DoD Internet NOTAM Distribution System (DINS). To fully understand where and how to get all available NOTAM information, it is important to understand the USNS. The U.S. NOTAM System is composed of a large central data management system.

8.2.1. DoD Internet NOTAM Distribution System (DINS). DINS is composed of a large central data management system deriving information from the US Consolidated NOTAM Office at her FAA Air Traffic Control Command Center located at Herndon, VA. Real-time NOTAM information is maintained and made available through the internet. Coverage includes all military airfields and virtually all domestic, international, and Flight Data Center (FDC) NOTAMs. If not covered by

DINS, the airfield does not transmit NOTAM data to the USNS. A plain language notice in re font is displayed advising the user of that fact. In such a case, you must contact the desired location directly for NOTAM information.

8.2.2. NOTAMs - Definition. NOTAM is defined in AFI 11-208 (DoD Notice to Airmen (NOTAM) System), as an unclassified notice containing information concerning the establishment of, condition of, or change in an aeronautical facility, service, procedures or hazards; the timely knowledge of which is essential for safe flight operations. NOTAM abbreviations are explained in the Flight Information Handbook (FIH) and the Notices to Airmen Publication (NTAP).

8.2.3. NOTAMs – Types. There are many different types of NOTAMs.

8.2.3.1. Military Summary Reports (Previously known as Installation NOTAMs). These NOTAMs contain information about individual military aerodromes; runway closures, NAVAID outages, frequency changes, runway lighting, etc.

8.2.3.2. Flight Data Center (FDC) NOTAMs. The most important thing to know about FDC NOTAMs is that they are regulatory. FDC NOTAMs contain important information such as amendments to published approaches, chart changes and temporary flight restrictions. FDC NOTAMs are broken down into the following categories: General FDC NOTAMs, Air Route Traffic Control Center (ARTCC) FDC NOTAMs, and Airports, Facilities & Procedural FDC NOTAMs.

8.2.3.2.1. General FDC NOTAMs. These FDC NOTAMs apply to all aircraft, regardless of departure, destination or route of flight. General FDC NOTAMs contain information including, but not limited to changes to U.S. Government flight information publications, hostile airspace advisories, special FAA regulations, changes to standard operating procedures in U.S. airspace, and any other general information which might affect flight operations.

8.2.3.2.2. ARTCC FDC NOTAMs. These FDC NOTAMs only apply to aircraft flying through the associated ARTCC. These NOTAMs are identified by the three letter center identifier beginning with a “Z” (ZHU – Houston Center). ARTCC FDC NOTAMs may include, but are not limited to, changes to published minimum altitudes and routings, in-flight hazards and advisories, special use airspace activity and airspace changes/restrictions.

8.2.3.2.3. Airports, Facilities & Procedural FDC NOTAMs. These NOTAMs cover civilian and some joint-use fields and include, but are not limited to, changes to local procedures, changes/revisions/amendments to published instrument approach and departure procedures, and changes/revisions to minimum altitudes.

8.2.3.3. Attention Notices. Attention Notices are general notices that apply to military pilots. They are broken down into the following groups with the associated abbreviation; All (ATTA), USAFE (ATTE), North America (ATTN), Caribbean and South America (ATTC) and PACAF (ATTP).

8.2.3.4. Civilian “D” (Distant) Series NOTAMs. These NOTAMs are the civilian equivalent of a Military Summary Report NOTAM. They contain information about individual civilian aerodromes; runway closures, NAVAID outages, frequency changes, runway lighting, etc.

8.2.3.5. Civilian “L” (Local) Series NOTAMs. These NOTAMs are equivalent to a military airfield advisory. L Series NOTAMs contain information that doesn’t require wide dissemination and will not prevent the use of an airfield’s runways. The information may, however, affect the use of other parts of an airfield. These NOTAMs are found by calling the local Flight Service Station (FSS) governing the field.

8.2.3.6. Notices to Airman Publication (NTAP). This book consists of four parts.

8.2.3.6.1. Part 1 contains FDC NOTAMs and NOTAMs which meet the criteria of "D" NOTAMs and are expected to remain in effect for an extended period of time.

8.2.3.6.2. Part 2 contains revisions to Minimum En Route IFR altitudes and changeover points as well as other information regarding a wide geographic area or not suited for Part 1.

8.2.3.6.3. Part 3 contains significant international NOTAMs including Foreign Notices, Department of State Advisories, and Overland/Oceanic Airspace Notices.

8.2.3.6.4. Part 4 contains graphical notices of items that will impact flight operations in the following areas; General Information, Special Military Operations, Major Sporting and Entertainment Events, Northeast United States, Southeast United States, East Central United States, South Central United States, Southwest United States, Northwest United States, Alaska/Hawaii and Special Airshow Section.

8.2.3.7. GPS NOTAMs. Are accessed through the DINS web page by entering the 4-letter identifier **KGPS**. When entered, this identifier will yield the user individual satellite information useful for updating Flight Management System (FMS) database information. GPS NOTAM information regarding GPS approach availability is obtained by entering the 4-letter ICAO airfield identifier on the NOTAM home page.

8.2.4. DoD NOTAM Web Site (http://www.notams.jcs.mil). The NOTAM web site is broken down into six separate pages; the Home page /Military Notices To Airmen, Center Area NOTAMs, US Army Europe, European Low Levels, EUCARF and ICAO Lookup.

8.2.4.1. Home Page/Military Notices to Airmen Page. Input the four-letter ICAO identifiers for the airfields you want to check NOTAMs for. You can enter up to 10 ICAO identifiers at any one time. You may also enter FIR identifiers, MOA names, special use airspace identifiers and ARTCC identifiers to check their NOTAMs as well as *KFDC* and *KGPS* to check FDC and GPS NOTAMs respectively. Click the “View NOTAMs” button to view the current NOTAMs for your selections. NOTAMs are displayed in plain language text unless “raw” format is selected. When raw format is selected, NOTAMs are presented in the international, machine-readable, ICAO code format with multiple report fields, NOTAM series and NOTAM numbers displayed.

8.2.4.2. Center Area NOTAMs Page. Check the boxes for Attention Notices and Flight Data Center (FDC) Regulatory Notices. Check the boxes for the appropriate Air Route Traffic Control Centers (ARTCCs). Click the “View Notices” button to view the current NOTAMs for your selections.

8.2.4.3. **US Army Europe Page**. This page provides data from the US Army Flight Operations Detachment Europe (AFOD) and contains NOTAMs on airfields, airspace, navigation/communications, special notices and updates throughout the European theatre.

8.2.4.4. European Low Levels Page. Updated information to low level routes within the European theatre of operations is provided by the US NOTAM Office-Europe. They contain low level summaries and daily updates. Simply check the desired box and click on “view NOTAMs” to access.

8.2.4.5. EUCARF Page. NOTAMs concerning operations and airspace controlled by the European Central Airspace Reservation Facility (EUCARF) can be obtained through this page. Information will include airspace, refueling tracks and ALTRVs currently reserved through EUCARF.

8.2.4.6. ICAO Lookup Page. This page contains a geographic listing of all sites covered by DINS allowing the user to find the four-letter identifier of the desired airfield and to determine if an airfield is covered by DINS and the USNS.

8.2.5. The FAA NOTAM Distribution System. Unlike DINS, which allows pilots to check their own NOTAMs, the FAA NOTAM Distribution System is based on a verbal briefing system. To obtain a verbal briefing, contact a Flight Service Station (FSS). The easiest way to accomplish this is to call 1-800-WXBRIEF. The FSS Briefer will provide you with NOTAM D information for any field you request. NOTAM L information must be requested from the *servicing* FSS or directly from the airfield. Flight Service Stations maintain a file of FDC NOTAMs affecting conditions within 400 miles of their facility. FDC information concerning conditions more than 400 miles away from the FSS, or that is already published in the NTAP, is given only on request. The Flight Service Station briefer assumes you have looked at the appropriate sections of the Notices to Airman Publication. They will not brief the information contained in the NTAP unless specifically requested.

8.2.6. DINS Web Page Limitations. It is important to understand that the DINS web page, while updating on a real-time basis, does not *auto-refresh* the information. This means that while the page is current up to the minute when it is originally accessed, no further updates are received unless the page is "refreshed" by clicking *VIEW—REFRESH*, or by reentering the selected ICAO identifiers and clicking on "view notices." Furthermore, new NOTAMs are not highlighted in any way. The only way to tell if information has changed is by comparing what you received earlier to what is currently being displayed. ***You must recheck the NOTAM web site prior to all flights to ensure you have the latest NOTAMs.***

8.2.7. The Airfield Suitability and Restrictions Report (ASRR). This publication is helpful in pre-mission planning and consists of two parts. Part One provides basic airfield and suitability information; Part Two provides airfield restrictions and other information for select airfields. ASRR information is available via the worldwide web address:
www.amc.af.mil/do/doa/doas.htm.

8.3. Navigation Options in the National Airspace System. There are two methods of navigating in the National Airspace System: on airways and off airways. Specific procedures for filing are found in FLIP General Planning unless noted otherwise.

8.3.1. On Airways. Two fixed route systems are established for air navigation purposes. They are the VOR and L/MF system, and the jet route system. To the extent possible, these route systems are aligned in an overlying manner to facilitate transition between each.

8.3.1.1. VOR and L/MF Airway System. The VOR and L/MF Airway System consists of airways designated from 1,200 feet above the surface (or in some instances higher) up to but not including 18,000 feet MSL. These airways are depicted on En Route Low Altitude Charts. ***Unless otherwise authorized by ATC, pilots are required to adhere to the centerline of airways or routes being flown.*** Special attention must be given to this requirement during course changes. Turns that begin at or after fix passage may exceed airway or route boundaries. Consequently, the FAA expects pilots to lead turns and take other actions considered necessary during course changes to adhere as closely as possible to the airways or route being flown. USAF pilots should attempt to adhere to course centerline whenever possible.

8.3.1.1.1. VOR Airways. Except in Alaska and coastal North Carolina, the VOR airways are based solely on VOR or VORTAC navigation aids and are identified by a "V" (Victor) followed by the airway number (e.g., V12). Segments of VOR airways in Alaska and North Carolina (V290) are based on L/MF navigation aids and charted in brown instead of black on en route charts.

8.3.1.1.2. L/MF Airways. The L/MF airways (colored airways) are based solely on L/MF navigation aids and are depicted in brown on aeronautical charts and are identified by color name and number (e.g., Amber One). Green and Red airways are plotted east and west. Amber and Blue airways are plotted north and south. Except for G13 in North Carolina, the colored airway system exists only in Alaska.

8.3.1.2. Jet Routes. The Jet Route system consists of jet routes established in Class A airspace. These routes are depicted on En Route High Altitude Charts. Jet routes are depicted in black on aeronautical charts and are identified by a "J" (Jet) followed by the airway number (e.g., J12). Jet routes, as VOR airways, are based solely on VOR or VORTAC navigation facilities (except in Alaska). Segments of jet routes in Alaska are based on L/MF navigation aids and are charted in brown instead of black on en route charts.

8.3.1.3. Area Navigation (RNAV) Routes. A method of navigation permitting aircraft operations on any desired course within the coverage and capabilities of the aircraft onboard navigation equipment.

8.3.1.3.1. Designated RNAV Routes. Permanent published and charted airway routes based on area navigation equipment, they are available for use by aircraft with RNAV capability.

8.3.1.3.2. Required Equipment for RNAV. FAA AC 90-45 outlines the RNAV equipment specifications for certification within the National Airspace System. The major types of appropriate equipment are:

8.3.1.3.3. VORTAC-Referenced or Course Line Computer (CLC) Systems. These systems account for the greatest number of RNAV units in use. In the military, most FMS units use the functions of a VOR, VOR/DME, DME, or TACAN station to update an onboard navigation computer. With any of these systems, the aircraft must remain within the service range of navigation station.

8.3.1.3.4. Inertial (INS) Systems. INS units are self-contained and require no information from external references. They provide aircraft position and navigation information in response to signals resulting from inertial effects on components within the system.

8.3.1.3.5. MLS Area Navigation (MLS/RNAV). MLS/RNAV equipment provides area navigation with reference to an MLS ground facility. The aircraft must remain within the service range of the navigation station.

8.3.1.3.6. LORAN-C. LORAN-C is a long-range radio navigation system of ground waves transmitted at low frequency to provide the user position information at ranges of up to 600 to 1,200 nautical miles from the navigation station at both en route and approach altitudes. The usable signal coverage varies through many environmental and physical characteristics and must be monitored by the aircrew during flight.

8.3.1.3.7. Global Positioning System (GPS). GPS is a space-based radio positioning, navigation, and time-transfer system. The system provides highly accurate position and velocity information, and precise time, on a nearly continuous global basis, to properly equipped users. The system is unaffected by weather, and provides a worldwide common grid reference system. GPS navigation equipment must be approved in accordance with the requirements specified in FAA TSO, AC and Notices pertaining to the intended operations (e.g., enroute, oceanic, terminal, non-precision, and precision approach). GPS navigation is not currently approved for use as the sole means of navigation equipment onboard the aircraft. Aircraft using GPS navigation equipment under IFR must be equipped with an approved and operational alternate means of navigation appropriate to the flight. Active monitoring of alternative navigation equipment is not required if the GPS receiver uses WAAS signals or RAIM for integrity monitoring. Active monitoring of an alternate means of navigation is required when the aircraft GPS equipment is not WAAS capable or when the RAIM capability of the GPS equipment is lost.

8.3.2. Off Airways (Direct). There are several methods pilots can use to fly off of the airway system, otherwise known as "direct" flight.

8.3.2.1. NAVAID to NAVAID. ***Aircraft may file along a direct course between NAVAIDs as long as the aircraft does not exceed the limitations of the NAVAIDs being used to define the course.*** For example, an "L" class VORTAC is only usable below 18,000 feet MSL and within 40 nautical miles of the station. NAVAID limitations can be found in the front of the FLIP IFR Supplement.

8.3.2.2. Degree-Distance Route Definition for Military Operations. Degree-distance route definition is a military-only privilege that allows certain aircraft to exceed the NAVAID limitations imposed by NAVAID to NAVAID filing restrictions. The specific procedures for filing and using degree-distance route definition are published in FAAH 7110.65. The use of degree-distance criteria is limited to aircraft performing specialized military missions.

8.3.2.3. Random RNAV Routes. Random RNAV routes are direct routes flown between any two points, based on aircraft onboard RNAV capability and defined in terms of latitude/longitude coordinates, degree-distance fixes, or offsets from established routes/airways at a specified distance and direction. Radar monitoring by ATC is required on all random RNAV routes within the National Airspace System. Factors ATC will consider in approving random RNAV routes include the capability to provide radar monitoring and compatibility with traffic volume and flow. ATC will radar monitor each flight; however, navigation on the random RNAV route is the responsibility of the pilot. Acceptable RNAV equipment is described in paragraph 8.3.1.3.1.

8.3.2.4. National Route Program (NRP). A FAA program designed to make air travel easier and more cost efficient by taking advantage of emerging technologies. Aircraft flying under the NRP will fly normal departure and arrival routes within 200 nautical miles of the departure and destination airports and direct routes of their choice in between. The equipment required to participate in the NRP is the same as the equipment required for RNAV. The NRP may eventually allow “free flight” route operations throughout the continental U.S. at FL 290 and above. Specific procedures and restrictions can be found in FLIP General Planning.

8.4. Planning for En Route. Preflight planning of the en route portion should be adequate to ensure a safe and efficient flight. As a minimum, aircrews should review:

8.4.1. Route. The intended route of flight (to include preferred routing located in AP/1) using current flight publications.

8.4.2. En route NOTAMs.

8.4.3. En route weather.

8.4.4. FLIP products. The appropriate FLIP products to ensure compliance with any special procedures that may apply.

8.4.5. Diversion fields. Emergency diversion fields and approaches.

8.4.6. Compliance. Comply with the jet route or airway system as published on the FLIP en route charts and air traffic clearances. You must also ensure your aircraft is equipped and authorized to operate in the airspace along your route of flight. For example, only aircraft certified through their MAJCOM for RNP-5 may operate in the European BRNAV structure. Consult your MAJCOM and MDS-specific guidance if you have any doubts concerning your aircraft’s capabilities.

8.4.7. Minimum Altitudes.

8.4.7.1. Altitude Clearances. Ensure altitude clearances received en route do not conflict with minimum en route altitudes (MEA), minimum obstruction clearance altitudes (MOCA), minimum reception altitudes (MRA), or minimum crossing altitudes (MCA) shown on en route charts.

8.4.7.2. Controlled Airspace. In controlled airspace, the air traffic controller will assign altitudes that provide obstacle clearance. You should use all available navigation aids to remain position-oriented and immediately query the controller if there is any uncertainty of the obstacle clearance provided by the assigned altitude**.** When flying via published routing (a route with minimum altitudes depicted), compliance with the minimum altitude published on the routing ensures obstacle clearance. ***If a published minimum altitude is not available, aircrews must determine minimum altitudes in accordance with AFI 11-202V3.***

8.4.7.3. Uncontrolled airspace. ***In uncontrolled airspace, you must ensure the altitudes flown will provide obstacle clearance during all phases of flight.***

8.4.7.4. Radio failure. In case of radio failure, you are responsible for minimum altitude selection. ***Comply with published radio failure procedures in the Flight Information Handbook (FIH).***

8.5. Planning the Approach. Preparation for flying an instrument approach begins with a study of the approach depiction during preflight planning. The end result of an approach--a landing or a missed approach--can be directly dependent upon the pilot's familiarity with the approach depiction.

8.5.1. Aircraft Categories and Instrument Approach Procedures Selection.

8.5.1.1. Category. ***An aircraft can fly an IAP only for its own category or higher, unless otherwise authorized by AF Instruction or MAJCOM directives.*** If it is necessary to maneuver at speeds in excess of the upper limit of a speed range for a category, the minimums for the next higher category should be used. The categories are as follows:

a. Category A - Speed less than 91 knots.
b. Category B - Speed 91 knots or more but less than 121 knots.
c. Category C - Speed 121 knots or more but less than 141 knots.
d. Category D - Speed 141 knots or more but less than 166 knots.
e. Category E - Speed 166 knots or more.

NOTE: If MAJCOMs allow aircraft to fly an IAP using a lower category the MAJCOM must publish procedures to ensure that aircraft do not exceed TERPs airspace for the IAP being flown to include circling and missed approach. Missed approach TAS is based on the category of approach just flown and will not exceed: CAT-A, 220 KTAS; CAT-B, 230 KTAS; CAT-C, 240 KTAS; CAT-D, 260 KTAS; CAT-E, 310 KTAS.

8.5.1.2. IAP chart. ***A current copy of the appropriate IAP chart must be available in the aircraft***. Low altitude IAP charts normally depict instrument approaches for categories A, B, C, and D aircraft. High altitude IAP charts depict instrument approaches for category C, D, and E aircraft. When an operational requirement exists, the low altitude IAP charts may depict category E procedures.

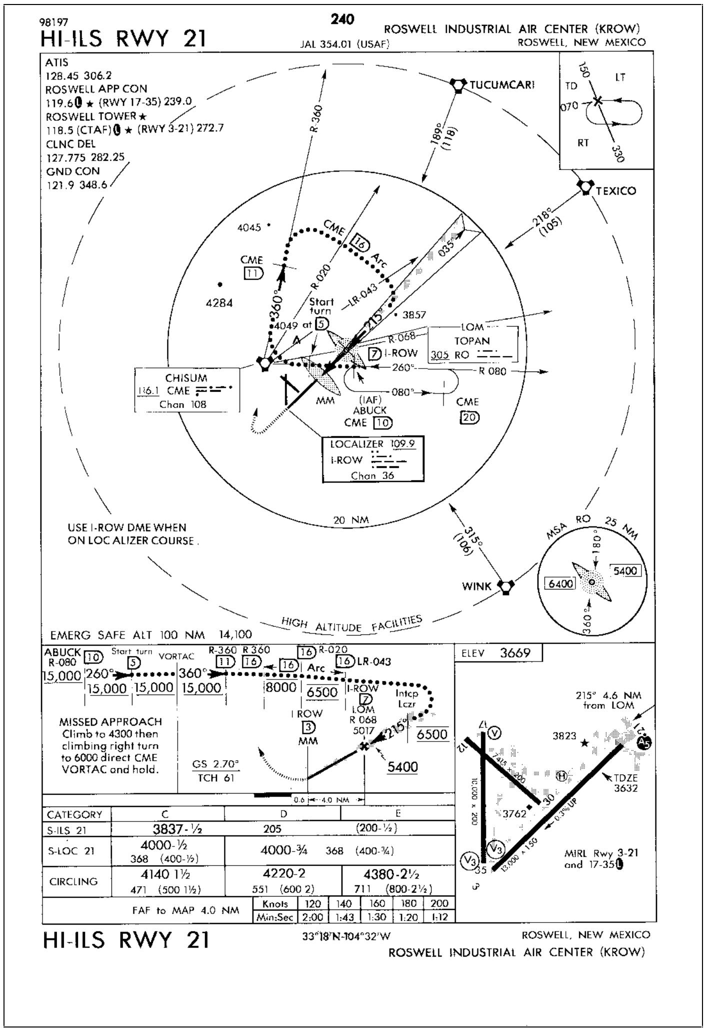
NOTE: ***Consult the Terminal Change Notice (TCN) to ensure the approach selected is current***.

8.5.1.3. Navigation Equipment Compatibility. ***Ensure the approach you select is compatible with the navigation equipment installed in your aircraft including the missed approach instructions. If there is a requirement to execute an approach procedure with incompatible missed approach instructions, coordinate alternate missed approach/departure instructions with ATC before reaching the IAF***. There may be no alternate missed approach procedure that ATC can issue other than the one that is published. Therefore, if an IAP lists a NAVAID as "Required" (e.g. "ADF REQUIRED"), you must have the equipment to receive that NAVAID installed and operating in your aircraft since there is no way for you to determine why the NAVAID is required. ***It is the responsibility of the pilot to thoroughly review each approach to determine what equipment is required to accomplish any specific approach procedure (Figure 8.6).***

NOTE: This requirement for alternate missed approach instructions does not preclude practice approaches if the field is VFR according to AFI 11-202V3.

8.5.1.3.1. Straight-in approaches. Straight-in approaches are identified by the types of navigation aids which provide final approach guidance and the runway to which the final approach courses are aligned. A slash (/) indicates that more than one type of equipment may be required to execute the final approach (VOR/DME, ILS/DME, etc.). Be aware that additional equipment may be required to execute the other portions of the procedure.

Figure 8.6. ILS Approach (para 8.5.1.3.).



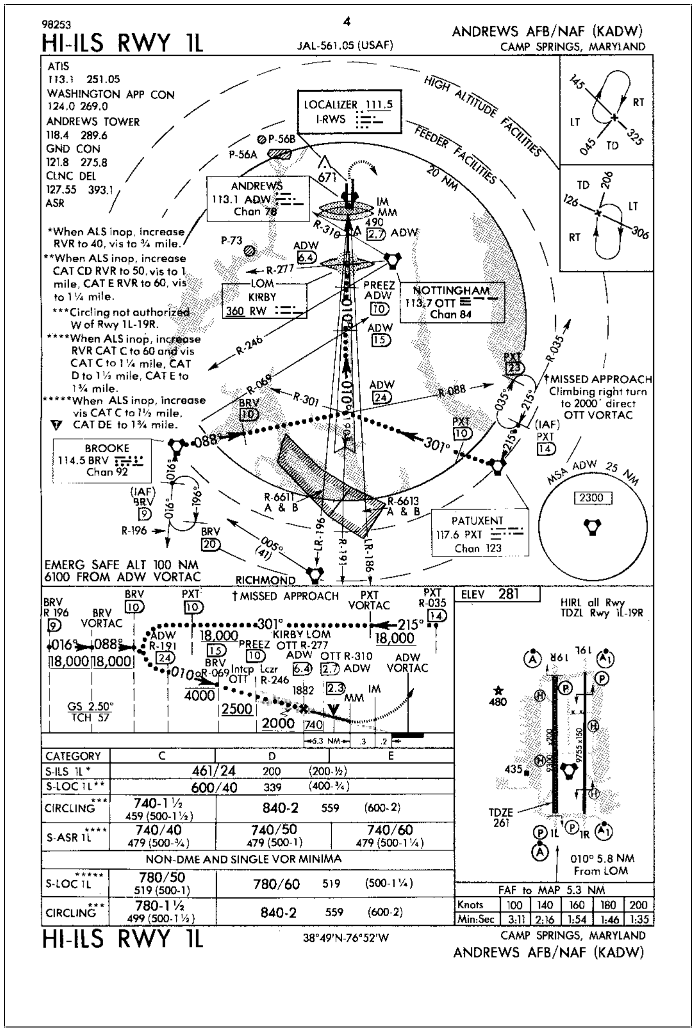
8.5.1.3.2. VOR approaches. Some VOR approaches are approved for use by TACAN equipped aircraft. These will be designated by the term "(TAC)" printed adjacent to the name of the procedure, for example, VOR-A (TAC).

8.5.1.3.3. Circling approaches. When the name of the approach is followed by a letter such as A, B, C, etc., the approach is designed for circling minimums only. Circling approaches are designated VOR-A, TACAN-B, NDB-C, etc.

8.5.1.4. Radar Minimums. Radar minimums by aircraft category may be found in a separate section in the IAP book.

8.5.2. Reviewing an IAP (Figure 8.7). Prior to departure, you should become familiar with all aspects of the IAP so that during the recovery you can concentrate on flying the maneuver rather than trying to fly and interpret it simultaneously. Here are some important areas to consider and techniques to use:

Figure 8.7. Review of the IAP (para 8.5.2).



CATEGORY	C	D	E
S-ILS 1L*	461/24 200 (200-½)		
S-LOC 1L**	600/40 339 (400-¾)		
CIRCLING***	740-1½ 459 (500-1½)	840-2 559 (600-2)	
S-ASR 1L****	740/40 479 (500-¾)	740/50 479 (500-1)	740/60 479 (500-1¼)
NON-DME AND SINGLE VOR MINIMA			
S-LOC 1L*****	780/50 519 (500-1)	780/60 519 (500-1¼)	
CIRCLING***	780-1½ 499 (500-1½)	840-2 559 (600-2)	

Knots	100	140	160	180	200
Min:Sec	3:11	2:16	1:54	1:46	1:35

8.5.2.1. Plan View.

8.5.2.1.1. Ground Track. Note the general ground track of the approach, the NAVAIDs that provide the course guidance, and the NAVAID location. (The NAVAIDs that appear in the name of an IAP are the NAVAIDs that provide the final approach guidance. Other types of NAVAIDs may be required to accomplish the approach and missed approach.)

8.5.2.1.2. Initial Approach Fix. Note the location of the IAF you plan to use as well as the NAVAID used to define the fix. Sometimes the IAF is displayed on the IAP by name only, and the NAVAID and radial/DME which defines the point is not listed. In this case, refer to the appropriate en route and terminal charts for the area to determine the NAVAID and the radial/DME which defines the IAF.

8.5.2.1.3. Holding Pattern. Note the location of the holding pattern and its relation to the initial approach fix (IAF).

8.5.2.1.4. Plan the Approach. Mentally fly the approach from the IAF to the missed approach point (MAP) and determine the lead points for radial, course, or arc interceptions. Identify the point where the aircraft should be configured for landing.

8.5.2.1.5. Missed Approach. Review the missed approach departure instructions and determine if your aircraft can comply with the required climb gradient if one is published.

8.5.2.1.6. Published Routings. Terminal routings from en route or feeder facilities normally provide a course and range from the en route structure to the IAF but may take the aircraft to a point other than the IAF if operational circumstances so require. (Low altitude feeder routes provide minimum altitudes.)

8.5.2.1.7. Minimum Safe Altitudes. Minimum Safe Altitudes consist of minimum sector altitudes and emergency safe altitudes. A minimum safe altitude is the minimum altitude that provides at least 1000 feet of obstacle clearance for emergency use within a specified distance from the navigation facility upon which the procedure is based (for example VORTAC, VOR, TACAN, NDB, or locator beacon at OM or MM). The minimum sector altitude provides the 1000 feet of obstacle clearance within 25 NM of the facility. An emergency safe altitude will provide the 1000 feet (2000 feet in designated mountainous areas) within 100 NM of the facility. If it is not clear on which facility the altitude is based, a note should state the facility that is used. Minimum safe altitudes do not guarantee NAVAID reception.

8.5.2.1.8. Scale. The inner ring gives a scale presentation of the approach that is normally within a 10 NM radius for low altitude approaches and 20 NM for high altitude approaches. However, it should be noted that the radius of the rings may differ. Some, but not necessarily all, obstacles are depicted. This inner ring is normally necessary for better portrayal of the IAP. On IAPs with a single ring, the entire plan view is to scale. The addition of multiple rings is the indicator that only the part of the approach inside the inner ring is to scale.

8.5.2.2. Profile View.

8.5.2.2.1. Altitude Restrictions. Note the altitude restrictions. Minimum, maximum, mandatory, and recommended altitudes normally precede the fix or facility to which they apply. If this is not feasible, an arrow will indicate exactly where the altitude applies. In some cases altitude restrictions are published in the plan view and not in the profile view. This is often the case with multiple IAFs where it is not feasible to show all the routings in the profile view.

8.5.2.2.2. Descent Gradients. Consider the descent gradient. For a low altitude IAP, the initial descent gradient will not exceed 500 feet per NM (approximately 5°); and for a high altitude approach, the maximum allowable initial gradient is 1,000 feet per NM (approximately 10°).

8.5.2.3. Landing Minimums. Review the landing minimums for your aircraft category to see how low you can descend on the approach and to determine if the forecast weather conditions will permit use of the IAP.

NOTE: The minimums published in FLIP must be the lowest possible minimums in accordance with TERPs–criteria; however, MAJCOMs may establish higher minimums for their pilots. The visibility values determine whether a straight-in approach may be flown. These values are based on all approach lighting being operational. When approach lighting is inoperative, the visibility minimums will normally be one-half mile higher. If a circling approach is to be flown, the weather must be at or above both the published ceiling and visibility.

NOTE: There may be situations when you are required to fly a circling approach which does not have a ceiling requirement published. In this case, the required ceiling will be the HAA plus 100 feet rounded up to the next one hundred foot value. For example, if the HAA is 757 feet, add 100 feet to get 857 feet and then round up to the nearest one hundred foot value which would be 900 feet. Your ceiling for the approach must be at or above 900 feet.

8.5.2.4. Aerodrome Sketch.

8.5.2.4.1. Field elevation. Check the field elevation. This is the highest point on any usable landing surface.

8.5.2.4.2. Touchdown zone elevation. Note the touchdown zone elevation. This is the highest point in the first 3,000 feet of the landing runway.

8.5.2.4.3. Runway. Observe the runway dimensions and layout.

8.5.2.4.4. Lighting systems. Check the types of approach lighting systems available.

8.5.2.4.5. Navigation facility location. Note the direction and distance of the runways from the navigation facility.

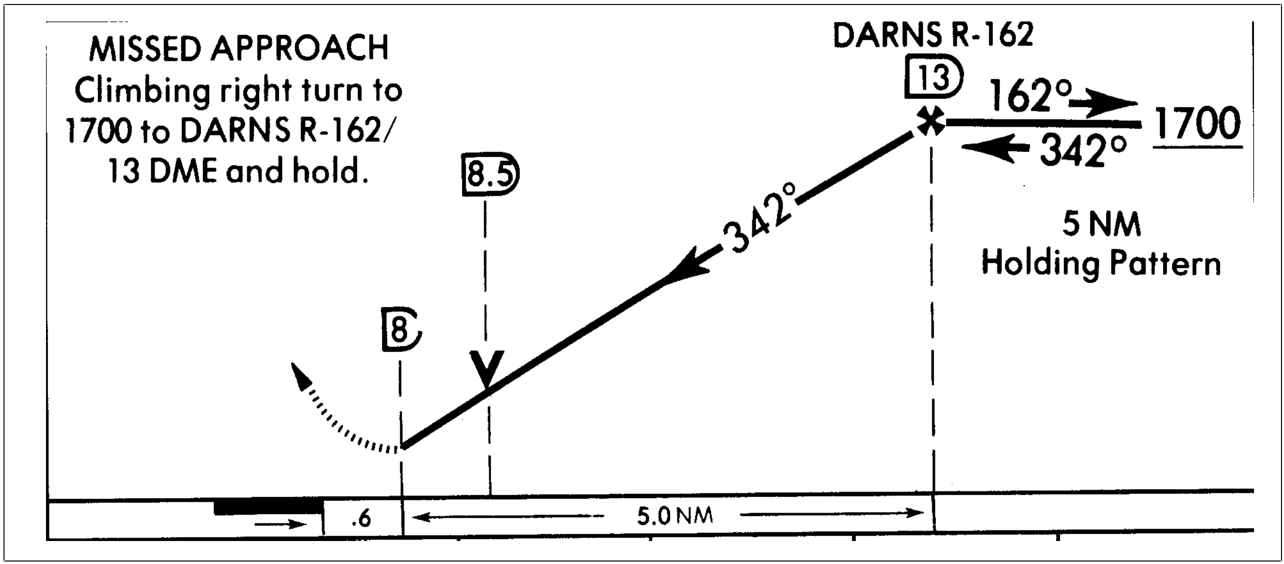
8.5.2.4.6. Obstructions. Check the location of prominent obstructions.

8.5.2.4.7. Final Approach Direction. The arrow shows the direction the final approach brings you in relation to the runway. This information can be quite helpful in helping you know where to look for the runway. It is also useful in determining how much maneuvering may be required to align the aircraft with the runway. A straight-in approach may bring your aircraft to the runway as much as 30 degrees off of the runway centerline and still be considered a straight-in approach.

8.5.2.5. Additional Information. Look carefully for notes on the IAP. Notes are used to identify either nonstandard IAP criteria or to emphasize areas essential for the safe completion of the approach.

8.5.2.6. Visual Descent Point (VDP). The VDP is a defined point on the final approach course of a nonprecision straight-in approach procedure from which a normal descent (approximately 3°) from the MDA to the runway touchdown point may be commenced provided visual reference with the runway environment is established. The VDP is normally identified by DME and is computed for the nonprecision approach with the lowest MDA on the IAP. A 75 MHz marker may be used on those procedures where DME cannot be implemented. VDPs are not a mandatory part of the procedure, but are intended to provide additional guidance where they are implemented. A visual approach slope indicator (VASI) lighting system is normally available at locations where VDPs are established. Where VASI is installed, the VDP and VASI glide paths are normally coincident. If VASI is not installed, the descent is computed from the MDA to the runway threshold. On multi-facility approaches, the depicted VDP will be for the lowest MDA published. No special technique is required to fly a procedure with a VDP; however, to be assured of the proper obstacle clearance, the pilot should not descend below the MDA before reaching the VDP and acquiring the necessary visual reference with the runway environment. The VDP is identified on the profile view of the approach chart by the symbol **V** (**Figure 8.8**).

Figure 8.8. Visual Descent Point (VDP) (para 8.5.2.6).



8.5.2.7. **Alternate minimums.** Some civil and foreign approaches may have ▲ or ▲ NA in the remarks. While the ▲ does not apply to Air Force pilots, ▲ NA does apply and has serious implications. The ▲ tells civilian pilots that the alternate minimums for the approach are non-standard and they must look in the front of the IAP book for new alternate minimums. Since Air Force alternate minimums are published in AFI 11-202V3, Air Force pilots may ignore the ▲. The ▲ NA tells civilian and military pilots that the specific approach cannot be used in order to qualify the field as an alternate because of a lack of either weather reporting facilities and/or the capability to monitor the NAVAID. Without weather reporting facilities at the airport a pilot will not be able to get a specific forecast for that airport as required by AFI 11-202V3. The lack of monitoring capability of the navigation facilities is a bigger problem. Without a monitoring capability the pilot won't get any advance warning if the NAVAID is not operating. This means if the NAVAID goes off the air, there is no one to issue a NOTAM to inform the pilot of the situation before an attempt is made to identify and use the NAVAID

8.5.3. Reviewing a Radar Approach. Depictions of radar approaches are not normally included in flight publications, but some important aspects of the approach are available.

8.5.3.1. IAP. It is helpful to review a published IAP for the airfield. In addition to helping you prepare for a backup approach in the event of radio failure, the IAP provides:

8.5.3.1.1. NAVAIDs. NAVAID frequencies and locations for position orientation and, in some cases, additional voice reception capability.

8.5.3.1.2. Altitudes. Minimum safe altitudes in the terminal area.

8.5.3.1.3. Stepdown altitudes. A stepdown altitude between the nonprecision final approach fix (FAF) and MAP that may alert you to the possibility of a stepdown on an airport surveillance radar (ASR) approach to the same runway.

8.5.3.1.4. Radar minimums. Depiction of radar minimums and the glide slope angle. Normally the precision approach radar (PAR) glide slope will coincide with the ILS glide slope.

8.5.3.1.5. Airport sketch. The airport sketch and all the information associated with it.

8.5.3.2. Operating hours. The IAP books contain complete radar minimums. The IFR Supplement contains time periods when the aerodrome and its NAVAIDs are operational. It also indicates when NAVAIDs will be off the air for NO-NOTAM preventive maintenance, as well as other items unique to the particular operation of the airfield.

8.6. Instrument Cockpit Check. Before flight, accomplish a thorough instrument cockpit check. You should check the applicable items listed below (unless your flight manual or command directives dictate otherwise):

8.6.1. Publications. Ensure appropriate, up-to-date publications are in the aircraft.

8.6.2. Pitot Heat. Check for proper operation.

8.6.3. Attitude Indicators.

8.6.3.1. Erect. Ensure it is erect and that the bank pointer is aligned vertically with the zero bank index. Check your flight manual for tolerance limits.

8.6.3.2. Flags. Ensure the warning flags are not visible.

8.6.3.3. Alignment. Check the pitch trim knob alignment and ensure it is within limits, then set the miniature aircraft or horizon bar for takeoff.

8.6.4. Magnetic Compass. Check the accuracy of heading information.

8.6.5. Clock. Ensure the clock is running and the correct time is set.

8.6.6. Vertical Velocity Indicator (VVI). Ensure the pointer is at zero. If the indicator does not return to zero, adjust it with a small screwdriver or use the ground indication as the zero position in flight.

8.6.7. Altimeters.

8.6.7.1. Current setting. Set current altimeter setting on barometric scale.

8.6.7.2. Known elevation. Check the altimeter at a known elevation and note any error in feet. If the error exceeds 75 feet, the instrument is out of tolerance for flight.

8.6.7.3. Check pointers. Ensure the 10,000/100 counter-drum-pointers indicate approximate field elevation. Check and ensure the low altitude warning symbol is in view.

8.6.7.4. Modes. Check both reset and standby modes on AIMS altimeter and set in accordance with the flight manual or command directives.

NOTE: Helicopter rotor operation may affect altimeter indications. Check individual helicopter flight manual for altimeter limitations if published.

8.6.8. Turn and Slip Indicator.

8.6.8.1. Turn needle. Check and ensure the turn needle indicates proper direction of turn.

8.6.8.2. Ball. Check the ball for freedom of movement in the glass tube.

8.6.9. Heading Indicators.

8.6.9.1. Accuracy. Check the accuracy of heading information. In-lieu of guidance in aircraft technical orders the aircraft's primary heading indicator should be within approximately 5 degrees of a known heading (i.e., runway heading).

8.6.9.2. Indicators. Ensure the heading indicators indicate correct movement in turns.

8.6.9.3. Set. Set adjustable heading indicators to the desired heading.

8.6.9.4. Bank steering. For flight director systems, check the bank steering bar for proper commands in the heading mode.

8.6.10. Airspeed and Mach Indicators.

8.6.10.1. Set. Set the airspeed or command mach markers as desired or as directed in the flight manual.

8.6.10.2. Indicators. Check the pointers or rotating airspeed scale for proper indications.

8.6.11. Airspeed Mach Indicator (AMI).

8.6.11.1. Airspeed Warning Flag. Ensure it is out of view.

8.6.11.2. Command Airspeed Marker. Set the marker as desired; that is, decision, rotation, climb speed, etc.

8.6.12. Altitude Vertical Velocity Indicator (AVVI).

8.6.12.1. Vertical Velocity. Check for a zero indication.

8.6.12.2. Altimeter. Make the same check as for conventional altimeter. Ensure the altimeter warning flag is out of view.

8.6.12.3. Command Altitude Marker. Set the command altitude marker as desired; that is, first anticipated level off, emergency return DH/MDA, etc.

WARNING: The command airspeed or altitude slewing switches should not be placed in the side detent position for takeoff due to the possibility of misreading those instruments.

8.6.13. Navigation Equipment and Instruments.

8.6.13.1. Tune and identify.

8.6.13.2. Pointers. Ensure the bearing pointers point to the station.

8.6.13.3. Flags. Check and ensure the range warning flag on the range indicator is out of view and the distance indicated is within one-half mile or 3 percent of the distance to the facility, whichever is greater.

8.6.13.4. Course set knob. Rotate the course set knob and check for proper CDI displacement.

8.6.13.5. To-from. Rotate the course set knob and check that the TO-FROM indication changes when the selected course is approximately 90° to the bearing pointer.

8.6.13.6. Designated checkpoints. When checking the VOR/TACAN at a designated ground checkpoint, the allowable CDI error is ±4° and the CDI and bearing pointer should agree within the tolerances specified for the aircraft.

8.6.13.7. Dual systems. If the aircraft has dual VOR or dual TACAN receivers, the systems are considered reliable for instrument flight if they check within ±4° of each other. However, if the VOR/TACAN is also checked at a designated ground checkpoint, the equipment must meet the requirement in the above bullet.

NOTE: The self-test mode incorporated into some VOR/TACAN/ILS sets provides an operational test of the set. The self-test does not, however, provide a test of the aircraft antennas. If the VOR/TACAN set self-test function checks within the aircraft's flight manual tolerances and the VOR/TACAN station identifier is received, the requirements of paragraph above are satisfied.

8.6.13.8. Other equipment. Check all other flight and navigation instruments and equipment for proper operation and accurate information.

8.6.13.9. GPS Navigation Database: Ensure the GPS navigation database is current.

Chapter 9

IFR DEPARTURE PROCEDURES

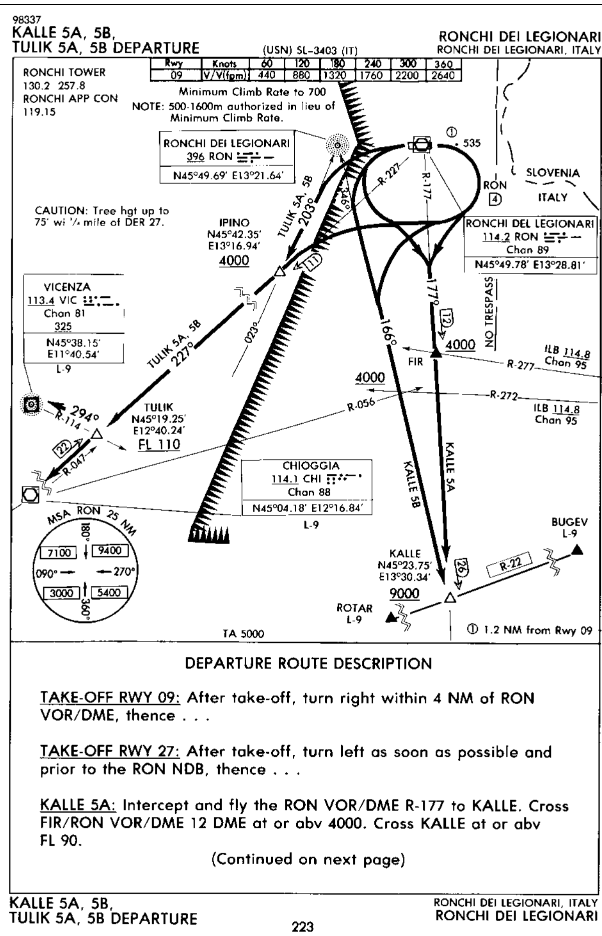
9.1. Introduction. Arriving at an airport is usually the focus of most of our attention; however, in many cases, departing an airport under IFR is a more hazardous operation. Arriving aircraft have several advantages over departing aircraft.

9.1.1. Performance. Most arriving aircraft are typically lightweight because they've burned most of their fuel enroute. A departing aircraft is much more performance-limited; often the aircraft is operating at its maximum performance just to clear obstacles.

9.1.2. Established Routing. Clearly established routing is almost always available to arriving aircraft. Normally, you will be able to choose from several published instrument approaches that provide a safe route to the airport as well as detailed obstacle information. A departing aircraft is faced with a sometimes confusing array of IFR departure procedures and often has little or no accurate information about close-in obstacles which will affect the selected departure method.

9.13. Escape Option. Several "escape" options are usually available for arriving aircraft; an arriving aircraft can level-off, climb and come back around and try again if the approach is not working out as planned. Departing aircraft have no such option; once the aircraft hits go/no-go speed, the crew is committed to the takeoff.

Figure 9.1. IFR Departure Procedures.



Overview

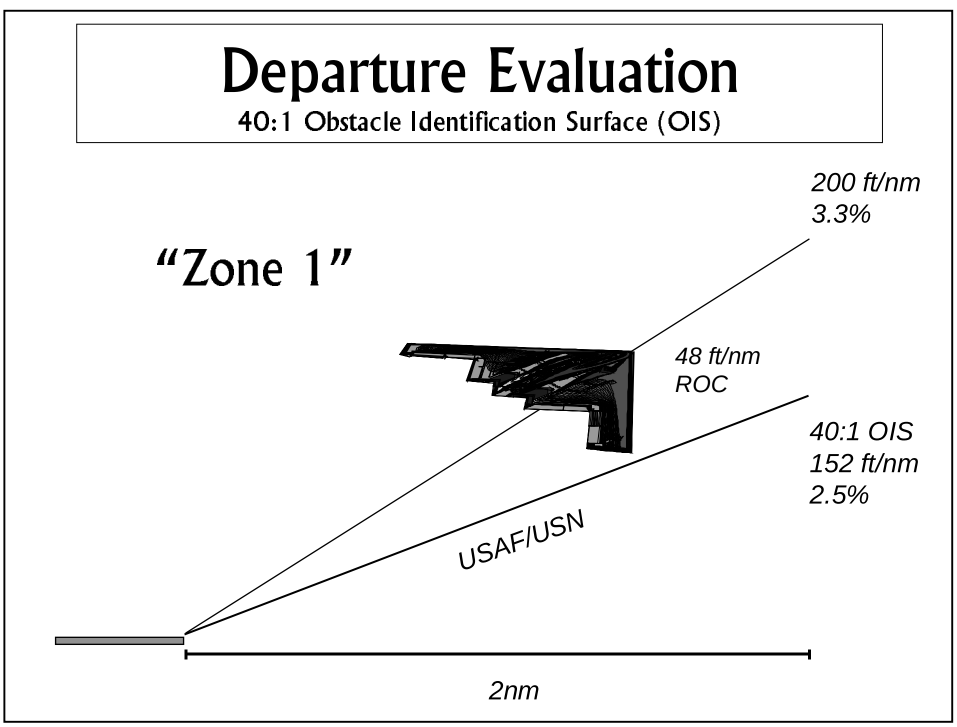
Understanding IFR departures is an essential part of preflight planning. This chapter will provide you with the facts you need to make good decisions about choosing the most appropriate method for departing an airport under IFR. In order to have a well-rounded understanding of departure procedures, it will be necessary to first learn the "facts" about departure TERPs and instrument departure procedure design. Once you grasp the nuts and bolts of departure TERPs, you are only halfway done. The next step is to understand the pros and cons of each departure method so you can fully understand the USAF's (and your MAJCOM's) operational policy as it affects departure planning.

9.2. Preparing for an IFR Departure. Chapter 5 of the FAA's Aeronautical Information Manual (AIM) has this to say about preparing for an IFR takeoff: "Each pilot, prior to departing an airport on an IFR flight should consider the type of terrain and other obstacles on or in the vicinity of the departure airport and a) Determine whether a departure procedure is available for obstacle avoidance, and b) Determine what action will be necessary and take such action that will assure a safe departure."

NOTE: Knowing the proper terminology is important. At the time of this writing, the FAA is in the process of renaming SIDs and IFR Departure Procedures in the United States. In the future, the FAA will refer to IFR departure procedures and SIDs using the phrase "Departure Procedures (DPs)." You may encounter several types of DPs in the new format: an ATC DP (like a SID – strictly for ATC, climb gradient depicted if required), an obstacle DP (what we now call an IFR departure procedure), a graphical DP (a complex IFR departure procedure converted to a graphic form), or other variations not identified yet. Although the terms "SID" and "IFR Departure Procedure" are being removed from the FAA's vocabulary, both are still widespread throughout the rest of the world. Until the transition in terminology is more complete, this chapter will still use the old terms.

9.3. How an Airport Becomes an Instrument Airport. Simply put, when an airport is first created, it is a VFR airport until it is determined that IFR operations are necessary. The first instrument procedure constructed at an airport is usually an instrument approach. Normally, whenever an instrument approach is built, the airport is also evaluated for instrument departures.

Figure 9.2. 40:1 Obstacle Identification Surface (OIS) (USAF/USN).

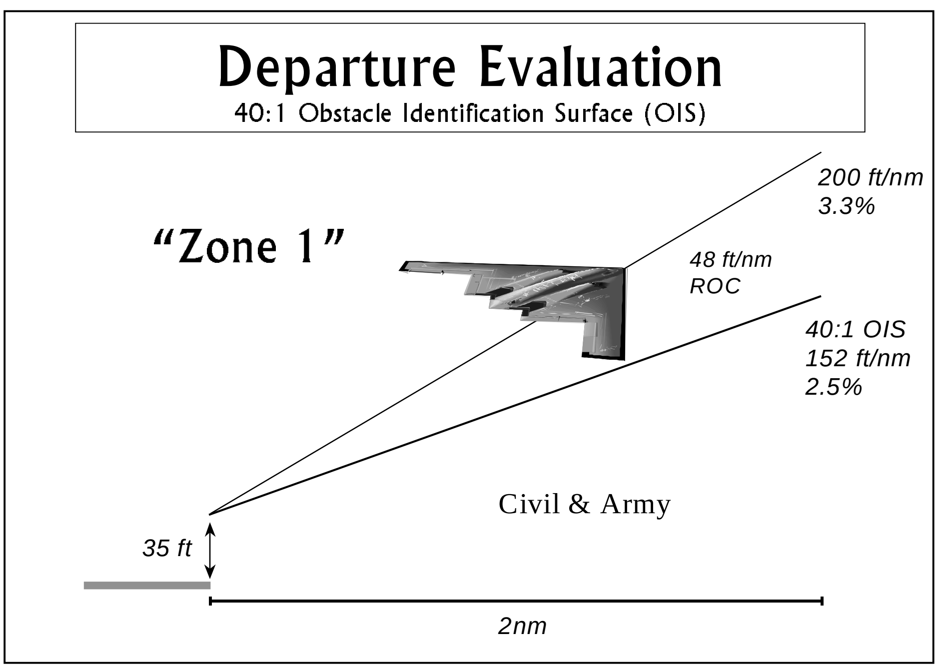


9.4. Obstacle Identification Surface (OIS). In order to assess the airport for instrument departures, the TERPs specialist looks for obstacles along a 40:1 slope from the departure end of the runway (**Figures 9.2 and 9.3**). The 40:1 slope is equivalent to a 2.5% gradient or 152 feet per nautical mile. TERPs also requires 48 feet per nautical mile of required obstacle clearance (ROC). When you add 48 feet per nautical mile to 152 feet per nautical mile, you get 200 feet per nautical mile, which is also equivalent to a 3.3% gradient. ***Unless a higher gradient is published, USAF aircraft are required to meet or exceed 200 feet per nautical mile on all IFR departures.***

NOTE: When the TERPs specialist "looks for obstacles," he uses many different sources in order to obtain the "best available" data to build an obstacle database. Some of the sources include civil engineering tabs (surveys), various high resolution maps and charts, and even products obtained from satellite imagery. Needless to say, the TERPs specialist's obstacle data is much more complete than any data an aircrew could ever obtain. The limited data available to the aircrew (aeronautical charts, FLIP, ASRR, etc.) is not adequate to plan an instrument departure; it is not complete nor does it provide sufficient detail.

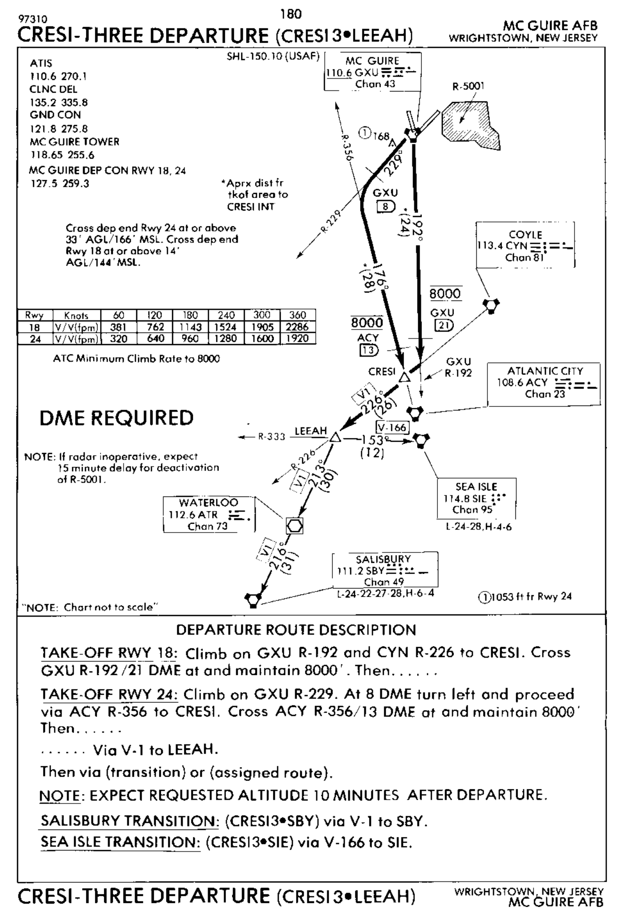
9.5. "Runway End Crossing Height" or "Screen Height." This discussion comes up so frequently, it's appropriate to devote several paragraphs to a discussion of how to determine the required runway end crossing height (also known as a "screen height"). An accurate determination of the proper height is crucial because if you do not make the runway end crossing height, you will be operating below the OIS. It's not an exact science, but the following paragraphs should help you determine the required runway end crossing height.

Figure 9.3. 40:1 Obstacle Identification Surface (OIS) (Civil and Army).



9.6. Determining Runway End Crossing Heights. If obstacles penetrate the 40:1 OIS, US TERPs criteria allows the TERPs specialist to raise the OIS as high as 35 feet above the departure end of the runway (DER) elevation to clear the obstacles. Raising the OIS in this manner requires aircraft to comply with a "runway end crossing height" to ensure obstacle clearance. This runway end crossing height is also known to some as a "screen height." There is no way to know if the FAA's TERPs specialist raised the OIS or not; therefore, you must always plan for the worst case and cross the departure end of the runway at 35 feet or higher (**Figure 9.3**). USAF and USN procedures are a little different; they always begin the OIS at zero feet at the DER, and if a runway end crossing height is required, it will be printed on the procedure (**Figure 9.4**). Here's the important rule to remember about runway end crossing heights or screen heights: ***In the United States, if the procedure is produced by anyone (including Army) other than USAF/USN, you must plan to cross the DER at or above 35 feet unless a higher altitude is published.***

Figure 9.4. DER Crossing Height Notification.



USAF/USN SIDs always begin the OIS at the DER elevation. If they don't, there will be a note on the procedure like the CRESSI-THREE DEPARTURE from McGuire AFB. The DER crossing height note is blown up below.

Cross dep end Rwy 24 at or above 33′ AGL/166′ MSL. Cross dep end Rwy 18 at or above 14′ AGL/144′ MSL.

9.7. "How Do You Know Who 'Produced' the Procedure?" Since knowing "who" produced the procedure is essential in determining what type of TERPs criteria was used in its construction, it is important to understand how to figure out whose criteria was used. At the top of each instrument approach procedure is an airport reference number. For example, if you look at the CRESI-THREE DEPARTURE in **Figure 9.4**, the airport reference number is "SHL-150.10." This number is unique to each airport and is a simply a record-keeping notation for the publisher. To figure out who "produced" the procedure, look in the parentheses to the right of the airport reference number. In the case of the

CRESI-THREE DEPARTURE at McGuire AFB, it was produced by the USAF. Sometimes the airport reference number has parenthetical information on both the left and the right as depicted on the SID from Ronchi Dei Legionari, Italy shown in **Figure 9.1**. In this case, the parenthetical info on the left indicates who (USN) requested the procedure be published in FLIP, and the parenthetical information on the right shows who produced the procedure (Italy).

9.8. Runway End Crossing Heights (ICAO). Runway end crossing heights are clearly identified in the United States; however, as soon as you leave the U.S., it becomes very difficult to determine what runway end crossing height applies (if any) because it is difficult for the aircrew to identify what type of TERPs criteria (if any) was used to construct the procedure. Because of this problem, we suggest you abide by the same assumptions that apply in the United States unless you can determine that different assumptions apply. This solution is certainly not a guarantee; but it is the best advice we can offer given the different standards used outside of the United States. Hopefully, the next few paragraphs will help explain how we've come to this recommendation.

9.9. Examples of Different TERPs Criteria. When you leave the United States, you will encounter instrument procedures built using many different types of TERPs criteria. Some of the different types of criteria are very similar to U.S. TERPs; however, some are significantly different. Just to give you an idea of what you will be up against, here are a few examples with respect to the runway end crossing height question: if the procedure was built using ICAO's PANS-OPs criteria, then the runway end crossing height should be 16 feet; if the procedure was built using NATO's APATC-1 criteria, then the runway end crossing height should be 35 feet; and if the procedure was constructed using Canadian TERPs criteria (GPH-209 or TP-308), then the runway end crossing height should be 35 feet. These are only a few of the different procedure design criterion you may see as you travel around the world.

9.10. Deviations from Standard Crossing Heights. Unfortunately, just because you know which type of TERPs criteria was used to construct the procedure does not mean you know what the actual runway end crossing height (if any) is. Let's use the ICAO's PANS-OPs criteria as an example. Just because you are flying out of an airport located in an ICAO member state does not mean the procedure was constructed using ICAO PANS-OPs criteria; in fact, even if it was constructed using PANS-OPs criteria, there is no guarantee they used the "16 foot" screen height provision. ICAO conventions are not necessarily binding, and member nations may choose to deviate from ICAO standards whenever it suits them. ICAO requests member nations who deviate from ICAO standards to make those differences known via the country's Aeronautical Information Publication (AIP), but once again, compliance with that request is also up to the individual country. (Even though the U.S. is an ICAO member, we take exception to many ICAO standards, and so do many other countries.)

9.11. The Review Process. AFI 11-202, Volume 3, *General Flight Rules*, requires that non-DoD/NOAA procedures be approved for use by the MAJCOM only after a review by the MAJCOM TERPs office. (For more information about this process, refer to Chapter 7 of AFMAN 11-217, Volume 2, *Instrument Flight Procedures*.) The review is normally conducted for one of two reasons: either the procedure is being reviewed prior to publication in DoD FLIP, or the procedure is being reviewed for one-time use by an aircrew because it is not published in DoD FLIP (like a Jeppesen approach at a location that is not regularly used).

NOTE: According to AFMAN 11-230, if an airport is used more than six times a year, its instrument procedures should be published in DoD FLIP. If this is not the case at a location you fly to frequently, let your MAJCOM TERPs office know.

9.12. Determining Screen Heights During the Review Process. USAF TERPs specialists, when reviewing host nation instrument procedures, are supposed to attempt to determine (among many other things) if there are any runway end crossing heights. If the country has provided the information via their AIP, then your MAJCOM TERPs office should make that information known to you after conducting the review. (This notification may be provided when the procedure is published in FLIP or it may come in the form of a review letter. Different MAJCOMs perform the notification in different ways.) If the country does not make the information available, you may have to make a determination on your own. Since most of the world uses the "35 foot" rule used by the FAA, we suggest you do the same unless you can determine that a different screen height applies. Use caution, be conservative, and make use of all available resources when attempting to determine the actual screen height.

9.13. No 40:1 OIS Penetrations. If no obstacles penetrate the 40:1 obstacle identification surface (OIS), then a minimum climb gradient of 200 feet per nautical mile will ensure proper obstacle clearance. In this case, a "diverse departure" will ensure obstacle clearance.

9.14. What is a "Diverse Departure?" If the airport has at least one instrument approach procedure (IAP), and there are no published IFR departure procedures (because there were no penetrations to the 40:1 OIS), then an aircraft departing can ensure obstacle clearance by executing a "diverse departure." ***In order to fly a diverse departure, fly runway heading until 400 feet above the field elevation before executing any turns while maintaining a minimum climb gradient of 200 feet per nautical mile (unless a higher gradient is published) until reaching a minimum IFR altitude.***

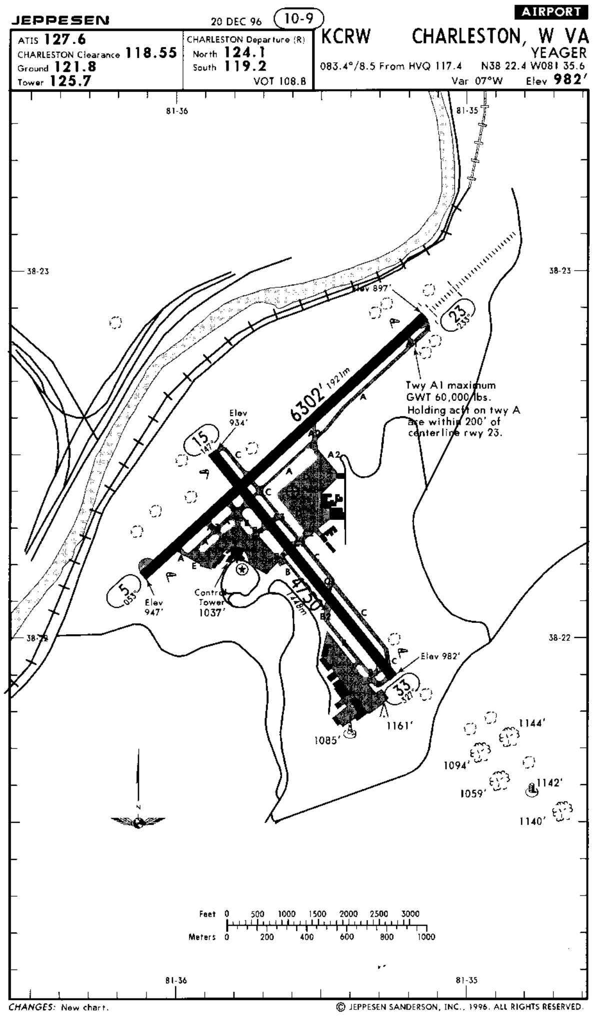
9.15. Obstacles Penetrate the 40:1 OIS. If any obstacles penetrate the 40:1 OIS, then the TERPs specialist must provide notification to the pilot as well as establish a method to avoid the obstacles. In some cases, IFR departures are not authorized from specific runways (**Figures 9.8 and 9.9**).

9.16. Notification. The TERPs specialist may fulfill this requirement using a variety of methods. On U.S. Government charts (FLIP, NOAA), the notification is provided by the placement of a special symbol on all of the IAPs and SIDs for the airport. The symbol is a white "T" on a black inverted triangle. From now on, we'll refer to this "T" symbol as the "Trouble T" since it usually means trouble for departing aircraft. The presence of the "Trouble T" means you need to consult the separate listing in the front of the approach plate titled, "IFR Takeoff Minimums and (Obstacle) Departure Procedures."

NOTES:

1. Outside of the US, the separate listing will be titled "IFR Takeoff Minimums and Departure Procedures."
2. Jeppesen charts do not use the "Trouble T" symbol. Instead, they publish IFR takeoff minimums and departure procedures on the back of the airfield diagram page. ***When using Jeppesen products, you must have the airfield diagram page – not just the approach charts.*** Without the airfield diagram page, you will have no way of identifying the proper method to plan your IFR departure. (**Figures 9.5, 9.6, and 9.7**)

Figure 9.5. Jeppesen Airport Diagram Page for Yeager Field (CRW).
Figure 9.6. Back of Jeppesen Airport Diagram Page for CRW.
Figure 9.7. DoD FLIP's Depiction of CRW's IFR Departure Procedure.



JEPPESEN 20 DEC 96 (10-9A) **AIRPORT**

CHARLESTON, W VA
YEAGER

GENERAL
Deer and birds in vicinity of airport.
Low level wind shear alert system.

ADDITIONAL RUNWAY INFORMATION

RWY				LANDING BEYOND Threshold	LANDING BEYOND Glide Slope	USABLE LENGTHS Threshold to Intersecting Runway	TAKE-OFF	WIDTH
5	HIRL CL REIL VASI-L	grooved	RVR		5157' 1572m			150' 46m
23	HIRL CL ALSF-I VASI-R	grooved	RVR		5433' 1656m	15/33 3750' 1143m		
15 ❶	MIRL REIL PAPI-R (angle 3.78°)							150' 46m
33	MIRL REIL AVASI-L (angle 3.30°)					5/23 3550' 1082m		

❶ Maximum GWT 60,000 lbs.

TAKE-OFF & IFR DEPARTURE PROCEDURE

	Rwy 5: With Mim climb of 210'/NM to 1400' CL & RCLM	Rwy 5: With Mim climb of 210'/NM to 1400' Adequate Vis Ref	Rwy 5: With Mim climb of 210'/NM to 1400' STD	Rwy 5: Other	Rwy 33: With Mim climb of 321'/NM to 1600' Adequate Vis Ref	Rwy 33: With Mim climb of 321'/NM to 1600' STD	Rwy 33: Other
1 & 2 Eng	TDZ RVR 6	RVR 16 or 1/4	RVR 50 or 1	300-1	1/4	1	300-1
3 & 4 Eng	Rollout RVR 6		RVR 24 or 1/2			1/2	

	Rwy 15: With Mim climb of 334'/NM to 1600' Adequate Vis Ref	Rwy 15: With Mim climb of 334'/NM to 1600' STD	Rwy 15: Other	Rwy 23: With Mim climb of 350'/NM to 1600' CL & RCLM	Rwy 23: With Mim climb of 350'/NM to 1600' Adequate Vis Ref	Rwy 23: With Mim climb of 350'/NM to 1600' STD	Rwy 23: Other
1 & 2 Eng	1/4	1	400-1	TDZ RVR 6	RVR 16 or 1/4	RVR 50 or 1	300-1
3 & 4 Eng		1/2		Rollout RVR 6		RVR 24 or 1/2	

IFR DEPARTURE PROCEDURE: Rwys 15,23,33, climb runway heading to 1600' before proceeding on course.

FOR FILING AS ALTERNATE

	Precision	LOC Rwy 5, LOC Rwy 23, VOR DME RNAV Rwy 15 RADAR-1	VOR-A VOR DME RNAV Rwy 33
A	700-2	800-2	800-2
B			
C			
D			800-2¼

CHANGES New chart.

CHARLESTON, WV
YEAGER . . . . Rwy 5, 300–1*
Rwy 15, 400–1**
Rwy 23, 300–1***
Rwy 33, 300–1****

* Standard with minimum climb of 210/NM to 1400.
** Standard with minimum climb of 334/NM to 1600.
*** Standard with minimum climb of 350/NM to 1600.
****Standard with minimum climb of 321/NM to 1600.
Rwys 15, 23, 33, climb rwy hdg to 1600 before proceeding on course.

9.17. Methods to Avoid Obstacles. The TERPs specialist will attempt to provide a method to avoid obstacles during climb to the minimum enroute altitude. Usually, IFR departure procedures will be published either in graphic or textual form. Other procedures you may encounter are SIDs or Departure Procedures (DPs). Under certain circumstances, obstacle clearance may be provided by specific ATC departure instructions that may include the use of radar vectors. ***It is the responsibility of the PIC to thoroughly review the published instrument procedures in order to determine the appropriate method to be used.*** Each of these methods will be described in detail in the following paragraphs.

9.18. Basic Rules for all IFR Departures. Before moving on to describe the different methods of IFR departures, let's summarize the basic rules that apply to all IFR departure procedures. ***No matter what method of IFR departure is used, these basic rules always apply:***

9.18.1. ***Delay all turns until at least 400 feet above the airport elevation unless an early turn is specifically required by the departure procedure.***

9.18.2. ***Climb at a minimum of 200 feet per nautical mile unless a higher gradient is published. Air Force aircraft must always meet or exceed the published climb gradient for the runway used.***

9.19. FAA Takeoff Weather Minimums. Before we move on, it is necessary to explain the FAA's takeoff weather minimums. The FAA's "standard" takeoff weather minimums are defined in FAR 91.175: one statute mile visibility for aircraft with two engines or less and one-half statute mile for aircraft with more than two engines. ***USAF aircraft will not use FAA takeoff weather minimums; minimum weather for takeoff is determined by AFI 11-202, Vol 3 as supplemented by MAJCOM or MDS flight directives.***

9.20. Methods of IFR Departures. In general, there are four methods that may be used to depart an airport under instrument flight rules (IFR):

1. Diverse Departures
2. Departure Procedures (DPs)
3. Standard Instrument Departures (SIDs)
4. Specific ATC Departure Instructions

Each method will be covered in detail in the following paragraphs beginning with "diverse departures" and working down the list to "Specific ATC Departure Instructions."

NOTE: Knowing the proper terminology is important. At the time of this writing, the FAA is in the process of renaming SIDs and IFR Departure Procedures in the United States. In the future, the FAA will refer to IFR departure procedures and SIDs using the phrase "Departure Procedures (DPs)." You may encounter several types of DPs in the new format: an ATC DP (like a SID – strictly for ATC, climb gradient depicted if required), an obstacle DP (what we now call an IFR departure procedure), a graphical DP (a complex IFR departure procedure converted to a graphic form), or other variations not identified yet. Although the terms "SID" and "IFR Departure Procedure" are being removed from the FAA's vocabulary, both are still widespread throughout the rest of the world. Until the transition in terminology is more complete, this chapter will still use the old terms.

9.21. Diverse Departures. The diverse departure was already described in paragraph 9.14. If the airport has at least one instrument approach procedure (IAP), and there are no published IFR departure procedures (because there were no penetrations to the 40:1 OIS), then an aircraft departing can ensure obstacle clearance by executing a "diverse departure." ***In order to fly a diverse departure, fly runway heading until 400 feet above the field elevation before executing any turns while maintaining a minimum climb gradient of 200 feet per nautical mile (unless a higher gradient is published) until reaching a minimum IFR altitude.***

NOTE: There are airports around the world where the diverse departure assessment has not been properly completed. At these airports, a diverse departure may not be authorized for certain runways. You will be notified via NOTAM or by a statement in the front of the book under the section titled, "IFR Takeoff Minimums and (Obstacle) Departure Procedures." The statement will say, "Diverse Departure Not Authorized."

9.22. "Will ATC Clear Me for a Diverse Departure?" ATC will not specifically "clear" you for a diverse departure. If you are "cleared as filed" and ATC does not issue you further instructions (by providing radar vectors or assigning a SID/DP), then ATC expects you to execute a diverse departure.. If a diverse departure is not authorized for your runway, you must coordinate another runway or departure method with ATC to depart the airport under IFR.

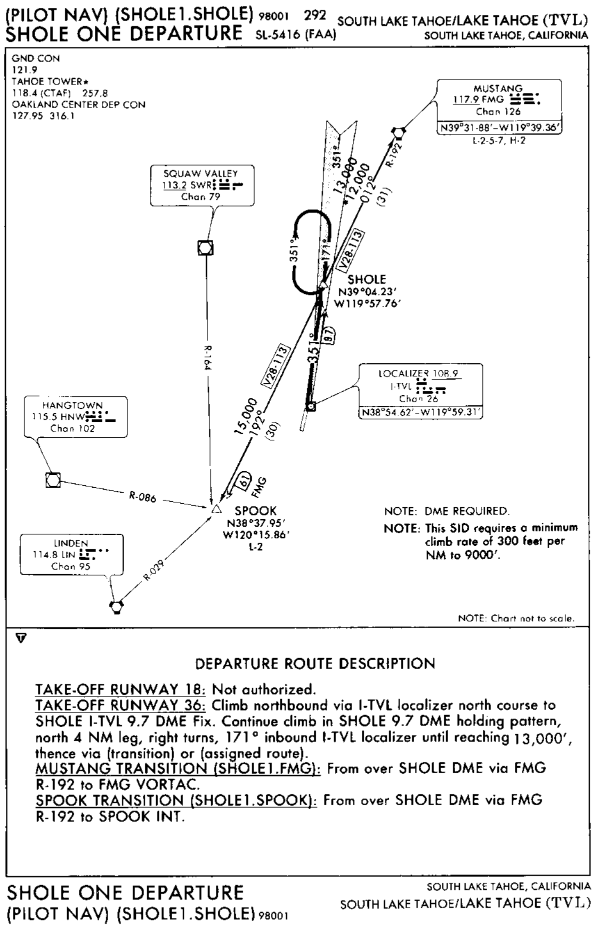
9.23. IFR Departure Procedures. According to the AIM, "Published instrument departure procedures assist pilots conducting IFR flight in avoiding obstacles during climbout to minimum enroute altitude (MEA)." Airports having penetrations to the 40:1 OIS will normally have non-standard takeoff weather minimums as well as an IFR Departure Procedure. This information is located in the front of DoD approach plates in the section titled, "IFR Takeoff Minimums and (Obstacle) Departure Procedures."

9.24. Watch Out for the "Trouble T." The approach chart and SID chart for each airport where takeoff minimums are not standard and/or departure procedures are published is annotated with a special symbol . The use of this symbol indicates that the separate listing in the front of the approach book should be consulted. ***The non-standard weather minimums and minimum climb gradients found in the front of the approach book also apply to SIDs/DPs and radar vector departures unless different minimums are specified on the SID.*** We'll discuss the significance of this statement in the paragraphs dealing with SID/DPs and radar vectors.

NOTE: Remember, not all publishers depict the information in the same way. For example, since Jeppesen does not use the "Trouble T" symbol; you must look at the airport diagram page to determine if any non-standard takeoff weather minimums and/or IFR Departure Procedures exist.

9.25. Designing an IFR Departure Procedure. When designing an IFR departure procedure, the most common four methods used by the TERPs specialist are: non-standard takeoff weather minimums, climb gradients, specific routing, or a combination of several methods. Don't forget; in some cases, an IFR departure may not be authorized. Before looking at each method in detail, let's look at two examples (**Figures 9.8 and 9.9**) where an IFR departure is not authorized.

Figures 9.8. and 9.9. IFR Departure Not Authorized.



TONOPAH, NV .... Rwy 15, 33, 2600-2*
Rwy 11, 29, NA

* Or standard with minimum climb of 260/NM to 8000. Rwy 15 turn left, Rwy 33 turn right. Climb direct TPH VORTAC. Continue climb in holding pattern (hold NE, RT, 246° inbound) to depart TPH VORTAC at or above 8000. Climb on course to MEA or assigned altitude.

"NA" = NOT AUTHORIZED!

These two examples (a SID and an IFR departure procedure) show two airports with an IFR departure not authorized from at least one of its runways.

To the left, you may not depart IFR from South Lake Tahoe on Runway 18 using the SHOLE ONE DEPARTURE.

Above, the IFR departure procedure from Tonopah prohibits IFR departures from Runway 11 and Runway 29.

9.26. Non-Standard Takeoff Weather Minimums. When obstacles penetrate the 40:1 OIS, non-standard takeoff weather minimums are normally provided for some civil pilots to "see-and-avoid" obstacles during departure. "See-and-avoid" is a type of "home field advantage" for pilots who are familiar with the airport's obstacle environment and who are flying aircraft that are usually not capable of meeting the minimum climb gradient. ***USAF aircraft are not authorized to use any departure procedure which requires the use of non-standard takeoff weather minimums to "see-and-avoid" obstacles. Furthermore, USAF aircraft are not authorized to create their own "see-and-avoid" weather minimums in lieu of meeting the required minimum climb gradient.*** Two examples are provided in **Figures 9.10 & 9.11**.

Figures 9.10. and 9.11. IFR Departure Procedures with Only Non-Standard Takeoff Minimums.

CHEYENNE, WY .... Rwy 26, 30, 300-1	**TUPELO MUNI– C.D. LEMONS , MS** .... Rwy 36, 300-1

In the examples above, you may not depart IFR (using any method to include radar vectors) from Runways 26 or 30 at Cheyenne, WY or from Runway 36 at Tupelo, MS.

9.27. Minimum Climb Gradient. The TERPs specialist may also provide a minimum climb gradient for use with the FAA's "standard" takeoff weather minimums (**Figures 9.12 & 9.13**). This is the type of IFR departure procedure most commonly used by USAF aircraft. Typically, the non-standard takeoff weather minimums will have an asterisk (*) leading you to a note which will say something like, "Or standard with minimum climb gradient of 300 ft/NM to 700 feet." When using this type of IFR departure, just substitute your MAJCOM-directed takeoff weather minimums where you see the word "standard." ***USAF aircraft must always meet or exceed the published climb gradient for the runway used.***

Figures 9.12. and 9.13. Minimum Climb Gradient To Be Used with Standard Weather.

GRAND JUNCTION, CO
WALKER FIELD .... Rwy 4, 22, NA
Rwy 11, 2700-2*
Rwy 29, 2700-2**
*Or standard with minimum climb of 280/NM to 8000.
**Or standard with minimum climb of 300/NM to 8000.
Comply with SIDs or: Rwy 11, climbing right turn via JNC R-088 to JNC VORTAC; Rwy 29, climb to 6000 then climbing left turn direct JNC VORTAC. Aircraft departing JNC R-221 CW R-060 depart on course, all other aircraft continue climbing in JNC VORTAC holding pattern (Hold W, LT, 075 inbound) to cross JNC VORTAC at or above: R-061 CW R-130 9500, R-131 CW R-220 10,500.
TAKE-OFF OBSTACLES: Rwy 11, 4949′ tree 1692′ from departure end of rwy, 438′ left of center-line.

JACKSON HOLE, WY........... Rwy 18, 3700-3*
Rwy 36, 3600-3**
*Or standard with minimum climb of 270′/NM to 10,100.
**Or standard with minimum climb of 310′/NM to 8800.
Rwy 18: Climb to 11,000 via JAC R-188, then climbing left turn direct JAC VOR/DME. Aircraft departing JAC VOR/DME R-356 CW R-037, or R-142 CW R-207, climb on course. All others continue climb in JAC VOR/DME holding pattern (hold S, RT, 006 inbound) to cross JAC VOR/DME at or above: R-038 CW R-141, 12,300; R-208 CW R-279, 12,200: R-280 CW R-355, 15,000.
Rwy 36: Climb Rwy heading to 7300, then climbing right turn to intercept JAC R-014 to NALSI INT/JAC 17.3 DME, continue climb via DNW R-267 to DNW VOR/DME. Aircraft departing DNW VOR/DME R-281 CW R-016, and R-088 CW R-218, climb on course. All others continue climb in DNW VOR/DME holding pattern (hold W. RT. 087 inbound) to cross DNW VOR/DME at or above: R-017 CW R-087, 12100; R-219 CW R-280, 13700.

9.28. Specific Routing. A third method used by the TERPs specialist is to provide a specific route of flight which will take the aircraft away from the obstacle (**Figures 9.14 & 9.15**). You have to be careful when using this type of IFR departure. Make sure there is no requirement to use a non-standard takeoff weather minimum in order to execute the procedure. A legitimate routing will not have a non-standard takeoff weather minimum published.

Figures 9.14. and 9.15. IFR Departure Procedures with Specific Routing.

PUEBLO MEMORIAL, CO.....................
Rwy 17, 26L/R turn left, Rwy 35 turn right, all aircraft climb direct PUB VORTAC. Continue climbing in PUB holding pattern (Hold NE, RT, 244° inbound to cross PUB VORTAC at or above: R-333 CW 178° 7000, R-179 CW 261° 10,600, R-262 7600, R-263 CW 332° 11,600).

RATON MUNI/CREWS FIELD, NM
When weather is below 1500–2: Rwys 2, 7, climb on R–040 CIM VORTAC NEbnd to 8000, then on course to assigned altitudes; Rwys 20, 25, climb on R–040 CIM VORTAC SWbnd to 8000, then on course to assigned altitude.

9.29. Combination of All Three Methods. Some IFR departure procedures use a combination of all three methods. Once again, make sure the procedure does not require the use of non-standard takeoff weather minimums. Here are a couple of examples – one we can use (**Figure 9.16**) and one we can't (**Figure 9.17**).

Figure 9.16. IFR Departure Procedure *Using a Combination of Methods.*

This IFR departure procedure from Provo Muni is fairly complex and the TERPs specialist used a combination of all three methods to design a safe departure. Also notice that the minimums change based on aircraft category**.**

Although an IFR takeoff is not authorized from Runway 6, you could use this IFR departure procedure for several of the other runways provided you can meet or exceed the appropriate climb gradients based on the runway used and your aircraft category**.**

PROVO MUNI, UT .... Rwy 6, NA
Rwys 13, 18, 3700-2*
Rwys 13, 18, 3700-2**
Rwy 24 3700-2***
Rwys 31, 36, 3700-2†
Rwys 31, 36, 3700-2††

* Or standard CAT A, B with minimum climb of 220′/NM to 9200.
** Or standard CAT C, D with minimum climb of 350′/NM to 7500.
*** Or standard with minimum climb of 220′/NM to 9200.
† Or standard CAT A, B with minimum climb of 220′/NM to 9200.
†† Or standard CAT C, D with minimum climb of 380′/NM to 8300.

Rwys 13, 18 climbing right turn; Rwy 24 climb rwy heading; Rwys 31, 36 climbing left turn. All aircraft climb via PVU VOR/DME R-228 to 8000 then climbing right turn direct FFU VORTAC. Aircraft departing FFU R-161 CW R-270 climb on course. All others continue climb in FFU VORTAC holding pattern (HOLD S, RT, 340 inbound) to cross FFU VORTAC at or above:
R-001 CW R-050 12,500
R-051 CW R-090 12,000
R-091 CW R-160 10,800
R-271 CW R-360 10,500

Figure 9.17. IFR Departure Procedure Using Combination – but an IFR Departure is Not Authorized (NA).

At first glance, you may think you could use this IFR departure procedure; however, if you look closely, you'll notice the procedure <u>requires</u> the use of non-standard takeoff weather minimums. For example, if you were planning to takeoff on Runway 7, the procedure requires you have 800-2 <u>and</u> still climb at 650 feet per nautical mile. Since the procedure requires the use of "see-and-avoid," it is not authorized for use by USAF aircraft.

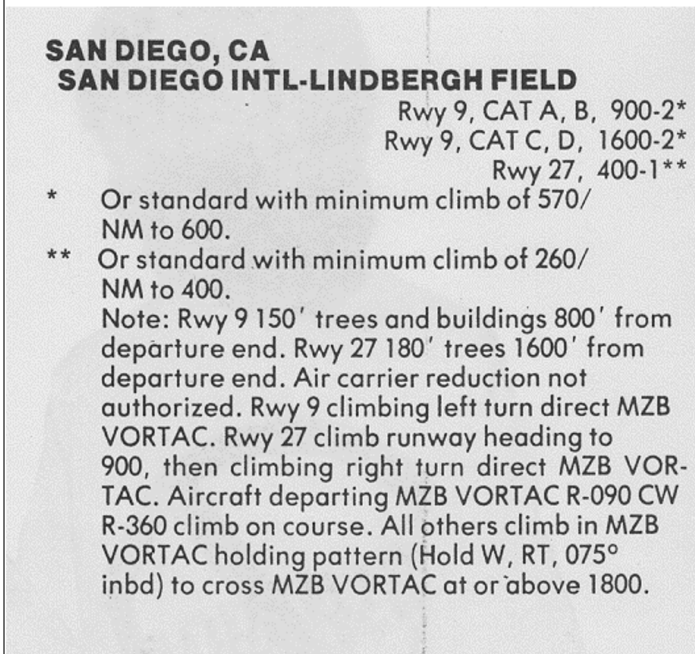
EAGLE, CO
EAGLE COUNTY REGIONAL.... Rwy 7, 5300-3*
Rwy 25, 5300-3**

* Or 800-2 with minimum climb of 650′/NM to 11,800.
** Or 1700-3 with minimum climb of 750′/NM to 11,200.

Rwy 7: Climb to 14,000 via outbound on the I-EGE localizer east course to intercept RLG R-198 (V-361-421) to RLG VORTAC before proceeding on course.
Rwy 25: Immediate climbing left turn to 13,500 via heading 215°, upon reaching 9000 or crossing SXW VOR/DME R-152 or DBL VOR/DME R-326, then climbing right turn to intercept DBL R-322, then via DBL R-322 to intercept RLG R-231 (V-8) to RLG VORTAC before proceeding on course.

9.30. Low Close-In Obstacles. The TERPs specialist is not allowed to publish climb gradients to heights 200 feet or less. These are typically obstacles that are very close to the runway and would create a very large climb gradient. Instead of publishing a climb gradient, the TERPs specialist will publish a NOTE informing you of the height and location of the obstacles (**Figure 9.18**). ***In addition to complying with the published climb gradient, you must also ensure you can clear any obstacles published in this type of NOTE.***

Figures 9.18. & 9.19. San Diego International, CA.



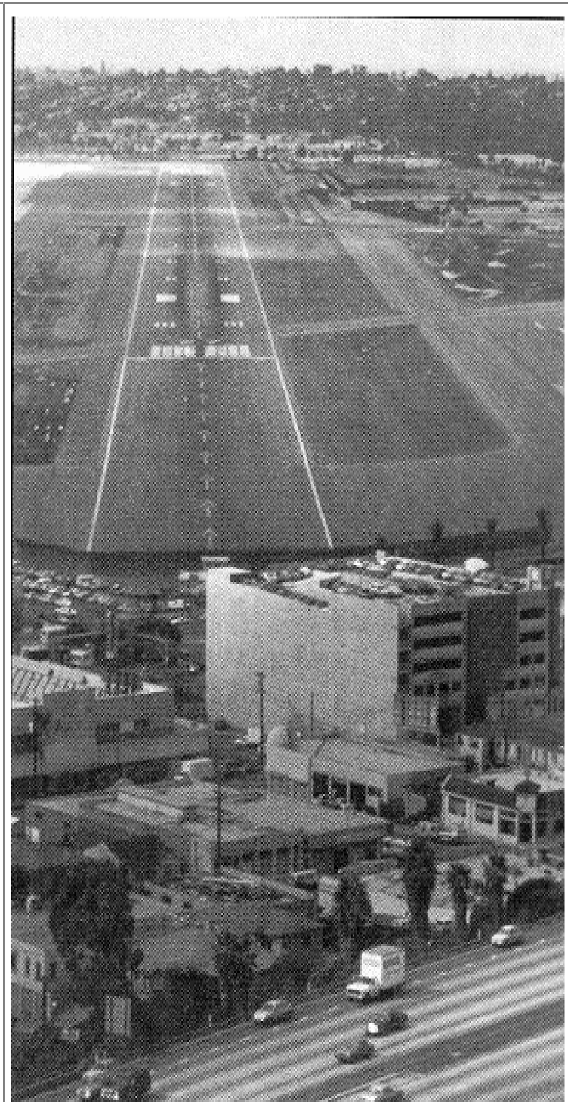
SAN DIEGO, CA
SAN DIEGO INTL-LINDBERGH FIELD

Rwy 9, CAT A, B, 900-2*
Rwy 9, CAT C, D, 1600-2*
Rwy 27, 400-1**

* Or standard with minimum climb of 570/ NM to 600.

** Or standard with minimum climb of 260/ NM to 400.

Note: Rwy 9 150′ trees and buildings 800′ from departure end. Rwy 27 180′ trees 1600′ from departure end. Air carrier reduction not authorized. Rwy 9 climbing left turn direct MZB VORTAC. Rwy 27 climb runway heading to 900, then climbing right turn direct MZB VORTAC. Aircraft departing MZB VORTAC R-090 CW R-360 climb on course. All others climb in MZB VORTAC holding pattern (Hold W, RT, 075° inbd) to cross MZB VORTAC at or above 1800.



9.31. "Will ATC Clear Me for an IFR Departure Procedure?" In most situations, ATC will not specifically clear you for an IFR departure procedure. If you are "cleared as filed" and ATC does not issue you further instructions (by providing radar vectors or assigning a SID/DP), then you are expected to fly the published instrument departure procedure for the runway used. AFI 11-202, Vol 3, states, ***"Unless otherwise cleared by ATC, pilots will fly the published instrument departure procedure for the runway used."***

NOTE: There is one exception: If you are departing an airport, and pilot compliance with the IFR departure procedure is necessary for traffic separation, then ATC may include the IFR departure procedure in your ATC clearance.

9.32. "How Do I File an IFR Departure Procedure?" At the time of this writing, there is no written guidance on how to "file" an IFR departure procedure although the AIM states, "any published DP may be filed and flown." Refer to FLIP General Planning for the most up-to-date guidance on filing. In the meantime, if you want ATC to know you are planning to fly the IFR departure procedure, you'll have to tell them. This is not a required call; however, in some situations (for example, a busy terminal area), it may be a good idea to give the controller a "heads-up."

9.33. SIDs/DPs Instead of IFR Departure Procedures. There are some airports that will provide obstacle clearance via a SID/DP instead of establishing an IFR departure procedure. You will be notified via NOTAM or by a statement in the front of the book under the section titled, "IFR Takeoff Minimums and (Obstacle) Departure Procedures." The statement will say, "RWY XX, use published DP for obstacle avoidance."

9.34. Standard Instrument Departures (SIDs). A SID is an ATC coded departure procedure that has been established at certain airports to simplify clearance delivery procedures. SIDs are preplanned IFR departure procedures printed for pilot use in graphic and/or textual form. SIDs are supposed to be simple, easy to understand, and (if possible) limited to one page. The actual SID is depicted by a heavy black line; thin black lines represent transition routings. The departure route description should be complete enough that the pilot can fly the SID with only the textual description.

9.35. SIDs Are Optimized for ATC. The first important thing to understand is that a SID is an "ATC" procedure. The definition does <u>not</u> say what pilots would like for it to say, "A SID is a procedure used by pilots which provides the optimum route to be used for obstacle clearance during climb to the minimum enroute altitude." The second important distinction is the purpose of SIDs – to "simplify clearance delivery;" not to help you avoid obstacles. When a SID is created, ATC draws the course they want you to fly on the chart. The purpose of this route of flight is not to provide an optimal route to avoid obstacles for you – it's for the convenience of ATC and their traffic management strategy. Just remember, a SID is good for pilots and ATC primarily because it simplifies clearance delivery and cuts down on radio chatter – and, secondarily, it may provide pilots with information that can be useful in avoiding obstacles during climb to a safe enroute altitude.

9.36. Using SIDs. Pilots operating from locations where SIDs exist can expect an ATC clearance containing a SID. ***In order to use a SID, the pilot must possess at least the textual description of the SID procedure.*** Controllers may omit the departure control frequency if a SID clearance is issued and the departure control frequency is published on the SID. ***ATC must be immediately advised if the pilot does not possess a charted SID or a preprinted SID description or, for any other reason, does not wish to use a SID.*** Notification may be accomplished by filing "NO SID" in the remarks section of the filed flight plan or by the less desirable method of verbally advising ATC.

9.37. SID Depictions. SIDs are usually depicted in one of two basic forms – Pilot Nav or Vector SIDs.

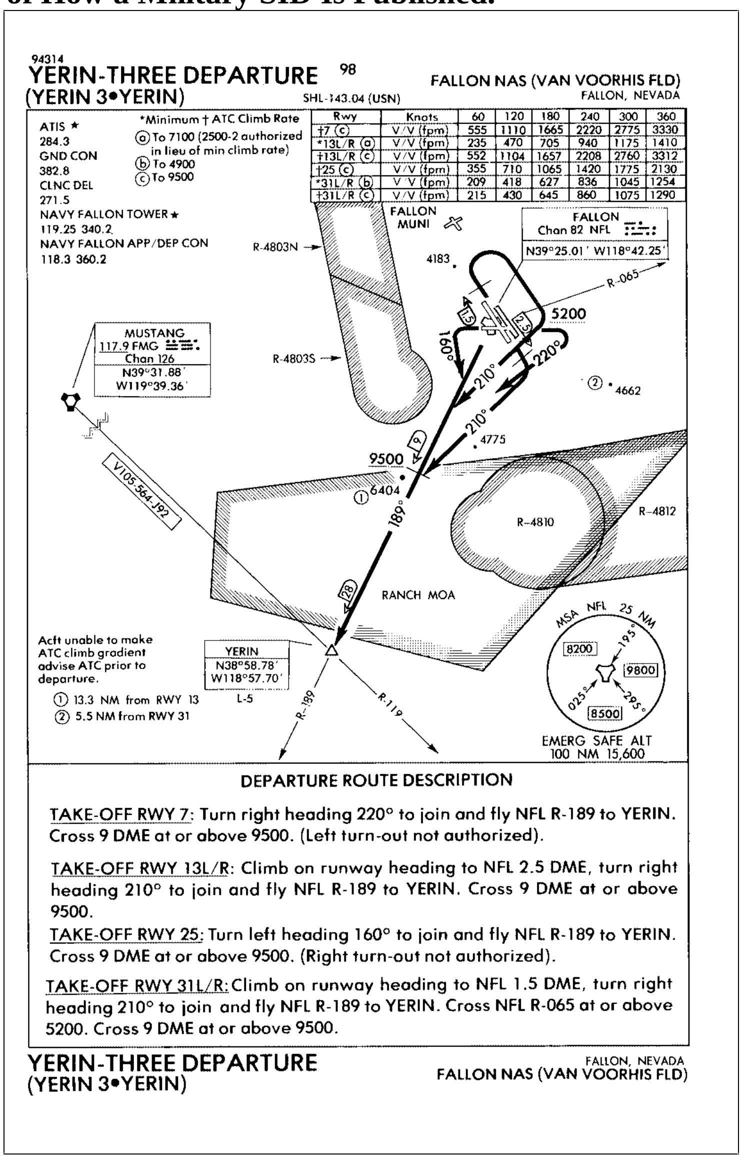
9.37.1. Pilot Navigation (Pilot NAV) SIDs. The pilot is primarily responsible for navigation on the SID route. They are established for airports when terrain and safety related factors indicate the necessity for a pilot NAV SID. Some Pilot NAV SIDs may contain vector instructions which pilots are expected to comply with until instructions are received to resume normal navigation on the filed/assigned route or SID procedure.

9.37.2. Vector SIDs. Vector SIDs are established where ATC will provide radar navigational guidance to a filed/assigned route or to a fix depicted on the SID.

9.38. Different Types of SIDs. SIDs are very common everywhere we fly. Even though SIDs seem about the same the world over, there are some very important differences which you must be aware of in order to fly them safely.

9.39. Domestic SIDs. In the United States, all SIDs are developed using U.S. TERPs criteria. Even so, there is a big difference between how military SIDs and civil SIDs are depicted. It's important to understand what each format provides (or does not provide) for you.

Figure 9.20. Example of How a Military SID Is Published.



9.40. Military SIDs. Generally speaking, military SIDs provide you with more information than civil SIDs. (The phrase "military SIDs" applies mainly to USAF/USN SIDs in the CONUS. Army SIDs are produced by the FAA in the CONUS and should be treated as civil SIDs.) During our discussion of military SIDs, we'll use the YERIN-THREE DEPARTURE at Fallon NAS, NV as an example (**Figure 9.20**).

9.40.1. Obstacles Are Charted. On a military SID, "prominent" obstacles (not all obstacles) which might create a hazard if departure procedures are not executed precisely, shall be shown in their exact geographic location (**Figure 9.21**). When portrayal of several obstacles would create clutter, only the highest of the group must be shown. The distance to the controlling obstacle, upon which the minimum climb rate is predicated, shall be depicted (**Figure 9.22**).

9.40.2. ATC Climb Gradients Identified. Military SIDs identify and publish ATC climb gradients that exceed 200 feet per nautical mile (**Figure 9.23**). ATC climb gradients are for crossing restrictions or other airspace considerations.

9.40.3. Obstacle Climb Gradients. Military SIDs identify and publish minimum climb gradients that exceed 200 feet per nautical mile which will ensure proper obstacle clearance (**Figure 9.23**).

CAUTION: Although military SIDs depict information about the "controlling obstacle," that information is <u>not</u> provided to assist you in creating your own departure. For example, you may not take the obstacle height and distance from the SID and determine a "new" climb gradient for the SID. To do so may expose you to other obstacles that are not depicted. USAF aircraft must meet or exceed the published climb gradient – not one that you have calculated.

Figure 9.21. Obstacles Are Depicted.

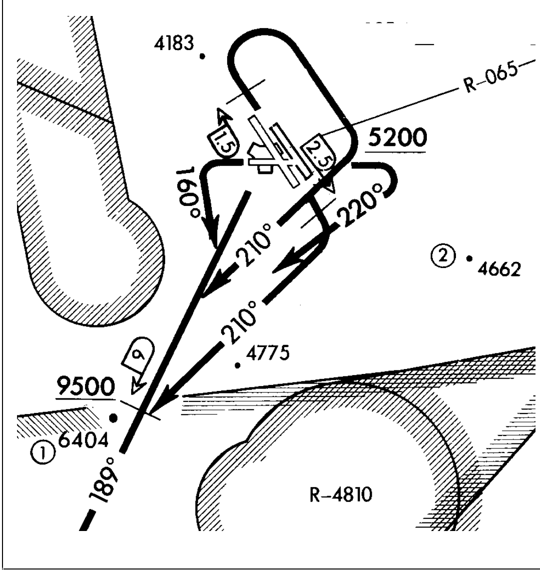


Figure 9.22. Controlling Obstacle Info Is Provided.

Acft unable to make ATC climb gradient advise ATC prior to departure.

① 13.3 NM from RWY 13

② 5.5 NM from RWY 31

9.41. Climb Gradient Table. Military SIDs provide information about both obstacle and ATC climb gradients. Typically, all climb gradient information is placed in a climb gradient table published on the SID. (The climb gradient table from the YERIN-THREE is reproduced in **Figure 9.23** below.) Minimum climb gradients are usually identified by an asterisk (*) and ATC gradients are usually indicated by a "dagger" (†) symbol. It is important to understand how to properly use the information presented in the climb gradient table.

Figure 9.23. Climb Gradient Table.

*Minimum † ATC Climb Rate
(a) To 7100 (2500-2 authorized in lieu of min climb rate)
(b) To 4900
(c) To 9500

Rwy	Knots	60	120	180	240	300	360
†7 (c)	V/V (fpm)	555	1110	1665	2220	2775	3330
*13L/R (a)	V/V (fpm)	235	470	705	940	1175	1410
†13L/R (c)	V/V (fpm)	552	1104	1657	2208	2760	3312
†25 (c)	V/V (fpm)	355	710	1065	1420	1775	2130
*31L/R (b)	V/V (fpm)	209	418	627	836	1045	1254
†31L/R (c)	V/V (fpm)	215	430	645	860	1075	1290

9.42. Climb Rate vs. Climb Gradient. The unit of measurement used actually describes climb rates in feet per minute (like VVI). Since the table's climb rate is based on feet per minute, it assumes a constant groundspeed. During climbout, you rarely hold a constant groundspeed (affected by TAS, winds, acceleration, pilot technique, etc.), so the climb rates in feet per minute are actually not very useful. Instead of a "climb rate," what you really need to know is the required "climb gradient" expressed in feet per nautical mile or percent gradient. The information you need is provided by the table, but you need to know how to pick it out.

CAUTION: Flying the VVI values represented in the climb gradient table does not guarantee obstacle clearance. In order to properly ensure obstacle clearance, you must compare your aircraft's climb performance to the required climb gradient (not the climb rate).

9.43. Determining the Climb Gradient in Feet Per Nautical Mile. By the magic of the "60-1 Rule" (described in AFMAN 11-217, Volume 2), the number which appears in the "60 knot" block of the climb gradient table closely approximates the required gradient in feet per nautical mile. If there is no "60" block, just divide the "120" block by two or divide the "180" block by three, etc. For example, using the climb gradient table in **Figure 9.23**, the minimum obstacle gradient for Runway 13L/R is 235 feet per nautical mile, and the minimum ATC gradient for Runway 13L/R is 552 feet per nautical mile.

9.44. Conversions. Armed with your climb gradient in feet per nautical mile, you can now convert to other units of measurement in order to assess your aircraft's required performance. Here are some of the common conversions:

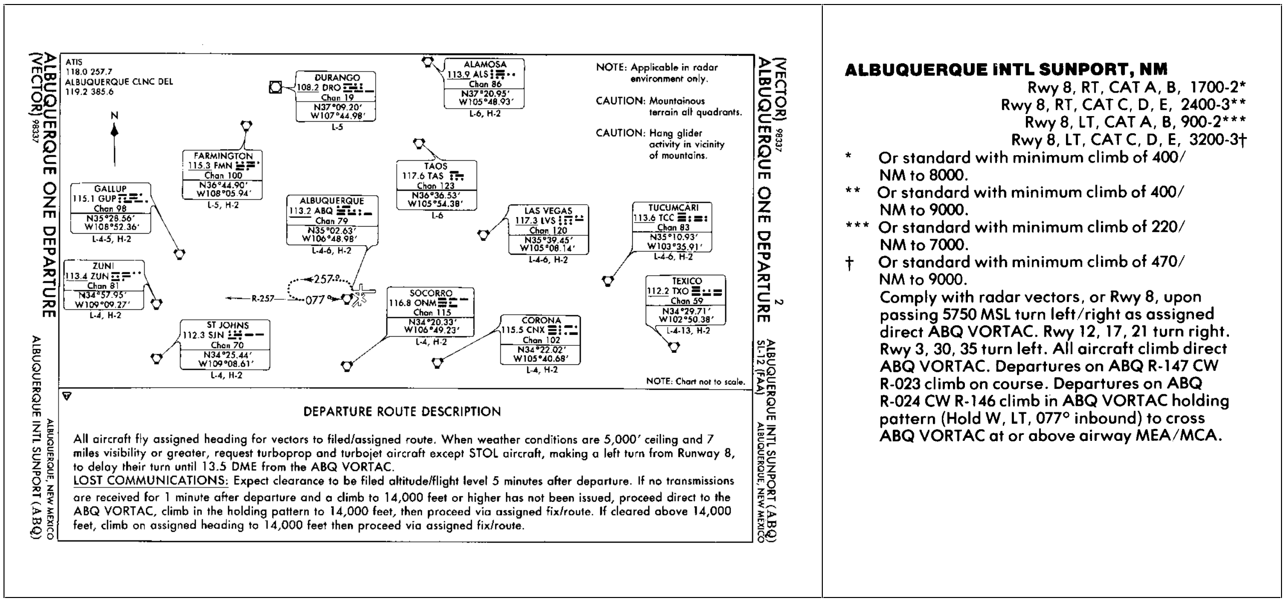
9.44.1. Feet Per Nautical Mile to Percent Gradient. To convert feet per nautical mile to percent gradient, divide the gradient in feet per nautical mile by 60 to convert to percent gradient. For example, if your required climb gradient is 300 ft/NM, divide by 60 to convert to percent gradient. In this case, 300 divided by sixty equals five, so your required climb gradient is 5%. Just reverse the process to convert percent gradient to feet per nautical mile. (For you purists, you should actually divide by 60.76.)

9.44.2. Feet Per Minute to Percent Gradient. If you are using a chart with a "100 knot" groundspeed block, you can take the feet per minute value in the "100 knot" column and divide it by 100 to calculate the required climb gradient in percent gradient. For example, if the climb rate in the "100 knot" column is 600 feet per minute, then divide by 100 to convert the climb rate to percent gradient. In this case, 600 feet per minute equates to a 6% climb gradient. To convert to feet per nautical mile, multiply by 60 to determine the required climb gradient in feet per nautical mile. In this case, the answer is 360 feet per nautical mile.

9.45. Civil SIDs. Although civil SIDs (FAA and CONUS Army procedures) in the United States are constructed using the same TERPs criteria as military SIDs, the information presented is significantly different. It is important to be aware of the differences.

9.46. No Obstacles Are Identified or Depicted. Although many obstacles may be present, civil SIDs do not provide any obstacle information to the pilot. For example, look at **Figure 9.24**. Most of you know there are plenty of obstacles (mountains) around Albuquerque; however, obstacles are not depicted on civil SIDs.

Figure 9.24. Civil Vector SID (Notice -- No obstacles are depicted.)



9.47. ATC Climb Gradients. Civil SIDs also do not normally identify ATC climb gradients in any way; it is up to the pilot to recognize and compute any ATC climb gradients. For example, look at the TATES TWO DEPARTURE in **Figure 9.25.** In this case, you need to compute your own gradient to cross TATES at or above 5,000 feet MSL.

Figure 9.25. Civil SID with ATC Gradient (Not Depicted).

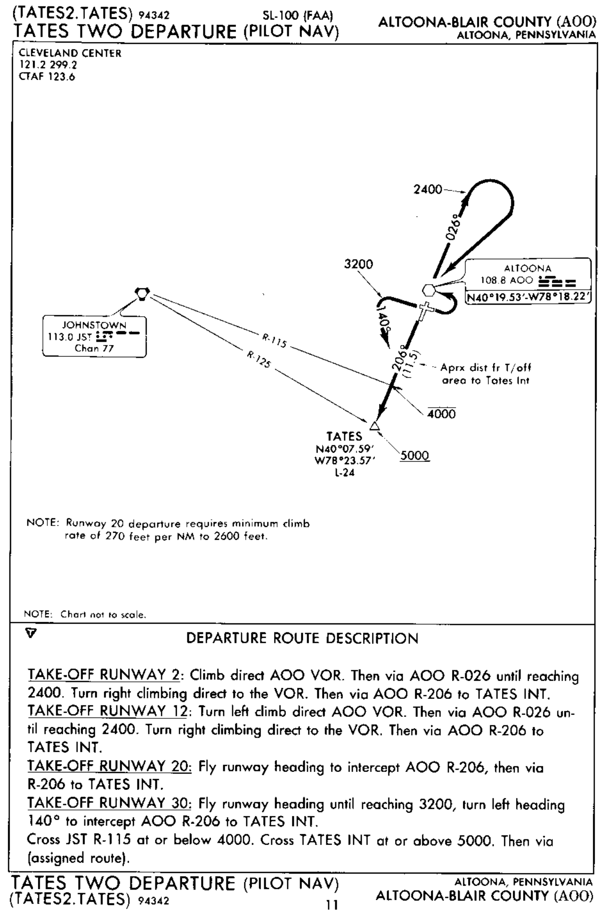
Civil SIDs Don't Depict ATC Gradients

If you were cleared to takeoff from Altoona-Blair County Airport via the TATES TWO DEPARTURE, your minimum climb gradient for obstacles is stated on the SID: 270 ft/NM to 2,600 feet MSL. There is an ATC climb gradient also; however, you must figure it out yourself since ATC gradients are not published on civil SIDs.

The required ATC gradient is 301 feet per nautical mile to cross TATES at or above 5,000 feet MSL.

To compute the gradient, divide the altitude to be gained by the distance to TATES. Field elevation at Altoona-Blair is 1,504 feet MSL. Don't forget you must cross the departure end at or above 35 feet AGL since this is a civil SID. Here's the math:

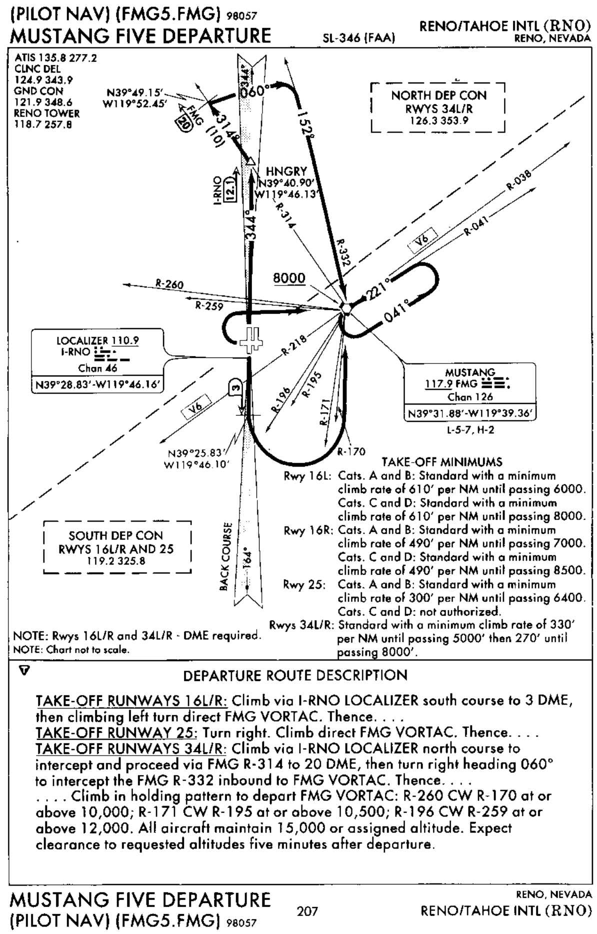
$$\frac{5{,}000 - 1504}{11.5} = 304 \text{ ft/NM}$$



9.48. Obstacle Climb Gradients. On civil SIDs, minimum climb gradients required for obstacle clearance will be depicted in one of two ways: depicted on the SID or included in the IFR departure procedure.

9.49. Climb Gradient Depicted On the SID. At some airports, the minimum climb gradient will be published on the SID like on the MUSTANG FIVE DEPARTURE from Reno/Tahoe Intl (**Figure 9.26**). In cases like the MUSTANG FIVE, although a "trouble T" is depicted on the SID, ***the climb gradient published on the SID itself takes precedence over the climb gradient contained in the IFR Departure Procedure*** **(Figure 9.27*).***

Figures 9.26. and 9.27. Civil SID With Climb Gradient Depicted on the SID.



RENO/TAHOE INTL, NV . . . . Rwy 7, 1600-2*
Rwy 16L, 2300-2**
Rwy 16L 3600-2***
Rwy 16R, 2000-2****
Rwy 16R, 3500-2†
Rwy 25, 1700-2††
Rwy 25, 4000-2†††
Rwy 34L/R, 1900-2††††

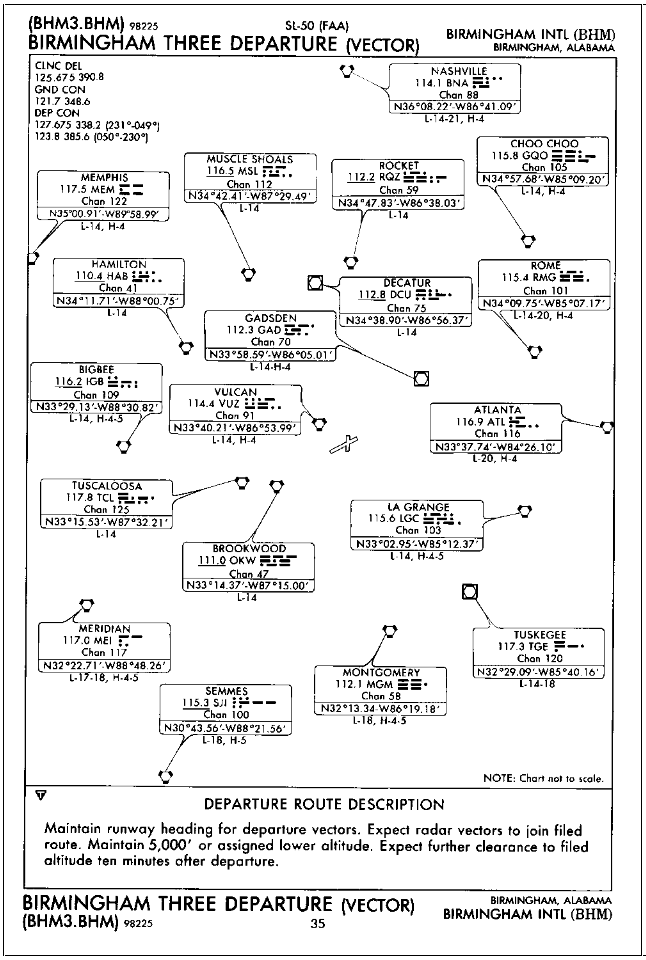
*Or standard with minimum climb of 590'/NM to 7000.
**Or standard CAT A, B, with minimum climb of 510'/NM to 6200.
***Or standard CAT C, D, with minimum climb of 510'/NM to 8500.
****Or standard CAT A, B, with minimum climb of 380'/NM to 7000.
† Or standard CAT C, D, with minimum climb of 380'/NM to 8500.
†† Or standard CAT A, B, with minimum climb of 310'/NM to 6400.
††† Or standard CAT C, D, with minimum climb of 490'/NM to 8900.
†††† Or standard with minimum climb of 270'/NM to 6700.

Rwy 7, turn left; climb direct FMG VORTAC. Rwy 16L/R; climb via I-RNO south course to 5500, then climbing left turn direct FMG VORTAC. Rwy 25; turn right climb direct FMG VORTAC. Rwy 34L/R; climb via I-RNO north course to 7500, then climbing right turn direct FMG VORTAC. All aircraft climb in FMG VORTAC holding pattern (hold NE, LT, 221 inbound) to depart FMG VORTAC; R-260 CW R-150 at or above 8600; R-151 CW R-170 at or above 10000;R-171 CW R-195 at or above 10500; R-196 CW R-259 at or above 12000.

In the two figures above, the SID is on the left and the IFR Departure Procedure (from the front of the approach book) is on the right. Although there is a "Trouble T" on the SID, the climb gradient published on the SID takes precedence over the climb gradients published in the IFR Departure Procedure. Always remember – fly the climb gradient associated with the route you actually fly.

9.50. Climb Gradient Included in the IFR Departure Procedure. In other situations, there will be no climb gradient published on the SID; however, the SID chart will depict a "Trouble T." In these cases, you must refer to the IFR Departure Procedures in the front of the approach book to determine the minimum climb gradient for the runway used. A good example is the BIRMINGHAM THREE DEPARTURE depicted in **Figures 9.28 and 9.29**. ***When no climb gradient is specified on the SID, you must comply with the gradient published with the IFR departure procedure for that runway.***

Figures 9.28. and 9.29. Vector SID With No Climb Gradient Depicted.



BIRMINGHAM INTL, AL

Rwy 5, 800-6 or standard with minimum climb of 360′ per NM to 1700. Air Carrier reductions not authorized. Rwy 18, 800-4 or standard with minimum climb to 340′ per NM to 1700. Rwy 36, 800-2.

IFR DEPARTURE PROCEDURE: Rwy 5, climb runway heading to1700 before turning on course. Rwy 18, climb runway heading to 2100 before turning on course. Rwy 23, climb runway heading to 2100 before turning on course. Rwy 36, climb runway heading 1700 before turning on course.

9.51. "What's the Required Climb Gradient?" Here are a couple of examples: You are departing Birmingham and receive the following clearance: "Track 32, cleared to Andrews AFB as filed via the Birmingham Three Departure (**Figures 9.28 and 9.29**)." In this case, there is no minimum climb gradient published on the SID; however, there is a "Trouble T," so you must consult the "IFR Take-off Minimums and (Obstacle) Departure Procedures" section in the front of the approach plate book.

9.51.1. Situation One. You are planning to depart on Runway 05. After consulting the IFR departure procedure in the front of the book, you discover the required climb gradient for Runway 05 is 360 feet per nautical mile to 1,700 feet MSL. While departing via the BIRMINGHAM THREE DEPARTURE, you must maintain 360 feet per nautical mile to 1,700 feet MSL.

9.51.2. Situation Two. Runway 05/23 is closed and Runway 36 is now the active. Now what will you do? If you look at the front of the book, you'll notice Runway 36 has only non-standard takeoff weather minimums published. There is no option to maintain a climb gradient with standard weather minimums like Runway 05 and Runway 18. In this situation, you may not takeoff IFR from Runway 36 – even with radar vectors.

9.52. SID Crossing Restrictions. Remember, on a civil SID, the only reason a climb gradient will be published is when it is required for obstacle clearance. It is also important to realize that crossing restrictions on SIDs may be established for traffic separation or obstacle clearance. The problem is that you will not be able to tell the difference just by looking at the SID. If you are ever in doubt about making a SID crossing restriction, notify ATC immediately. When no gradient is specified, the pilot is expected to climb at least 200 feet per nautical mile to MEA unless required to level off by a crossing restriction.

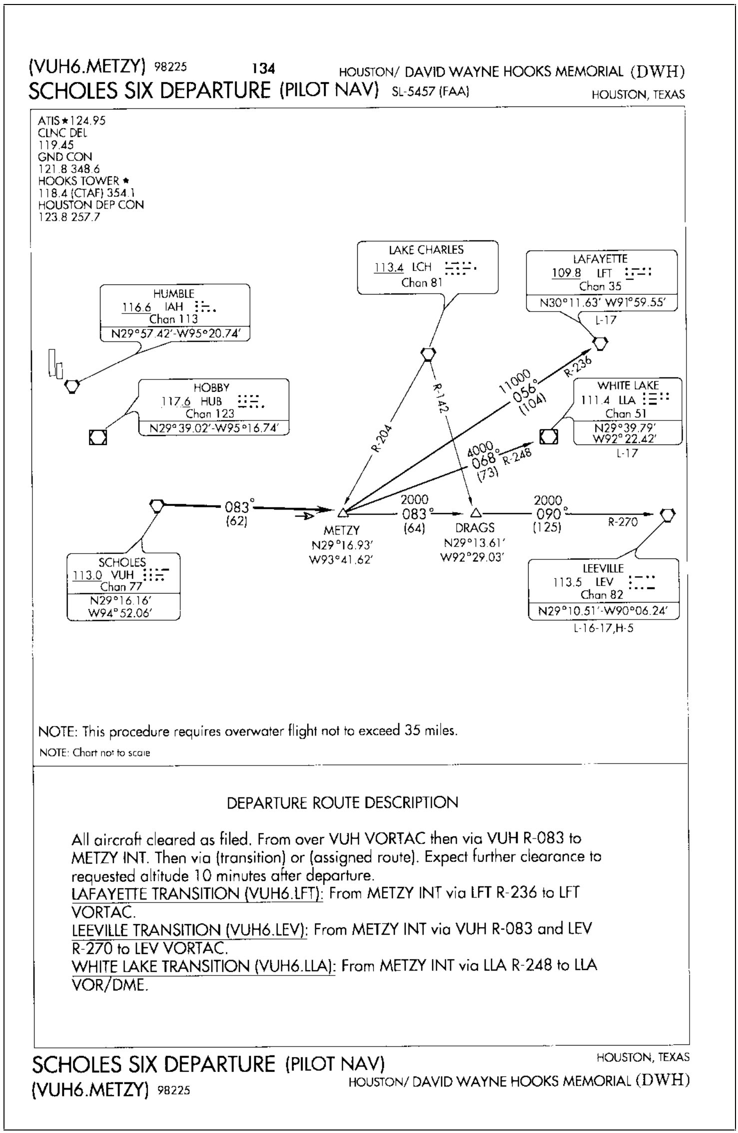
9.53. "Will ATC Clear Me To Fly a SID?" If ATC wants you to fly a SID, it will normally be included in your clearance. The controller will state the SID name, the current number and the SID transition name after the phrase "Cleared to (destination) airport" and prior to the phrase, "then as filed," for ALL departure clearances when the SID or SID transition is to be flown. Controllers may omit the departure control frequency if a SID has or will be assigned and the departure control frequency is published on the SID.

9.54. "How Do I File a SID?" Select a SID and/or SID transition routing which is appropriate for your desired route of flight. To file the SID, place the SID coded identifier as the first entry in your route of flight. For example, look at the SCHOLES SIX DEPARTURE out of Houston (**Figure 9.30**). To just file the SCHOLES SIX to METZY, you would place "VUH6.METZY" as the first entry in your route of flight. If you wanted to file one of the transition routes, then you need to use the appropriate transition's coded identifier. For example, if you were flying to Lafayette, you would probably want to file the LAFAYETTE TRANSITION. In this case, "VUH6.LFT" would be the first entry in your route of flight. More information about filing SIDs can be found in FLIP.

9.55. SID Altitudes. In your initial clearance, ATC will provide you with an altitude to climb and maintain. In some cases, your initial altitude will be published on the SID.

9.56. Amended Clearances. ATC may change your altitude clearance at any time after receiving your initial clearance. The important point to remember is that the last ATC clearance has precedence over the previous ATC clearance. When the route or altitude in a previously issued clearance is amended, the controller will restate applicable altitude restrictions. If the altitude to maintain is changed or restated, whether prior to departure or while airborne, and, previously issued altitude restrictions are omitted, those altitude restrictions are canceled, including SID/DP/STAR altitude restrictions.

Figure 9.30. Scholes Six Departure.



9.56.1. An Example. ATC initially gives you the following clearance: "Track 32, cross Ollis intersection at or above 3,000; Gordonsville VOR at or above 12,000; maintain FL 200." Shortly after departure, the controller changes the altitude to be maintained to FL240. If the controller wants you to continue to comply with the previously issued altitude restrictions, he will restate them like this: "Track 32, amend your altitude. Cross Ollis at or above three thousand; cross Gordonsville at or above one two thousand; maintain flight level two four zero." If he wants you to climb unrestricted to FL 240 and disregard the previously issued altitude restrictions, he will issue the following clearance: "Track 32, climb and maintain flight level two four zero."

CAUTION: It is important to understand the different types of altitude restrictions that may be depicted on SIDs/DPs/STARs. Although you may be able to disregard ATC altitude restrictions after receiving an amended clearance, some altitude restrictions are depicted due to terrain and/or obstacles. Obviously, these types of restrictions can never be disregarded. If there is any question about your new clearance and/or the applicable altitude restrictions, query the controller.

9.57. Restrictions Not Depicted On the SID. If it is necessary for the controller to assign a crossing altitude that differs from the SID altitude, the controller should repeat the changed altitude for emphasis. If you are radar vectored or cleared off an assigned SID, you may consider the SID canceled unless the controller adds “Expect to resume SID.” If ATC reinstates the SID and wishes any restrictions associated with the SID to still apply, the controller will state: “Comply with restrictions.”

CAUTION: When pilots and controllers discuss changes to SIDs, the potential for miscommunication is high. If there is any question about your clearance, query the controller.

9.58. Specific ATC Departure Instructions. Before beginning our discussion of specific ATC departure instructions, it’s important to take note of a few terms. The first thing you need to know about a radar departure is what the term, “radar contact” means. In plain English, it means the controller sees your aircraft’s radar return on his scope and he has positively identified you. It’s also important to understand what “radar contact” does not mean – it does not mean the controller now has responsibility for your terrain/obstacle clearance. Specifically, here’s what the AIM says: “The term ‘radar contact,’ when used by the controller during departure, should not be interpreted as relieving pilots of their responsibility to maintain appropriate terrain and obstruction clearance.” AIM goes on to say that “Terrain/obstruction clearance is not provided by ATC until the controller begins to provide navigational guidance in the form of radar vectors.” Even this statement is a little misleading; ATC is never solely responsible for your terrain/obstruction clearance. A better way to describe this relationship would be to say, “ATC does not begin to share responsibility for terrain/obstacle clearance until the controller begins to provide navigational guidance.”

CAUTION: All ATC systems are not created equal. While you may trust an FAA controller nearly 100%, you would be foolish to have the same amount of confidence in a controller in an undeveloped country who does not even speak your language. Ask some of the more experienced pilots in your unit about flying in South America or Africa. The pilot is always ultimately responsible for terrain/obstacle clearance; be careful who you trust to help you with that responsibility.

9.59. Explanation of the Term ‘Specific ATC Departure Instructions.’ In most cases, the term “specific ATC departure instructions” refers to radar vectors; however, there are some situations when ATC’s departure instructions do not meet the strict definition of a “radar vector.” For example, prior to departure, tower may issue you the following clearance, “Track 32, on departure, turn right heading 360, climb and maintain 5,000 feet.” In this case, technically, this instruction is not a “radar vector” because it is not “navigational guidance based on the use of radar.” Even so, if you are operating in a radar environment, you are expected to associate departure headings with radar vectors to your planned route of flight. Although not as common as the example above, there are situations when ATC may give you specific departure instructions even when radar is not available.

9.60. Lack of Specific ATC Departure Instructions. It is equally important to understand what you must do when you do not have any specific ATC departure instructions. ***Unless cleared otherwise by ATC (via a SID or radar vector, for example), you must fly the IFR departure procedure established for the runway you select.*** If the airport meets diverse departure criteria, you may depart using a diverse departure.

Figure 9.31. ILS RWY 13 at KBTR.

Two Examples. After contacting clearance delivery, you receive the following IFR clearance: "Track 32, you are cleared as filed to Andrews AFB, on departure climb and maintain 16,000 feet, expect flight level 370 ten minutes after departure. Departure frequency will be 119.3, squawk 2122."

Example 1:

If you are departing from Baton Rouge Metropolitan/Ryan Field (**Figure 9.31**), this is what you should do: Since Baton Rouge meets diverse departure criteria (instrument approach, no "Trouble T"), you should fly runway heading to 400 feet above field elevation, and then turn in the shortest direction to proceed to your filed route of flight while maintaining a climb gradient of 200 feet per nautical mile or greater until reaching the appropriate IFR minimum altitude.

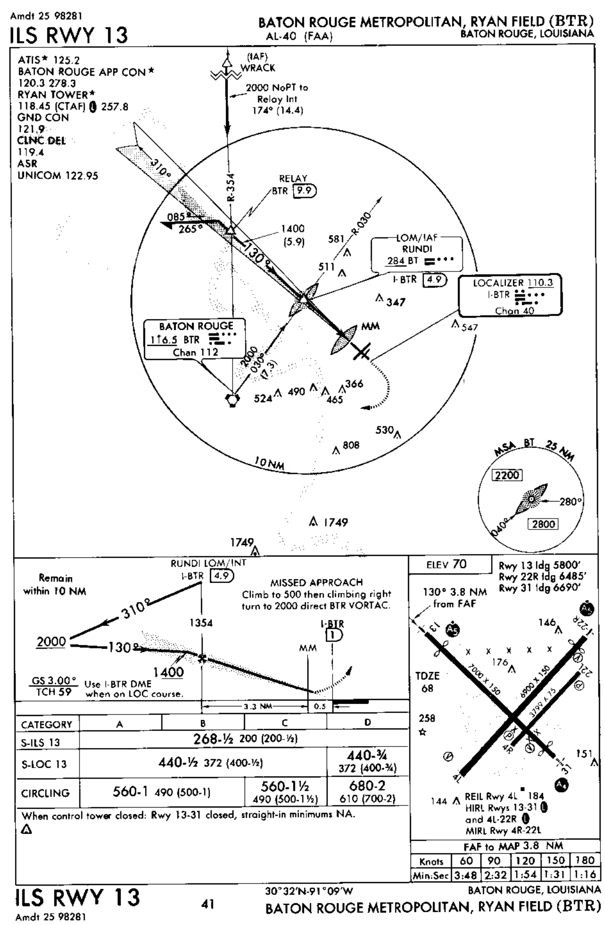
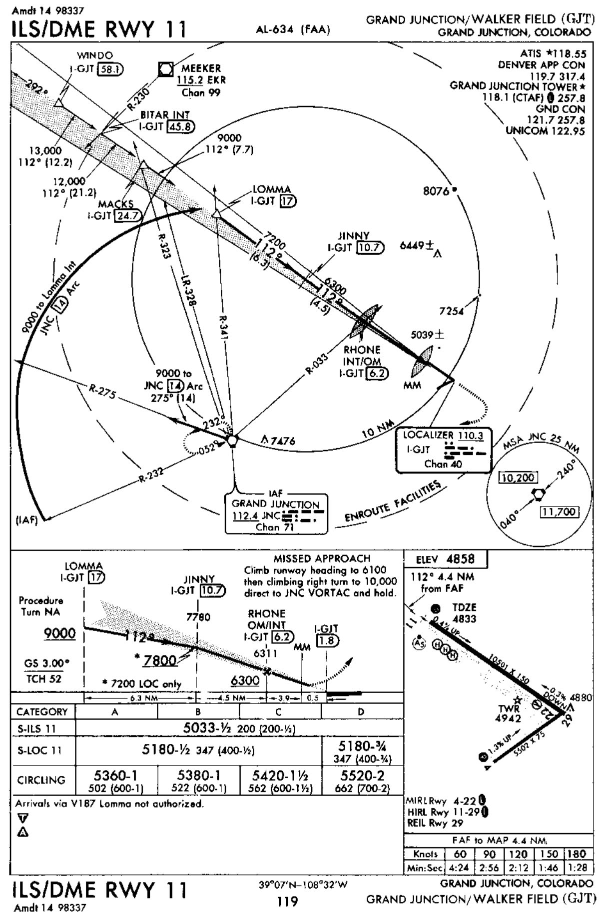


Figure 9.32. ILS/DME RWY 11 at KGJT.

GRAND JUNCTION, CO
WALKER FIELD .... Rwy 4, 22, NA
Rwy 11, 2700-2*
Rwy 29, 2700-2**
*Or standard with minimum climb of 280/NM to 8000.
**Or standard with minimum climb of 300/NM to 8000.
Comply with SIDs or: Rwy 11, climbing right turn via JNC R-088 to JNC VORTAC; Rwy 29, climb to 6000 then climbing left turn direct JNC VORTAC. Aircraft departing JNC R-221 CW R-060 depart on course, all other aircraft continue climbing in JNC VORTAC holding pattern (Hold W, LT, 075 inbound) to cross JNC VORTAC at or above: R-061 CW R-130 9500, R-131 CW R-220 10,500.
TAKE-OFF OBSTACLES: Rwy 11, 4949' tree 1692' from departure end of rwy, 438' left of center-line.



Example 2:

Using the same clearance, if you are departing from Grand Junction/Walker Field (**Figure 9.32**), your actions will be significantly different. For example, if you are taking off on Runway 11, this is what you should do: Since Grand Junction has a "Trouble T," refer to the front of the book to find the IFR departure procedure for Runway 11. Notice IFR departures are "not authorized" for Runways 04 and 22.

To takeoff on Runway 11, you must be able to climb at 280 feet per nautical mile to 8,000 feet MSL. After takeoff, you should fly the IFR departure procedure and then turn in the shortest direction to proceed to your filed route of flight.

9.61. Minimum Climb Gradients. When receiving specific ATC departure instructions, it is sometimes difficult to determine the minimum climb gradient. If there is no SID or IFR departure procedure published for the runway used, then 200 feet per nautical mile should be sufficient to provide obstacle clearance. ***If the runway used has a minimum climb gradient published (either by SID, IFR departure procedure, or by notification from ATC), then you are required to meet or exceed the published climb gradient even when executing a radar departure.***

9.62. Determining the Required Climb Gradient. Here are three examples. Prior to departure, you receive the following clearance, "Track 32, on departure, turn right heading 350, climb and maintain 5,000 feet."

9.62.1. Example 1. Let's say you are departing from an airport that meets diverse departure criteria (such as Baton Rouge/Ryan Field in **Figure 9.31**). Since there is no minimum climb gradient published for any runway at Baton Rouge, then you may depart via radar vectors, and a minimum climb gradient of 200 feet per nautical mile will ensure proper obstacle clearance.

9.62.2. Example 2. If you receive the same clearance for Runway 05 at Birmingham (**Figures 9.28 and 9.29**), your actions will be different. Although there is no minimum climb gradient published on the SID, there is an IFR departure procedure published. In this case, you may follow the departure instructions; however, you must meet or exceed 360 feet per nautical mile until reaching 1,700 feet MSL according to the IFR departure procedure.

9.62.3. Example 3. If you receive the same clearance for RWY 36 at Birmingham (**Figures 9.28 and 9.29**), then you may not depart under IFR since RWY 36 only has non-standard takeoff weather minimums published.

9.63. Summary. Hopefully, this chapter has given you a good general knowledge base from which to make the appropriate decisions about how to depart an airport safely under IFR. This chapter, combined with guidance from your MAJCOM and data contained in your aircraft T.O., should arm you with the knowledge you need to evaluate each departure. Just remember though -- the system is far from perfect, and there will be gaps and inconsistencies in the procedures you are asked to fly. That's where you come in -- you'll have to fill in the gaps by using common sense and your best judgement.

9.64. Additional Sources of Information. If you are interested in learning more about IFR departure procedures, here are some additional resources for you to consult:

<u>FAA Documents</u>
Aeronautical Information Manual (AIM)
US Standard for Terminal Instrument Procedures (TERPs), Order 8260.3
Air Traffic Control Handbook, Order 7110.65
Facility Operation and Administration, Order 7210.3
Instrument Departure Procedure (DP) Program, Order 8260.46
Flight Procedures and Airspace, Order 8260.19C

<u>ICAO Documents</u>
ICAO Doc 4444, *Procedures for Air Navigation Services: Rules of the Air and Air Traffic Services (PANS-RAC)*
ICAO Doc 8168, Volumes 1 & 2, *Procedures for Air Navigation Services: Aircraft Operations (PANS-OPS)*

<u>USAF Documents</u>
AFI 11-202, Volume 3, *General Flight Rules*
AFMAN 11-217, Volume 2, *Instrument Flight Procedures*
AFI 11-230, *Instrument Procedures*
AFMAN 11-226(I), *US Standard for Terminal Instrument Procedures (TERPs)*

<u>InterNet Resources</u>
Wally's TERPs Page (<u>www.terps.com</u>)
AIS Home Page (<u>http://www.randolph.af.mil/12ftw/12og/ais/</u>)
HQ AFFSA Home Page (<u>http://www.andrews.af.mil/tenants/affsa/affsaxo.htm</u>)

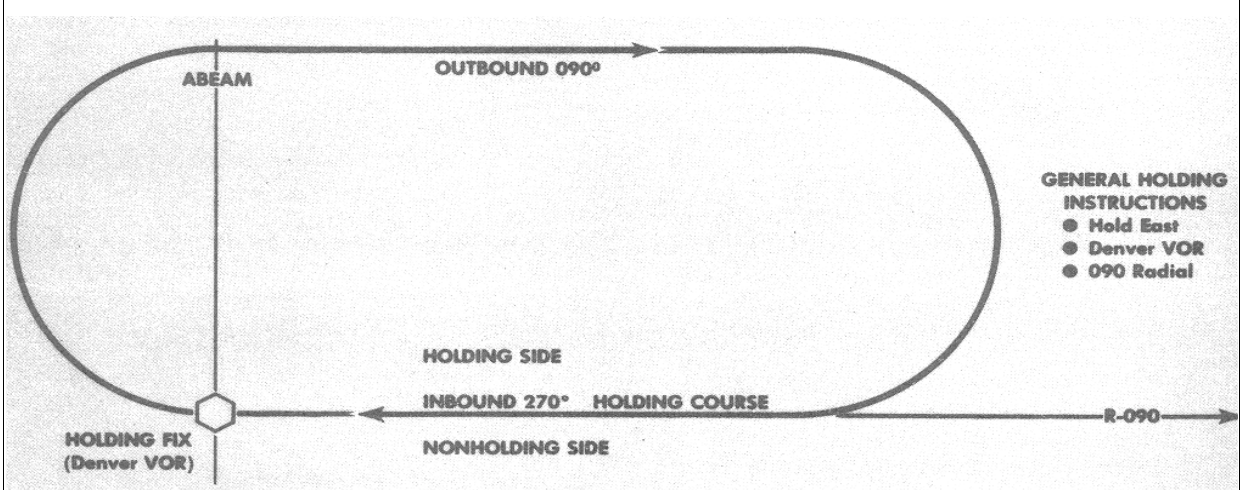
Chapter 10

HOLDING

10.1. Definition.

10.2. Basic. Holding is maneuvering an aircraft in relation to a navigation fix while awaiting further clearance. The standard no-wind holding pattern is flown by following a specified holding course inbound to the holding fix, making a 180° turn to the right, flying a heading outbound to parallel the holding course, and making another 180° turn to the right to intercept and follow the holding course to the fix (**Figure 10.1**). The holding pattern is nonstandard when the turns are made to the left. ***Unless otherwise instructed by ATC, pilots are expected to hold in a standard pattern.*** The standard no-wind length of the inbound kegs of the holding pattern is 1 minute when holding at or below 14,000 feet mean sea level (MSL) and 1½ minutes when holding above 14,000 feet MSL. DME holding patterns specify the outbound leg length. If holding at a DME fix without specified outbound leg length, use timing procedures listed above.

Figure 10.1. Holding Pattern (para 10.2).



10.2.1. Course Guidance. Holding patterns have inbound course guidance provided by a VOR, TACAN, NDB, or localizer. While in holding, the localizer signal is the most accurate method of determining aircraft position. However, if a VOR, TACAN or NDB also defines the holding pattern, it's the pilot's option as to which NAVAID to use.

NOTE: AFJMAN 11-226 TERPs, states that the use of TACAN station passage as a fix is not acceptable for holding fixes or high altitude initial approach fixes. ***Therefore, if the aircraft is TACAN-only equipped, do not hold directly over a TACAN or VORTAC facility or plan to use these facilities as high altitude IAFs.***

10.3. Holding Instruction.

10.3.1. Charted Holding Patterns. ATC clearances requiring holding where holding patterns are charted, include the following instructions:

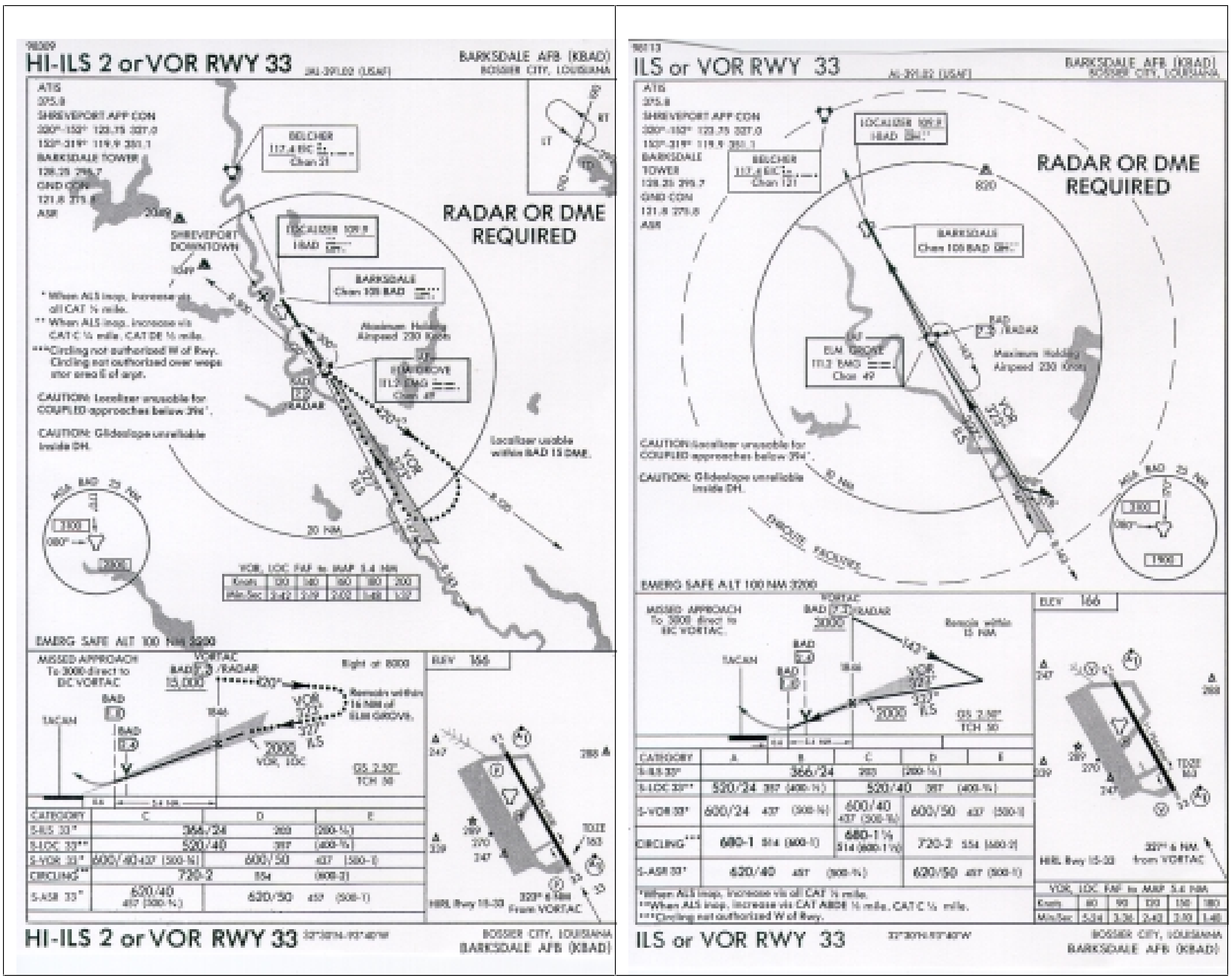
–**Direction.** Direction of holding from the fix.

–**Holding fix.** The name of the holding fix.

Example*:* “Cleared to NIGEL, hold east as published.”

NOTE: AIM describes “charted” holding patterns as “those holding patterns depicted on U.S. government or commercially produced (meeting FAA requirements) low/high altitude enroute, and area or STAR charts.” Although the AIM and GP do not specifically mention the use of published holding patterns depicted on instrument approach procedures, in day-to-day operations they are used frequently. If the controller clears you to “hold as published” using a holding pattern published on an approach plate, make sure you are holding in the correct pattern. In some situations, there may be more than one published holding pattern at the same fix. (Take a look at the example in **Figures 10.2 and 10.3**.) If there is any doubt about your clearance, query the controller.

Figures 10.2. and 10.3. Charted Holding Pattern.



10.3.2. Non-charted Holding Patterns. If ATC clears you to hold in a non-charted holding pattern, they will normally provide you with the following information:
–**Direction.** Direction of holding from the fix.
–**Holding fix.** The holding fix.
–**Holding course.** Radial, course, bearing, airway, or route on which the aircraft is to hold.
–**Leg length.** Outbound leg length in miles, if DME or RNAV is to be used.
–**Direction of turn.** Left turns, if nonstandard.

NOTE: If detailed holding instructions are given, the length of the inbound leg in minutes and the direction of holding pattern turns are added to the previous instructions.

10.3.3. Further Clearance. When holding instructions are issued for either a charted or uncharted holding pattern, the controller should issue a time to expect further clearance (EFC).
10.3.4. Clearance Limit. ATC should issue holding instructions at least 5 minutes before reaching a clearance limit fix. When an aircraft is 3 minutes or less from a clearance limit and a clearance beyond the fix has not been received, the pilot is expected to start a speed reduction so that ***the aircraft will cross the fix at or below the maximum holding airspeed. If holding instructions have not been received upon arrival at the fix, hold in accordance with procedures in FLIP. For two-way radio failure holding procedures, refer to the Flight Information Handbook***.
10.3.5. Maximum Holding Speeds. Maximum holding airspeeds are defined by TERPs and have nothing to do with the holding speed specified in the aircraft flight manual. ***Do not exceed the maximum holding airspeeds listed below.*** ATC may be able to approve holding speeds in excess of these maximums, if aircraft performance considerations require. For ICAO holding airspeeds, refer to Chapter 23.
10.3.5.1. All Aircraft

0-6000 ft MSL	200 KIAS
above 6000 – 14000ft MSL	230 KIAS
above 14000ft MSL	265 KIAS

10.4. Holding Pattern Procedures.
10.4.1. Holding Procedure. ***The aircraft must cross the holding fix, turn outbound and remain within the holding airspace.***
10.4.2. Established in Holding. You are considered established in the holding pattern upon initial passage of the holding fix.
10.4.3. Bank Angle. ***Unless correcting for known winds, make all turns during entry and while holding at:***
3 degrees per second, or
30 degree bank angle, or
bank angle commanded by the flight director system.

10.4.4. Entry Turns. The angular difference between the inbound holding course and the heading at initial holding fix passage determines the direction of turn to enter the holding pattern. There are a number of techniques to enter holding which should keep you within holding airspace. Any of the techniques may be used.

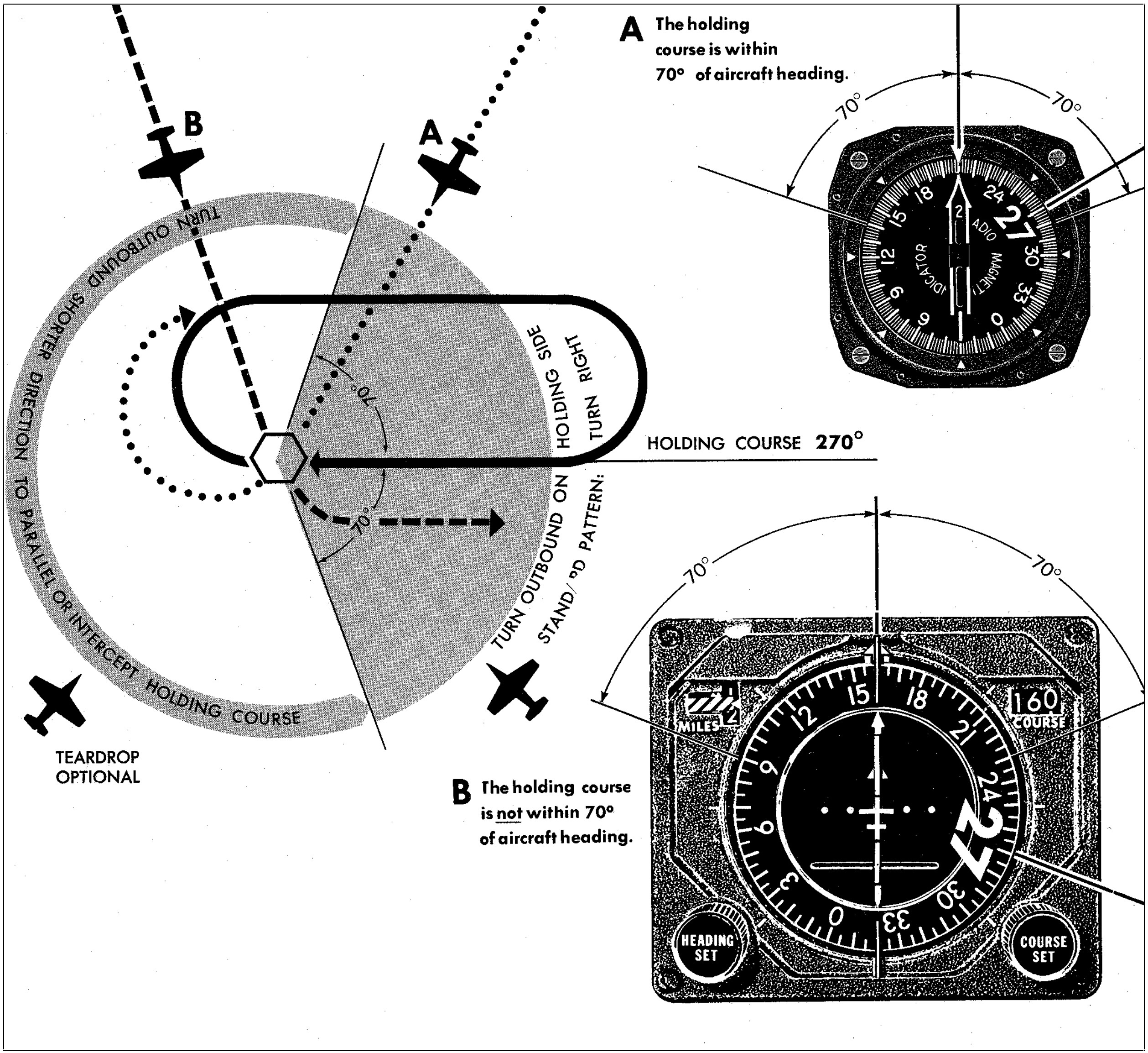
10.4.4.1. Technique A ("70 Degree Method") (Figure 10.4):

10.4.4.1.1. Within 70°. If the inbound holding course is within 70° of the aircraft heading, turn outbound on the holding side to parallel the holding course. (For a standard pattern, turn right to enter.) Upon completion of the outbound leg, proceed direct or intercept the holding course to the fix.

10.4.4.1.2. Not within 70°. If the inbound holding course is not within 70° of the aircraft heading, turn outbound in the shorter direction to parallel the holding course. If this turn places you on the non-holding side, either parallel (adjust for wind) or attempt to intercept the holding course outbound. If you are on the non-holding side or on the holding course at the completion of the outbound leg, turn toward the holding side, then proceed direct or intercept the holding course to the fix.

10.4.4.1.3. Teardrop. The teardrop entry may be used at pilot discretion when entering holding on a heading conveniently aligned with the selected teardrop course. As a guide, consider yourself conveniently aligned when your aircraft heading is within 45° of the selected teardrop course. Upon reaching the holding fix, turn on the holding side and proceed on an outbound track not to exceed 45° from the outbound course. (Depending on your offset requirements, a teardrop course of less than 45° may be desired.) If course guidance is available, attempt to intercept the selected teardrop course outbound.

Figure 10.4. 70 degree Method.



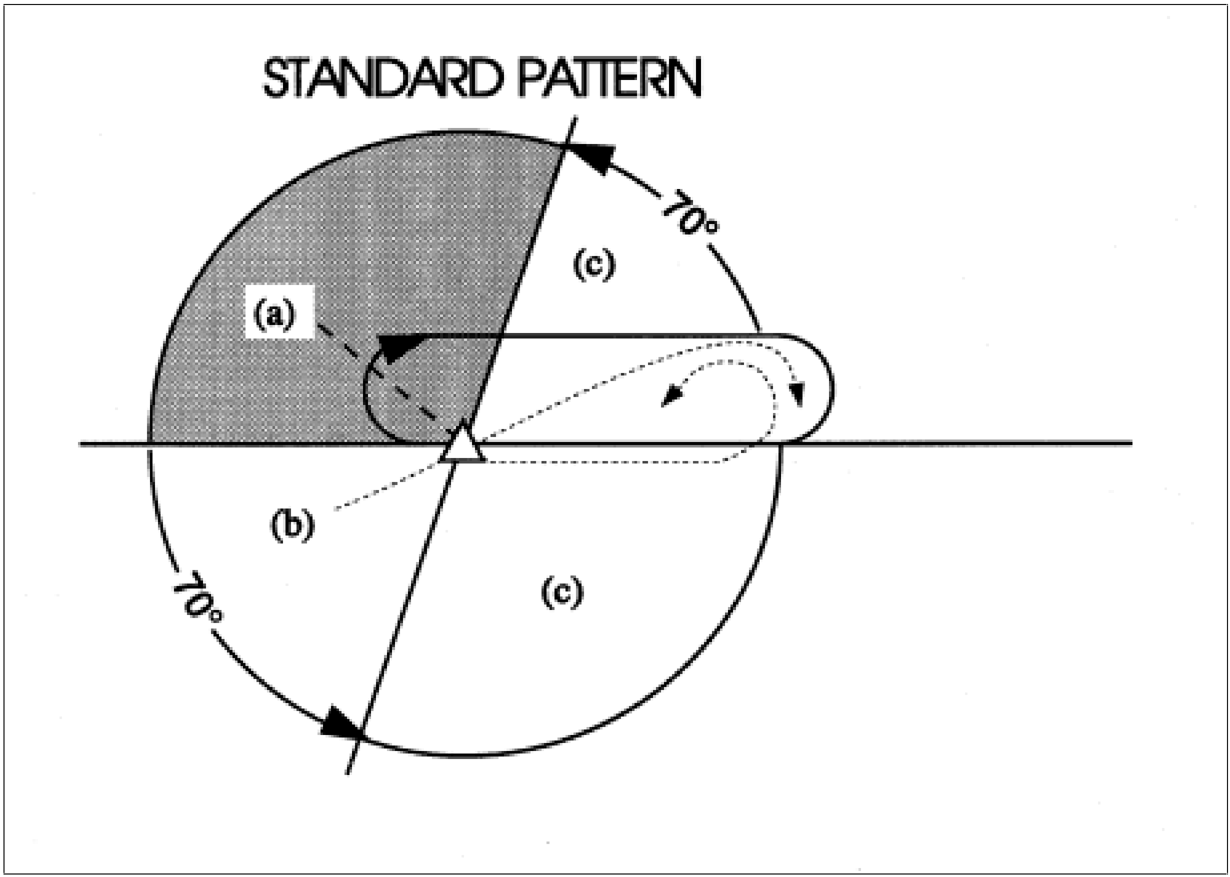
10.4.4.2. Technique B ("AIM Method"): Enter the holding pattern based on your heading (±5°) relative to the three entry sectors depicted in Figure 10.5. Upon reaching the holding fix, follow the appropriate procedure for your entry sector:

10.4.4.2.1. Sector A (Parallel). Turn to a heading to parallel the holding course outbound for the appropriate time or distance, then turn in the direction of the holding pattern and return to the holding fix or intercept the holding course inbound.

10.4.4.2.2. Sector B (Teardrop). Turn outbound to a heading for a 30-degree teardrop entry (on the holding side) for the appropriate time or distance, then turn in the direction of the holding pattern to intercept the inbound holding course.

10.4.4.2.3. Sector C (Direct). Turn to follow the holding pattern.

Figure 10.5. AIM Method.



10.4.5. Timing. ***The maximum inbound leg time is 1 minute at or below 14,000 feet MSL and 1½ minutes above 14,000 feet MSL. On the initial outbound leg, do not exceed the appropriate time for the altitude unless compensating for a known wind. Adjust subsequent outbound legs as necessary to meet the required inbound time. ATC expects pilots to fly the complete holding pattern as published. Therefore, do not shorten the holding pattern without clearance from ATC.***

10.4.5.1. Outbound. ***Begin outbound timing when over or abeam the fix. If you cannot determine the abeam position, start timing when wings level outbound.***

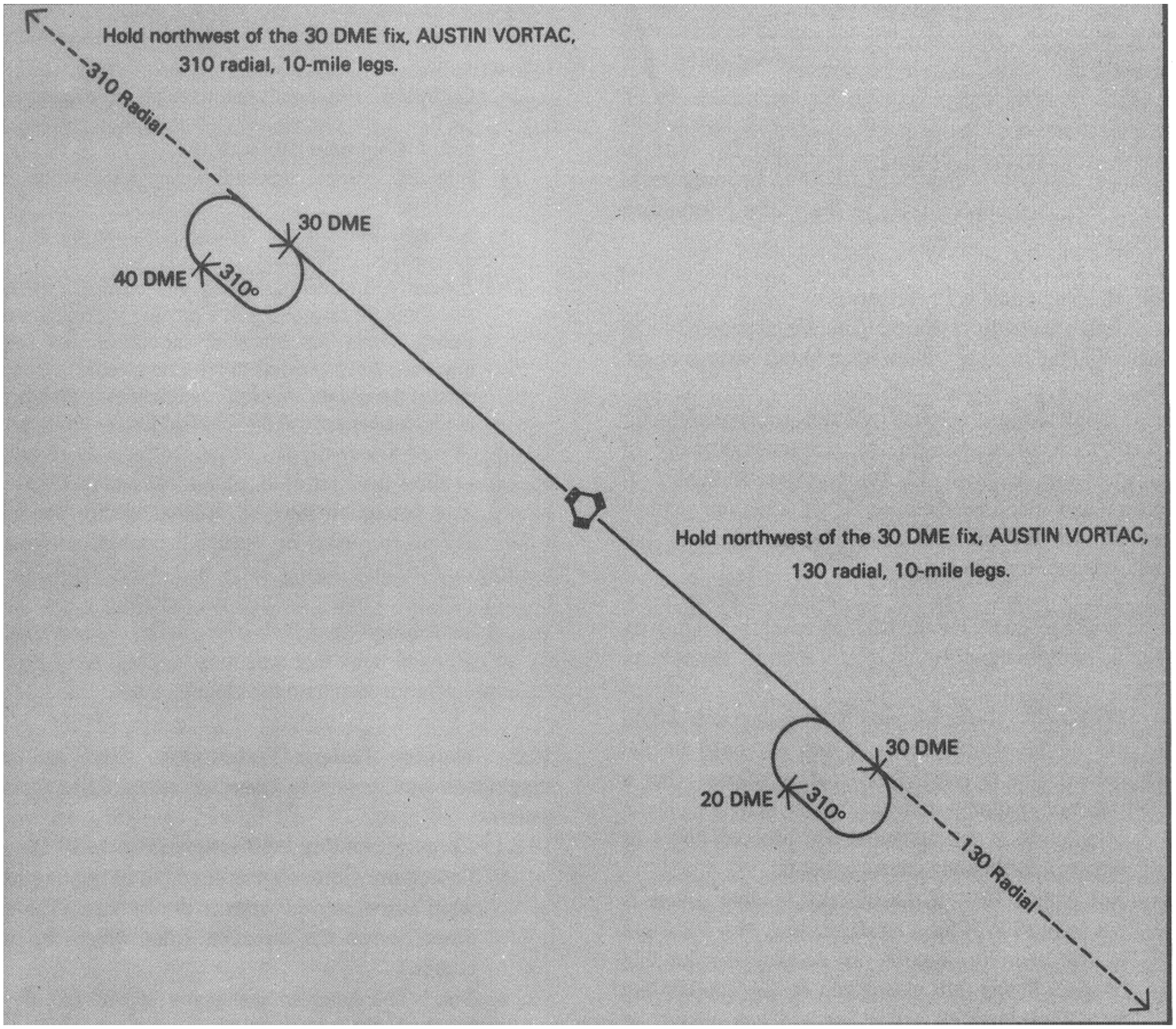
10.4.5.2. Inbound. ***Begin inbound timing when wings level inbound.***

10.4.5.3. TACAN. ***For TACAN holding, start turns at the specified DME limits.***

10.4.5.4. Timing Adjustments. ***When you receive a clearance specifying the time to depart a holding pattern, adjust the pattern within the limits of the established holding procedure so as to depart at the time specified.***

10.5. Holding Pattern Suggestions. Here are some suggestions and points to consider when flying holding patterns:

Figure 10.6. Copying Holding Instructions (para 10.5.1).



10.5.1. Copying Holding Instructions (Figure 10.6).

–**Direction.** Compare the direction of holding to the wind arrow used in weather depictions. (The wind arrow shows the direction from which the wind comes.)

–**Fix.** The head of the arrow is the fix; fly the inbound course to the head.

–**Draw.** Draw or visualize the remainder of the pattern by the instructions given.

10.5.2. Timing.

10.5.2.1. Inbound Legs. After completing the first circuit of the holding pattern, adjust the time outbound as necessary to provide the desired inbound times. In extreme wind conditions, even though the turn inbound is initiated when abeam the station, the inbound leg may exceed the 1 or 1½ minute limit. In this case, you are authorized to exceed the time limit inbound.

10.5.2.2. Adjustments. Knowing the time it takes you to fly a holding pattern will allow you to meet an EFC. As an approximation, 1/100th of TAS will give the number of minutes to fly a 360° turn at 30° of bank. (For example, at 350 knots true airspeed (KTAS), a 360° turn takes about 3.5 minutes.) Aircraft flying standard rate turns cover 360° in 2 minutes. Add to the time for turning the number of minutes to fly the inbound and outbound legs.

10.6. Drift Corrections.

10.6.1. Calculating drift corrections. Knowledge of drift correction and TAS relationship can be very useful, especially in those instances where course guidance is not available; for example, the outbound leg of a holding pattern or a procedure turn. The following techniques may be used to determine approximate drift correction when the crosswind component is known:

10.6.1.1. Mach. Divide the crosswind component by the mach times 10. Example: 50 knots crosswind and 300 KTAS (.5M) = 10° drift correction, or

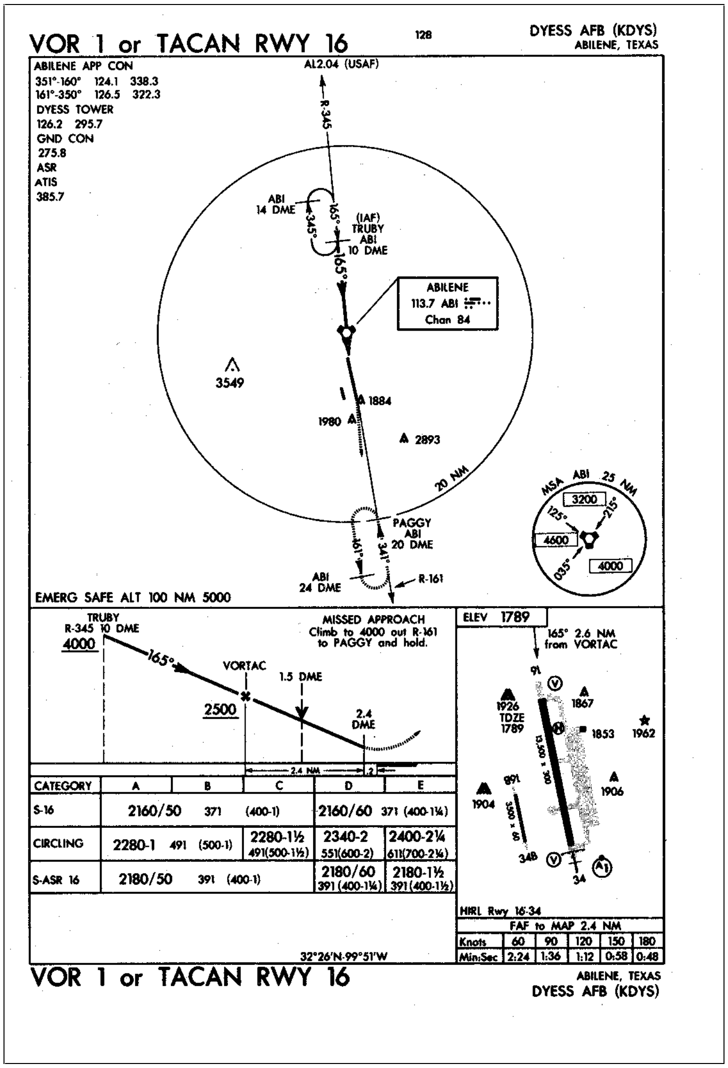
10.6.1.2. TAS. Divide the crosswind component by the aircraft speed in nautical miles per minute. Example: 30 knots crosswind and 180 KTAS (3NM per minute) 30÷3 = 10° drift correction.

10.6.2. Applying drift corrections. Compensate for wind effect primarily by drift correction on the inbound and outbound legs. When outbound, triple the inbound drift correction; e.g., if correcting left by 8 degrees when inbound, correct right by 24 degrees when outbound.

10.7. High Altitude Approach Plate Depiction (postage stamp). Holding pattern entry turns depicted on high altitude approach charts are provided for pilot convenience and are consistent with the intent of the entry procedures explained in paragraphs **10.4.4.1** and **10.4.4.2.** However, the teardrop depiction shows a teardrop entry if the aircraft heading is within 40° of a 30° teardrop course at the holding fix passage.

10.8. Descent. If you are established in a holding pattern that has a published minimum holding altitude (**Figure 10.7**), and are assigned an altitude above that published altitude, you may descend to the published minimum holding altitude when you have been cleared for the approach (unless specifically restricted by ATC). Minimum holding altitude is the same as the IAF altitude for holding patterns where the IAF is located in the holding pattern unless otherwise noted or depicted. For those holding patterns where there is no published minimum altitude at the IAF and no depicted holding altitude, the minimum holding altitude is the same as the minimum altitude at the FAF (or next segment). In this case, upon receiving an approach clearance, maintain the last assigned altitude until established on a segment of the instrument approach procedure being flown. (If a lower altitude is desired, request clearance from the controlling agency.)

Figure 10.7. Minimum Holding Altitude (para 10.8).



Chapter 11

ARRIVAL

11.1. En Route Descent Procedure/Technique.

11.1.1. En route. The en route descent frequently allows a pilot to transition from an en route altitude to the final approach instead of flying an entire FLIP instrument approach procedure (IAP). It may be flown either via radar vectors or nonradar routings, using approved navigation aids. Air traffic control (ATC) will not insist on an en route descent. ATC will not authorize an en route descent if abnormal delays are anticipated, nor will they terminate the service without the pilot's consent except in an emergency.

11.1.2. Final Approach. The type of final approach to be flown must be understood by you and the controller (ILS, PAR, visual pattern, etc.). Except for radar finals, request an en route descent to a specific final approach. If the requested en route descent is to a radar final, select a backup approach that is compatible with existing weather and aircraft equipment. If you experience lost communications, you are automatically cleared to fly any published approach.

11.2. Descent. ATC requirements probably have more influence over when to begin the descent than any other single factor. Other items to consider before starting an en route descent are range, desired descent rate, weather, terrain, and low altitude fuel consumption. If ATC issues a radar vector and/or an altitude to maintain, all applicable altitude restrictions must be restated if 1) the vector takes the aircraft off an assigned procedure which contains altitude restrictions or 2) previously issued clearance included crossing restrictions.

NOTE: FAA controllers are not required to respond to clearance readbacks; however if your readback is incorrect, distorted or incomplete, the controller is obligated to make corrections. If you are unsure of the clearance and/or instructions, query the controller.

CAUTION: Descent gradients in excess of 10° (1,000 ft/NM) in IMC may induce spatial disorientation. In addition, exceeding a 10° descent gradient below 15,000 feet AGL substantially decreases margin for error in avoiding obstacles and terrain, and may not provide effective radar monitoring.

11.2.1. Starting Descent. ***Before starting descent, review the IAP for the type of final planned, recheck the weather (if appropriate), check the heading and attitude systems, and coordinate lost communication procedures (if required).*** Review of the IAP for any approach (nonprecision and precision) should include, but is not limited to, the following: minimum or emergency safe altitudes, navigation frequencies, descent rates, approach minimums, missed approach departure instructions, and aerodrome sketch.

11.2.2. During Descent.

11.2.2.1. Descent Rate. During the descent, control descent rate and airspeed to comply with any altitude or range restrictions imposed by ATC.

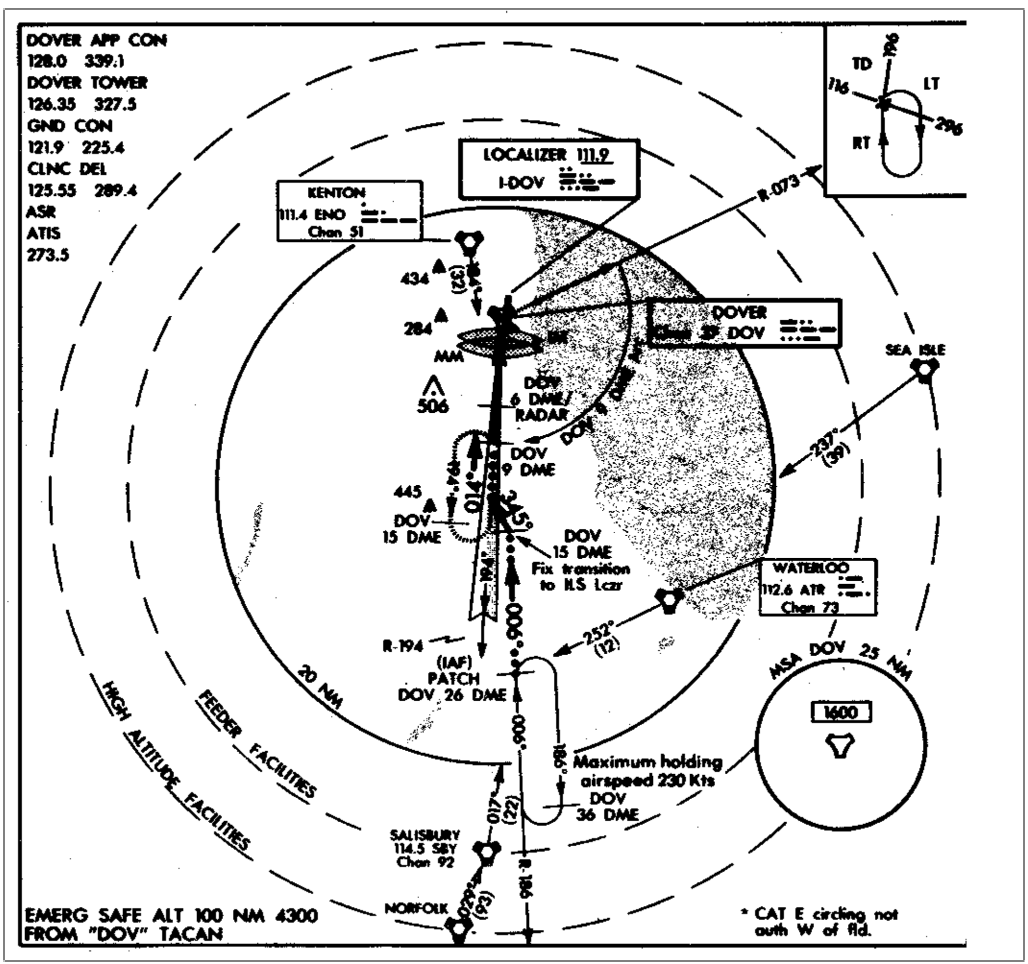
11.2.2.2. Reduce Airspeed. Reduce airspeed to 250 KIAS or less when below 10,000 feet MSL as required by AFI 11-202V3.

11.2.2.3. Radar Vectors. When descending via radar vectors, remain oriented in relation to the final approach fix by using all available navigation aids. Have the IAP available for the approach to be flown along with an alternate or backup procedure to be used if available. Note the minimum safe, sector, or emergency safe altitudes. Be prepared to fly the approach when cleared by the controller. ***Once cleared for the approach, maintain the last assigned altitude and heading until established on a segment of a published route or IAP.*** Use normal lead points to roll out on course. Do not climb above last assigned altitude to comply with published altitude restrictions unless instructed to do so. If at any time there is doubt as to whether adequate obstacle clearance is provided or controller instructions are unclear, query the controller. The controller should inform you if radar contact is lost and provide you with a new clearance or additional instructions. If advised that radar contact is lost while in IFR conditions and there is a delay in receiving new instructions, ask the controller for a new clearance or advise the controller of your intentions. (This is particularly important if below minimum safe, sector, or emergency safe altitude.)

11.3. High Altitude Procedures.

11.3.1. Terminal Routings. Terminal routings from en route or feeder facilities normally provide a course and range in nautical miles (not DME) to the Initial Approach Fix (IAF) but in some circumstances may take you to a point other than the IAF (**Figure 11.1**). If you use other than a published routing, do not exceed the operational limitations of the selected NAVAIDs.

Figure 11.1. Feeder Routes (High Altitude) (para 11.3.1).



11.3.2. Before the IAF. ***Before reaching the IAF, review the IAP, recheck the weather (if appropriate), check the heading and attitude systems, and obtain clearance for the approach.*** If holding is not required, reduce to penetration airspeed or below before reaching the IAF. Accomplish the descent check in accordance with the aircraft flight manual. Set the altimeter in accordance with FLIP instructions.

11.3.3. En route Approach Clearance. ***If cleared for an approach while en route to holding fix that is not collocated with the IAF, proceed to the IAF via the holding fix, unless specifically cleared to proceed direct to the IAF. However, if the IAF is located along the route of flight to the holding fix, begin the approach at the IAF.*** If in doubt as to the clearance, query the controller (**Figure 11.2**).

11.3.4. Approach Clearance. ***When ATC issues an approach clearance, proceed to the IAF then turn immediately in the shortest direction to intercept the approach course.*** Clearance for the approach does not include clearance to use holding airspace. ***However, if you are established in holding and cleared for the approach, complete the holding pattern to the IAF unless an early turn is approved by ATC.*** If your heading to the IAF is within 90° of the approach course, you may use normal lead points to intercept the course. If your heading is not within 90° of the approach course and you desire to maneuver the aircraft into a more favorable alignment prior to starting the approach, obtain clearance from ATC (**Figure 11.3**).

Figure 11.2. Cleared for the Approach While En Route to the Holding Fix (paras 11.3.3 and 11.4.4).

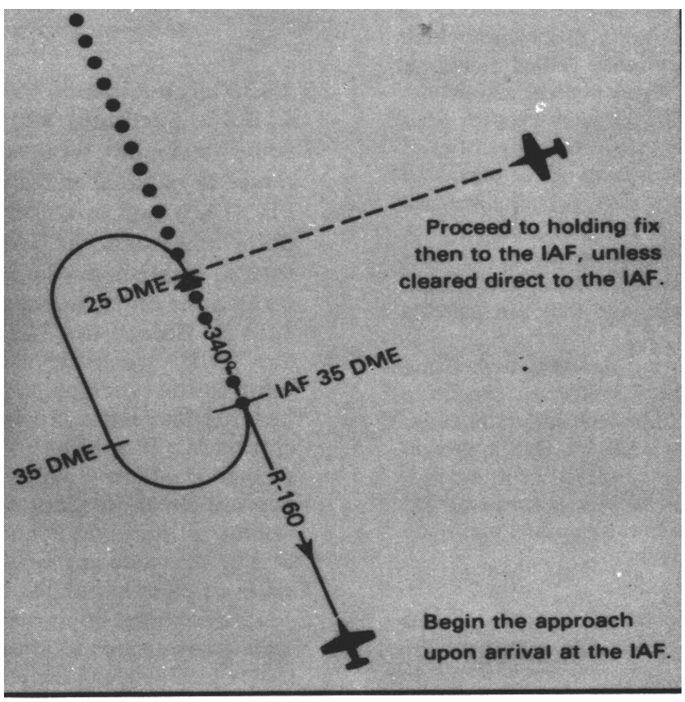
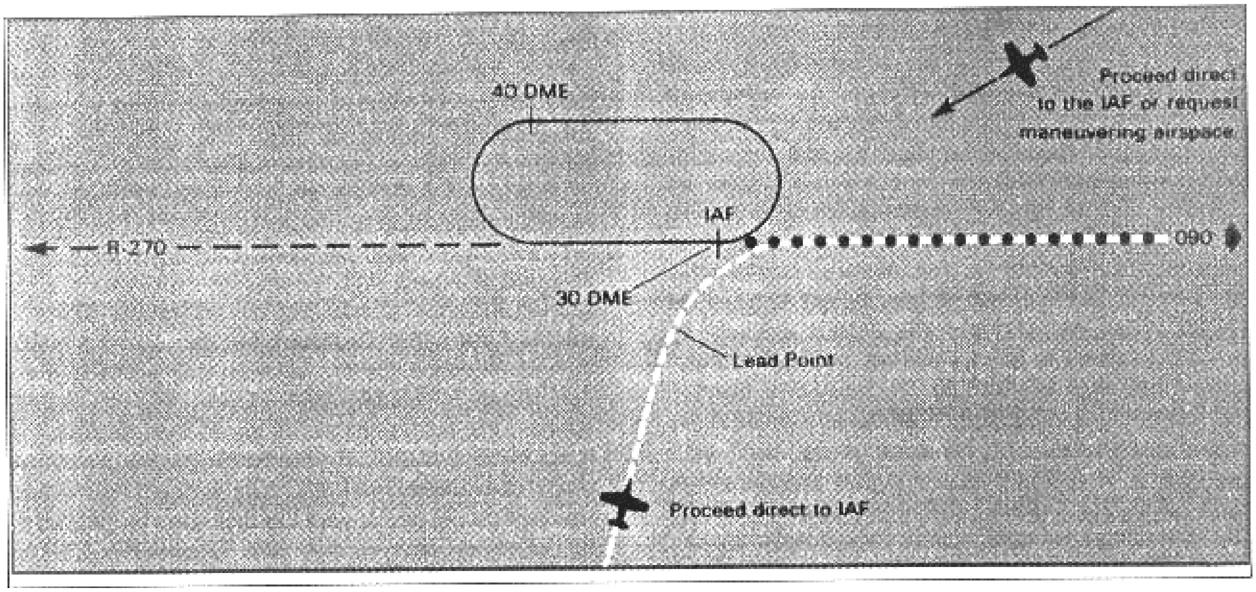


Figure 11.3. Leading the Turn at the IAF (paras 11.3.4 and 11.4.6).



11.3.5. Altitude. ***When cleared for the approach, maintain the last assigned altitude until established on a segment of the published routing or instrument approach procedure (IAP). Once on the published routing or a segment on the IAP, do not descend below the minimum safe altitude for that segment. High altitude penetration descent may be initiated when abeam or past the IAF with a parallel or intercept heading to the course.*** The controller should assign you the depicted IAF altitude. If you are not assigned the IAF altitude and cannot make the descent gradient by starting the penetration from your last assigned altitude, request a lower altitude.

NOTE: For non-DME teardrop approaches, you should not penetrate from an altitude above the depicted IAF altitude.) If maneuvering, such as a holding pattern, is necessary to lose excess altitude, obtain clearance to do so. Remember that you must be able to comply with subsequent mandatory and maximum altitudes.

11.4. Low Altitude Procedures.

11.4.1. Terminal routings. Terminal routings from en route or feeder facilities are considered segments of the IAP and normally provide a course, range, and minimum altitude to the IAF. They may take the aircraft to a point other than the IAF if it is operationally advantageous to do so. If you use other than a published routing, do not exceed the operational limitations of the selected NAVAIDs. A low altitude IAF is any fix labeled as an IAF or any procedure turn/holding-in-lieu-of a procedure turn fix.

11.4.2. Ranges and Altitudes. Ranges published along the terminal routing are expressed in nautical miles (not DME). The altitudes published on terminal routing are minimum altitudes and provide the same protection as an airway minimum en route altitude (MEA).

11.4.3. Before the IAF. ***Before reaching the IAF, review the IAP chart, recheck the weather (if appropriate), check the heading and attitude systems, and obtain clearance for the approach.*** If holding is not required, reduce to maneuvering airspeed before reaching the IAF. Accomplish the descent check in accordance with the aircraft flight manual.

11.4.4. Enroute Approach Clearance. ***If cleared for an approach while en route to a holding fix which is not collocated with the IAF, either proceed via the holding fix or request clearance direct to the IAF*** (**Figure 11.2**). ***If the IAF is located along the route of flight to the holding fix, begin the approach at the IAF. If you overfly a transition fix, fly the approach via the terminal routing.*** If in doubt as to the clearance, query the controller.

11.4.5. Altitude. ***When cleared for the approach, maintain the last assigned altitude until established on a segment of a published route or instrument approach procedure (IAP).*** At that time, the pilot may descend to the minimum altitude associated with that segment of the published routing or instrument approach procedure.

11.4.6. Approach Clearance. When clearance for the approach is issued, ATC expects an immediate turn in the shortest direction to intercept the procedural course upon reaching the IAF. Clearance for the approach does not include clearance for the holding airspace. ***However, if established in holding and cleared for the approach, complete the holding pattern to the IAF unless an early turn is approved by ATC.*** If your heading is within 90° of the procedural course, you may use normal lead points to intercept the course. If your heading is not within 90° of the procedural course, you may need to maneuver the aircraft for a more favorable alignment prior to starting the approach. If maneuvering (other than an immediate turn at the IAF to intercept the procedural course) is desired, obtain clearance from ATC since clearance for the approach does not include clearance for use of holding or maneuvering airspace (**Figure 11.3**).

NOTE: ATC will not assign an altitude that does not provide obstacle clearance; however, pilots are ultimately responsible for terrain clearance. The following information will aid you in monitoring assigned altitudes:

–Low altitude charts may provide several different altitudes that will ensure obstacle clearance, depending upon aircraft position.

–If proceeding to an IAF via an airway, the MEA/MOCA will provide obstacle clearance. If using a published terminal route, the published minimum altitude along that route ensures obstacle clearance.

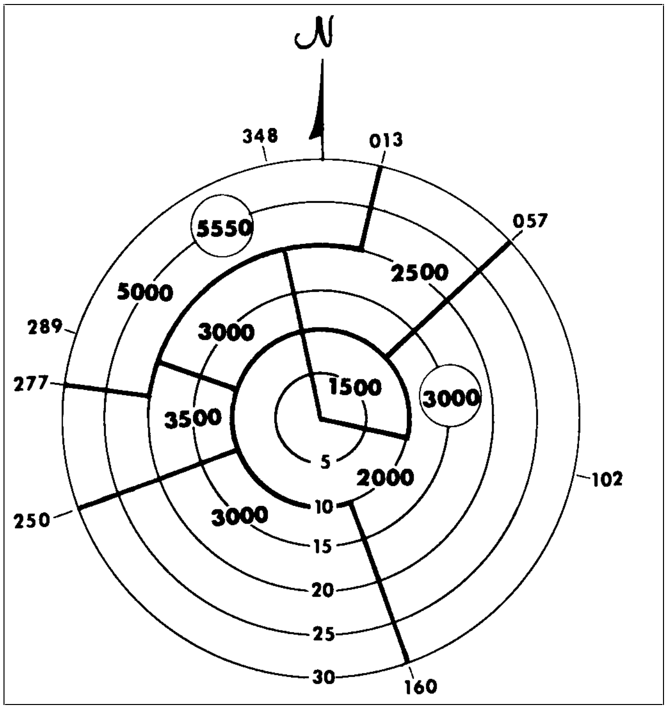
–If not proceeding via a published route, obstacle clearance can be guaranteed by maintaining the OROCA, ORTCA, minimum sector altitude, or emergency safe altitude (depending upon aircraft position and altitudes printed on the approach chart).

–If you require a lower altitude to start the approach, request it from ATC. Remember that you may start an approach at a higher than published IAF altitude provided it is not a mandatory or maximum altitude. If you do this, you must comply with the remaining altitude restrictions on the approach. If maneuvering is required to lose excess altitude prior to starting the approach, a clearance from ATC is also required.

11.5. Radar Vectors. The use of radar vectors is the simplest and most convenient way to position an aircraft for an approach. Using radar, air traffic controllers can position an aircraft at almost any desired point, provide obstacle clearance by the use of minimum vectoring altitudes, and ensure traffic separation. This flexibility allows an aircraft to be vectored to any segment of a published routing shown on the IAP or to a radar final. Radar controllers use minimum vectoring altitude (MVA) charts that are prepared by the air traffic facilities at locations where there are numerous different minimum IFR altitudes (**Figure 11.5**). The MVA chart is divided into sectors that are large enough to accommodate vectoring of aircraft within the sector at the MVA. Minimum altitudes are established at 1,000 feet or 2,000 feet in designated mountainous areas (in mountainous areas, MVAs may be authorized at 1,000 feet in order to achieve compatibility with terminal routes or IAPs). Obstructions may be enclosed in a 3 NM buffer area (5 NM if the obstruction is beyond 40 NM from the radar antenna); MVAs may be lower than nonradar

MEAs/MOCAs. They may also be below emergency safe, or minimum sector altitudes. When being radar vectored, IFR altitude assignments will be at or above MVA.

Figure 11.5. Minimum Vector Altitude (MVA) Chart (para 11.5).



WARNING: "Traffic Advisories" is an additional service that the controller will provide to you if the workload permits. Be aware that traffic information while on a PAR final is almost nil due to narrow azimuth scan of the PAR equipment. "Radar monitoring" during a nonprecision instrument approach will not provide altitude warning information if the aircraft descends below a safe altitude. The controller may vector the aircraft to any segment of an IAP prior to the FAF and clear an aircraft for an approach from that point. The controller will issue an approach clearance only after you are established on a segment of the IAP; or you will be assigned an altitude to maintain until you are established on a segment of the IAP. The following general guidance applies to the radar controller when positioning an aircraft for a final approach:

11.5.1. Radar Vector Weather Requirements. When the reported ceiling is at least 500 feet above the minimum vectoring altitude and the visibility is at least 3 miles, aircraft will be vectored to intercept the final approach course as follows:

–At least 1 mile from the FAF at a maximum intercept angle of 20°.

–At least 3 miles from the FAF at a maximum intercept angle of 30°.

11.5.2. Final Approach Intercept Requirements. At all other times, unless specifically requested by the pilot, aircraft will be vectored to intercept the final approach course at least 3 miles from the FAF at a maximum intercept angle of 30°.

11.5.3. Vectoring Requirements. In either case, aircraft will be vectored:

–At an altitude not above the glide slope for a precision approach.

–At an altitude that will allow descent in accordance with the published procedure for a nonprecision approach.

NOTE: These procedures do not apply to vectors to a visual approach.

11.6. Pilot Responsibilities.

11.6.1. During Vectors. ***While being radar vectored, repeat all headings, altitudes (departing and assigned), and altimeter settings; and comply with controller instructions.***

11.6.2. Orientation. Remain oriented in relation to the final approach fix by using available navigation aids. ***Have the IAP available for the approach to be flown.*** Note the minimum sector, or emergency safe altitudes. Start the before-landing checklist (landing check), review approach minimums, and determine the approximate initial rate of descent required on final approach. Be prepared to fly the approach when cleared by the controller. ***Once you receive approach clearance, maintain the last assigned altitude and heading until established on a segment of a published routing or IAP.*** Use normal lead points to roll out on course. Then use any available means (such as DME, crossing radials, or radar) to accurately determine your position. From that point, comply with all course and altitude restrictions as depicted on the approach procedure except that you must not climb above the last assigned altitude to comply with published altitude restrictions unless so instructed by the controlling agency. Establish final approach configuration and airspeed prior to the FAF (unless flight manual procedures require otherwise).

11.6.3. Maneuvering. If maneuvering is required to lose excess altitude prior to the FAF, obtain a clearance from the controlling agency. Descent maneuvering may include execution of a procedure turn, descent in a published holding pattern, additional radar vectors, or other such maneuver.

CAUTION: If at any time there is doubt as to whether adequate obstacle clearance is provided or controller instructions are unclear, query the controller. The controller should inform you if radar contact is lost and give a new clearance or instructions. If you are advised that radar contact is lost and there is a delay in receiving new instructions, ask the controller for a new clearance or advise the controller of your intentions. (This is particularly important if below minimum sector, or emergency safe altitude.)

11.7. Standard Terminal Arrivals (STARs) and Flight Management System Procedures (FMSPs)

11.7.1. Definition. A STAR is an ATC coded IFR arrival route established for assignment to arriving IFR aircraft for certain airports. An arrival FMSP is basically a STAR which can only be used by aircraft equipped with an approved FMS (designated by the "/E" or "/F" TD code from the FLIP General Planning). The purpose of both is to simplify clearance delivery procedures and facilitate transition between enroute and instrument approach procedures.

NOTE: The term STAR used in the following paragraphs refers to both STARs and FMSPs**.**

11.7.1.1. Mandatory Speeds and/or Altitudes. STARs may have mandatory speeds and/or crossing altitudes published. Some STARs have planning information depicted in inform pilots what clearances or restrictions to "expect." "Expect" altitudes/speeds are not considered STAR restrictions until verbally issued by ATC. They are published for planning purposes and should not be used in the event of lost communications unless ATC has specifically advised the pilot to expect these altitudes/speeds as part of a further clearance. Additionally, STARs will normally depict MEAs. MEAs are not considered restrictions. However, pilots are expected to remain above MEAs.

11.7.1.2. Altitude Clearance. ***Pilots shall maintain last assigned altitude until receiving authorizations/clearance to change altitude. At that time, pilots are expected to comply with all published/issued restrictions.*** The authorization may be via a normal descent clearance or the phraseology "DESCEND VIA."

11.7.1.2.1. Example of Lateral Routing Clearance Only. "Track 32, cleared the NEILL ONE ARRIVAL." In this case, you are cleared the NEILL ONE routing but are expected to maintain your present altitude awaiting further clearance.

11.7.1.2.2. Example of Routing with Assigned Altitude. "Fame 22, cleared DEWEY ONE arrival; descend and maintain flight level two four zero." In this situation, you are cleared via the DEWEY ONE's routing and cleared to descend to FL240.

11.7.1.2.3. "DESCEND VIA" Clearances. A "DESCEND VIA" clearance authorizes pilots to vertically and laterally navigate, in accordance with the depicted procedure, to meet published restrictions. Vertical navigation is at pilot's discretion; however, ***adherence to published altitude crossing restrictions and speeds is mandatory unless otherwise cleared.*** MEAs are not considered restrictions; however, pilots are expected to remain above MEAs.

11.7.1.2.3.1. Example of "DESCEND VIA" Clearance. "Track 66, Descend Via the BLAKE ONE arrival." If you receive this "DESCEND VIA" clearance, you are expected to vertically and laterally navigate in accordance with the BLAKE ONE arrival. Although descent is as pilot's discretion, adherence to published altitude crossing restrictions and speeds is mandatory unless other wise cleared by ATC. A good example of a STAR with this type of clearance is the JAMMN ONE ARRIVAL into Salt Lake City, Utah.

11.7.1.2.3.2. Notify ATC. ***Pilots cleared for vertical navigation using the phraseology "Descend Via" shall inform ATC upon initial contact with a new frequency.*** For example, "Track 32, descending via the NEILL ONE ARRIVAL."

11.7.2. Anticipate Use of STARs. Normally, pilots of IFR aircraft destined to locations where STARs have been published should expect to be issued a clearance containing the appropriate STAR for the destination airport.

11.7.3. Must Have Textual Description. Use of STARs requires pilot possession of at least the approved textual description. As with any ATC clearance or portion thereof, it is the responsibility of each pilot to accept or refuse an issued star. Pilots should notify ATC if they do not wish to use a STAR by placing "NO STAR" in the remarks section of the flight plan or by verbally stating the same to ATC (this is the less desirable method).

11.7.4. Pilot Responsibilities. ***Before filing or accepting a clearance for a STAR, make sure you can comply with any altitude and/or airspeed restrictions associated with the procedure.*** If you filed a STAR in your flight plan, then an initial ATC clearance of "Cleared as filed" clears you for the STAR routing (not altitudes) as well. Clearance for the STAR is not clearance for the approach the procedure may bring you to.

11.7.5. Where STARs Are Published. Normally, STARs are published in FLIP. In the CONUS, STARs are found in the East/Central/West Civil SID/STAR book.

11.7.6. Profile Descents. Although Profile Descents no longer exists in the CONUS, you may encounter them in other parts of the world. (For an example, look at Lester B. Pearson International Airport in Toronto.) A profile descent is an uninterrupted descent (except where level flight is required for speed adjustment; e.g. 250 knots at 10,000 feet MSL) from cruising altitude/level to interception of a glideslope or to a minimum altitude specified for the initial or intermediate approach segment of an instrument approach. The Profile Descent normally terminates at the approach gate or where the glideslope or other appropriate minimum altitude is intercepted.

Chapter 12

HIGH ALTITUDE APPROACHES

12.1. Application. An en route descent or a high altitude instrument approach enables an aircraft to transition from the high altitude structure to a position on and aligned with an inbound course to the FAF, at FAF altitude in the final approach configuration. ATC will usually issue a clearance for a specific type of approach. The omission of a specific type in the approach clearance indicates that any published instrument approach to the aerodrome may be used. ***Unless you receive an appropriate ATC clearance to deviate, fly the entire instrument approach procedure starting at the IAF.***

12.2. Non-DME Teardrop Approaches. Teardrop approaches are usually associated with VOR or NDB facilities (**Figure 12.1**).

12.2.1. Station Passage. ***When station passage occurs at the IAF, turn immediately in the shorter direction toward the outbound course and attempt to intercept it. Begin descent when you are established on a parallel or intercept heading to the approach course and outbound from the IAF. If you arrive at the IAF at an altitude below that published, maintain altitude and proceed outbound 15 seconds for each 1,000 foot the aircraft is below the published altitude before starting descent. If you arrive at the IAF at an altitude above that published, a descent to the published IAF altitude should be accomplished prior to starting the approach. If descent is required at the IAF, obtain clearance to descend in a holding pattern. Set the altimeter in accordance with FLIP.***

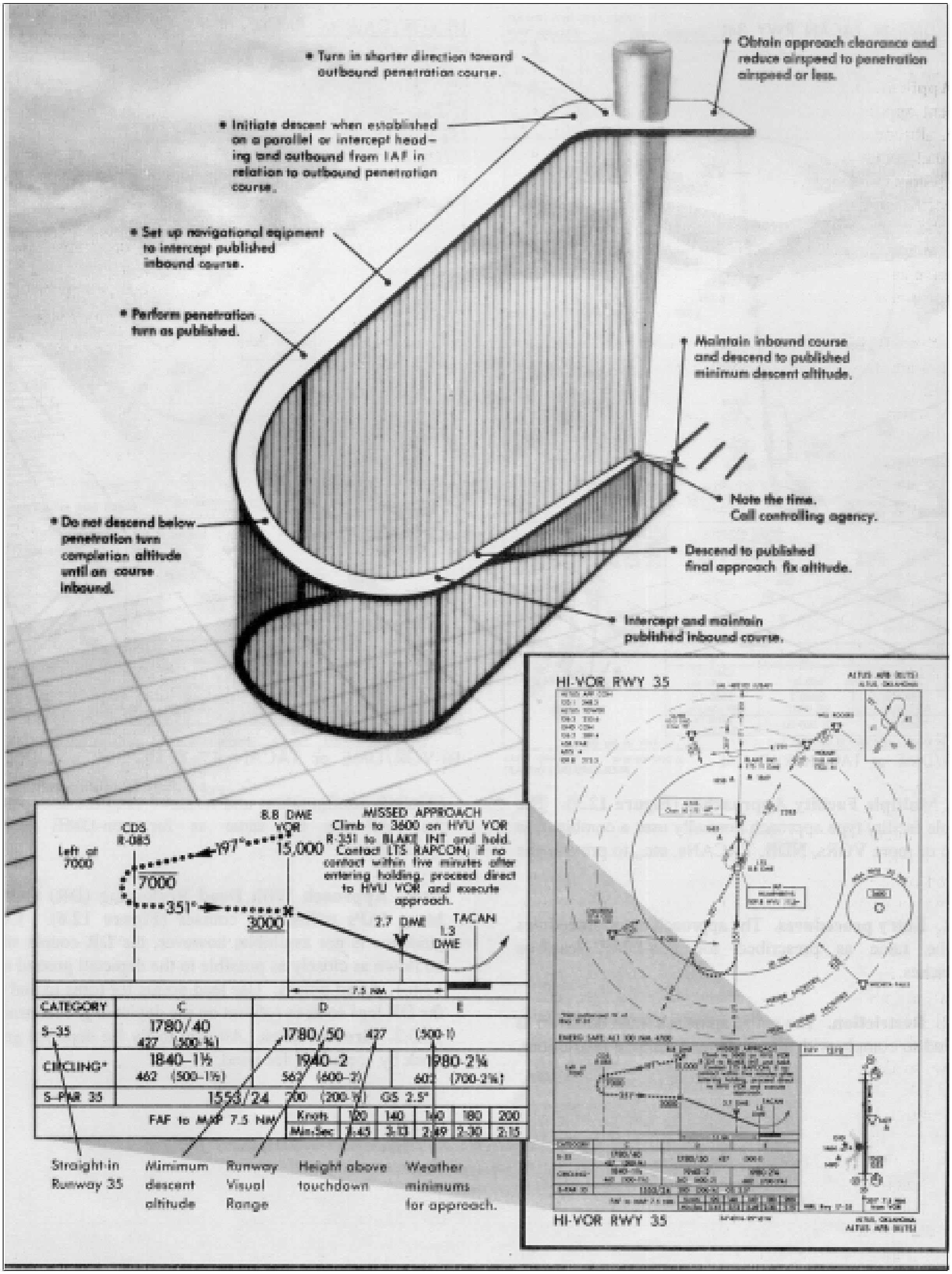
NOTE: ***Use a descent gradient of 800-1,000 ft/NM (8-10°) to ensure you remain within protected airspace.***

12.2.2. Fly-off. Some approaches use a fly-off (altitude or range) restriction before starting descent. In these cases, ***attempt to intercept the outbound course and comply with the altitudes depicted on the approach chart unless otherwise instructed by ATC.*** Since the pilot cannot be expected to determine accurate groundspeed during a constantly changing true airspeed descent, depicted range restrictions should not be shown on non-DME teardrop high altitude approaches. Penetration turns should be annotated "left or right turn at (altitude)." ***When a penetration turn altitude is not published, start the turn after descending one-half the total altitude between the IAF and FAF altitudes.*** One technique to determine the start turn altitude is to add the IAF and FAF altitudes and divide by two. ***Before reaching the penetration turn altitude, set up the navigation equipment to intercept the published inbound approach course. Recheck the altimeter and the direction of penetration turn.***

12.2.3.Penetration Turn. ***Fly the penetration turn in the direction published.*** A 30° angle of bank is normally used during the penetration turn; however, bank may be shallowed if undershooting course. If it is apparent that you will undershoot the inbound penetration course, roll out on an intercept heading. Use normal inbound course interception procedures to intercept the course.

NOTE: ***If a penetration turn completion altitude is depicted, do not descend below this altitude until you are established on the inbound segment of the published approach procedure.*** Remember, obstacle clearance is based on the pilot attempting to maintain the course centerline; a pilot must use position orientation and pilot judgment to determine when to descend while attempting to intercept the course.

Figure 12.1. Non-DME Teardrop-High Altitude Approach (para 12.2).



12.2.4. Descent. Continue descent to FAF altitude. Establish approach configuration and airspeed prior to the final approach fix unless the aircraft flight manual procedures require otherwise.

12.3. Radial Approaches. These approaches are associated with TACAN or VORTAC facilities (**Figure 12.2**). The entire approach track is formed by one or more radials.

12.3.1. Crossing the IAF. ***When over the IAF, turn immediately in the shorter direction toward the approach course.*** Intercept the published approach course using appropriate course intercept procedures. If your heading is within 90° of the approach course, you are not required to overfly the IAF; you may use normal lead points to intercept the course (**Figure 12.3**).

12.3.2. Descent. ***Start the descent when the aircraft is abeam or past the IAF on a parallel or intercept heading to the approach course.*** (For DME approaches, crossing the arc is considered abeam the IAF.) ***Intercept the course and comply with the altitudes depicted on the approach chart.*** (Aircraft configuration and airspeed requirements prior to the FAF are the same as for non-DME teardrop.)

Figure 12.2. Radial - High Altitude Approach (para 12.3).

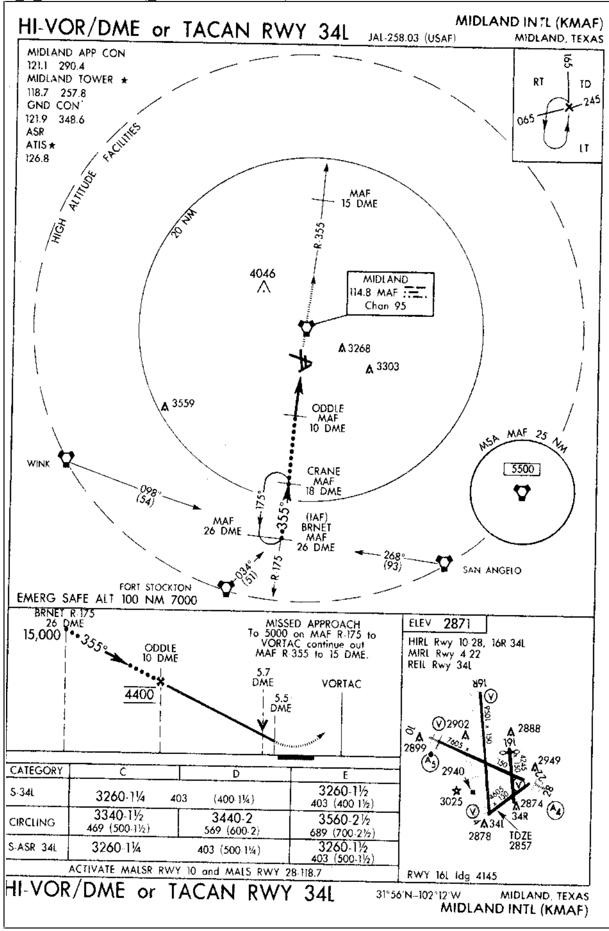
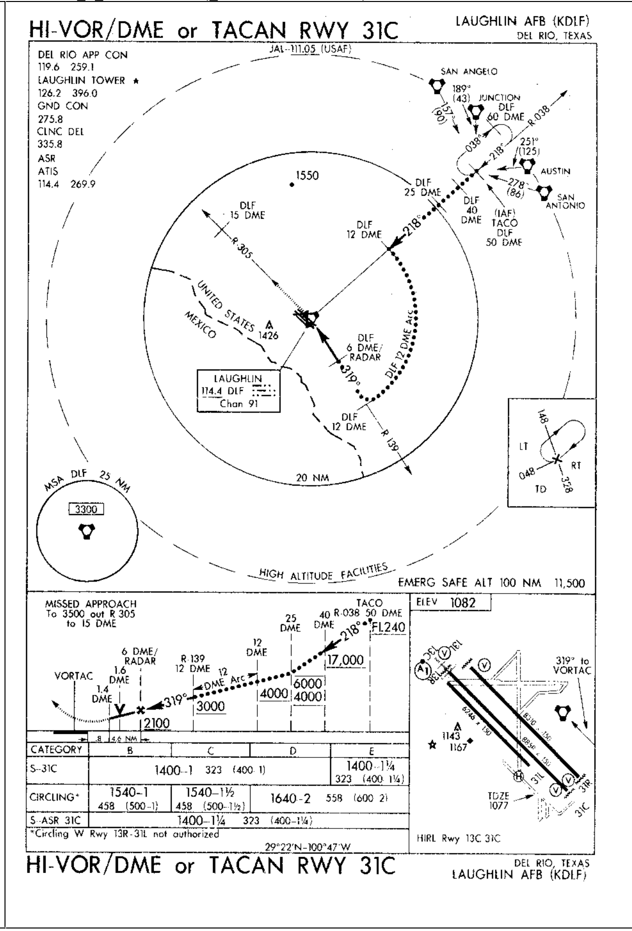


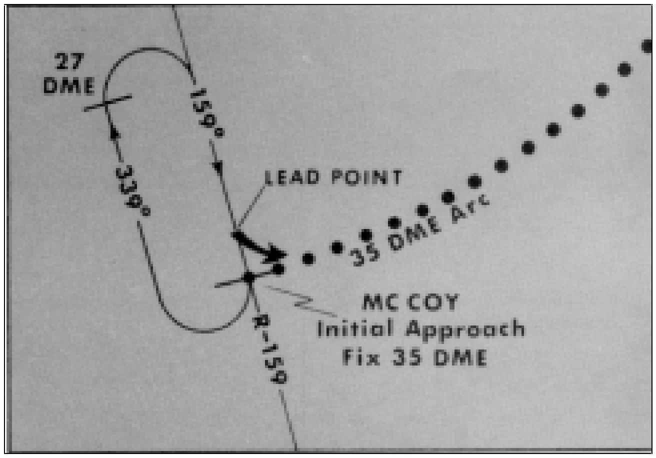
Figure 12.3. Arc and Radial Combination Approach (para 12.3.1).



12.4. Radial and Arc Combination Approaches (Figure 12.3). These require the use of arc intercept procedures. Flight procedures are the same as for a radial approach. However, if established in a holding pattern and the IAF is located on an arc or on a radial at a distance less than that required for a normal lead point, you may turn early to intercept the arc (**Figure 12.4**). ***Start the descent when you are established on an intercept to the arc and abeam or past the IAF in relation to the initial approach***

track. (Aircraft configuration and airspeed requirements prior to the FAF are the same as for non-DME teardrop.) An arc or radial altitude restriction only applies while established on that segment of the approach to which the altitude restriction applies. Once a lead point is reached, and a turn to the next segment is initiated, the pilot may descend to the next applicable altitude restriction. This may be especially important to facilitate a reasonable rate of descent to final approach fix altitude.

Figure 12.4. Determining Lead Point (para 12.4).



NOTE: ***When an altitude restriction is depicted at a fix defined as an intersection of a radial and an ARC the restriction must be complied with no later than the completion of the lead turn associated with that fix.*** If the restriction is met during the lead turn, consider yourself established on the next segment and continue to descend to the next applicable altitude restriction.

12.5. Multiple Facility Approaches (Figure 12.5). The multiple facility type approach normally uses a combination of two or more VORs, NDB, TACANs, etc., to provide the track.

12.5.1. Entry Procedures. The approach entry procedures are the same as prescribed for non-DME teardrop approaches.

12.5.2. Restriction. ***The entire approach must be flown as depicted to comply with all course and altitude restrictions.*** (Aircraft configuration and airspeed requirements prior to the FAF are the same as for non-DME teardrop approaches.)

12.6. Approach With Dead Reckoning (DR) Courses. Many IAPs utilize DR courses (**Figure 12.6**). Course guidance is not available; however, ***the DR course should be flown as closely as possible to the depicted ground track.***

12.6.1. Lead points. ***Use lead points for turns to and from the DR legs so as to roll out on the depicted ground track.***

12.6.2. Ground track. ***Attempt to fly the depicted ground track by correcting for wind.***

Figure 12.5. Multiple Facility Approach (para 12.5).

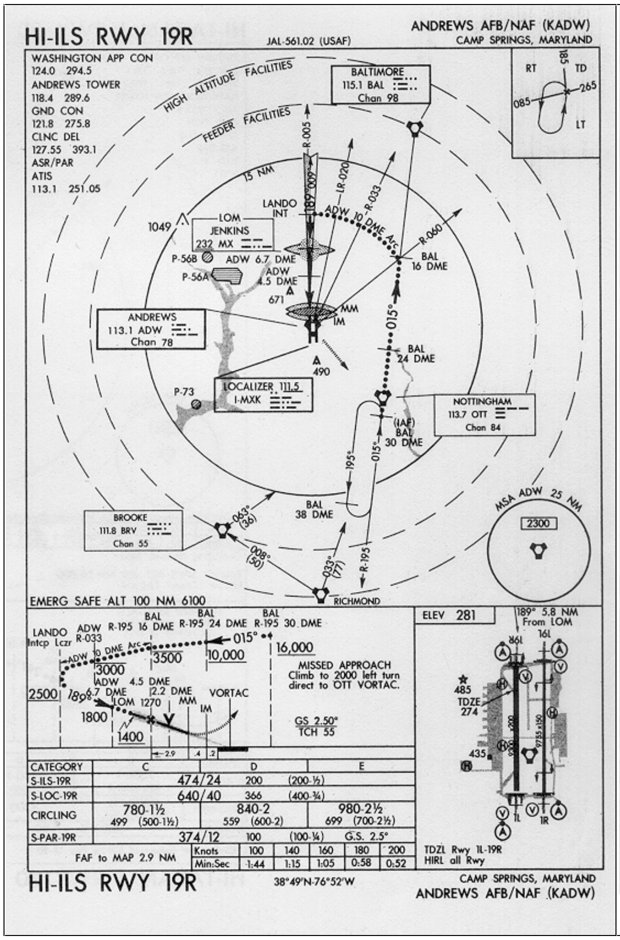
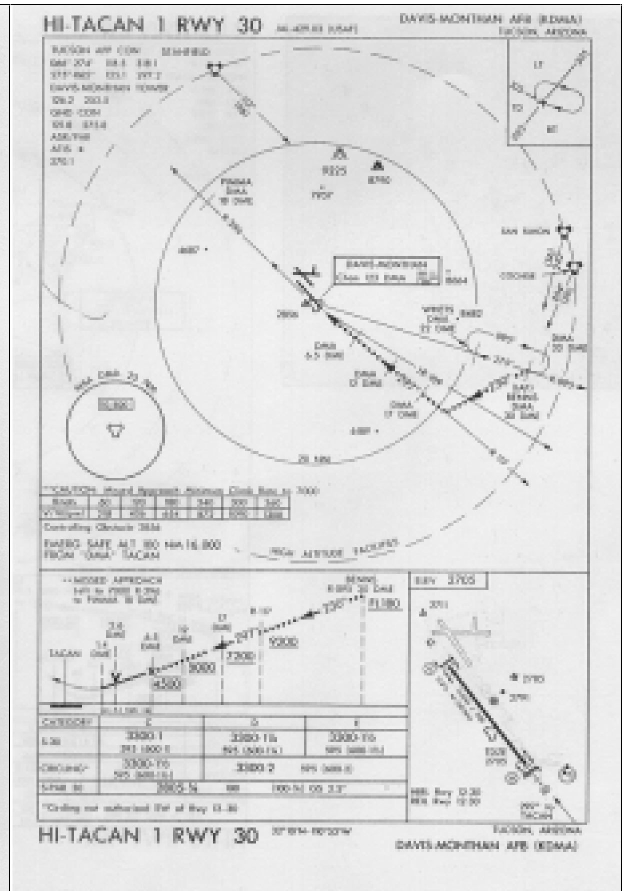


Figure 12.6. Dead Reckoning Courses (para 12.6



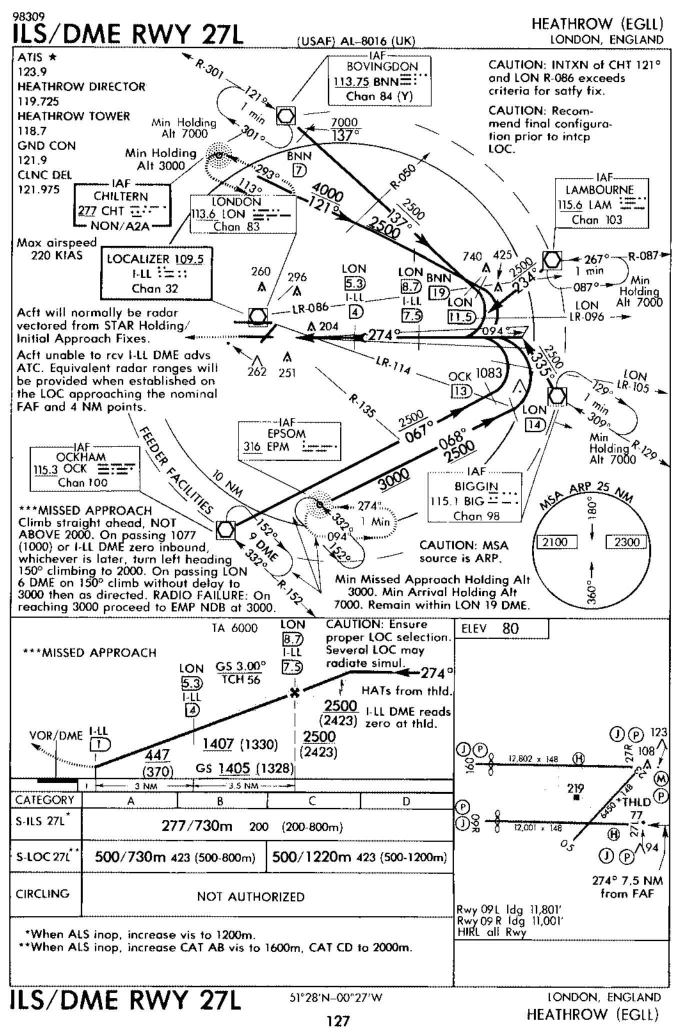
Chapter 13

LOW ALTITUDE APPROACHES

13.1. Introduction. Low altitude approaches are used to transition aircraft from the low altitude environment to final approach for landing. Low altitude instrument approach procedures exist for one purpose -- to assist you in guiding your aircraft to the final approach fix, on course, on altitude, and in the final approach configuration. It has become normal to expect ATC to provide radar vectors to final; however, you must always be prepared to execute the "full procedure" when appropriate.

NOTE: This chapter deals primarily with low altitude approaches flown in FAA airspace. Many of our techniques for flying "stateside" low altitude approaches have their origins in ICAO procedures. To learn about significant differences between flying low altitude procedures in the United States versus ICAO procedures, refer to Chapter 23, ICAO Procedures.

Figure 13.1. Low Altitude Procedure at Heathrow (EGLL).



13.2. Overview. There are two broad categories of low altitude approaches: course reversals and procedure tracks. Before we look at each type in detail, here are some guidelines that apply to all low altitude approaches:

13.2.1. Initial Approach Fix (IAF). Most approaches begin at an IAF. ATC will normally clear you to the appropriate IAF and then clear you for the approach. ***Unless ATC specifically clears you otherwise, you are expected to fly to the IAF and execute the full instrument approach procedure as published.***

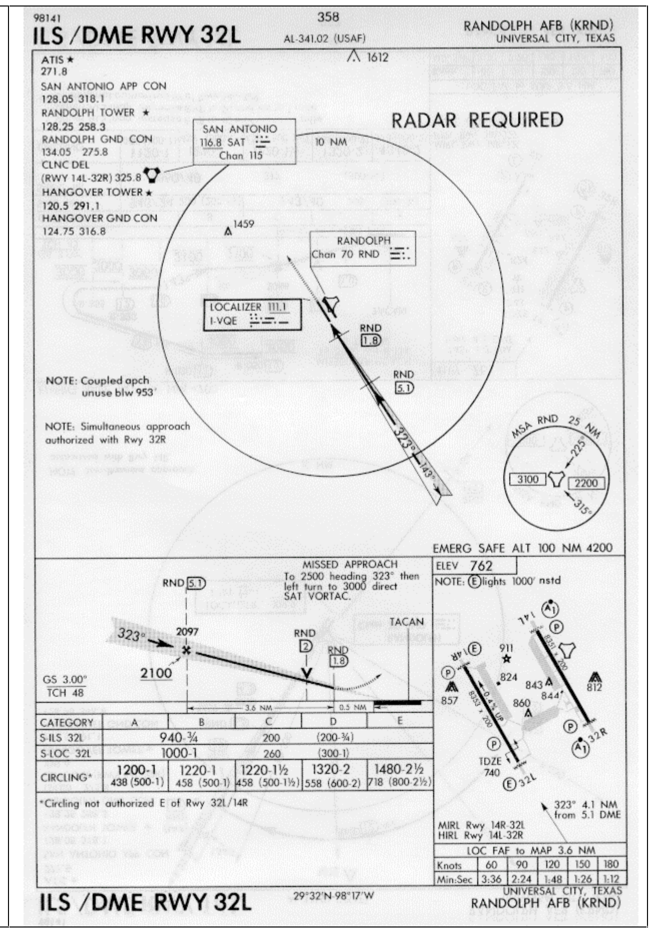
13.2.2. Final Approach Segment. Some approaches depict only a final approach segment, starting at the FAF (**Figure 13.2**). In these cases, radar is required to ensure you are properly aligned with the final approach course at the appropriate altitude. ***When ATC clears you for the approach, maintain the last assigned altitude until established on a segment of the published instrument approach procedure (IAP).***

Figure 13.2. Approach Depicting Only the Final Approach Segment.

Example

Approach With Final Segment Only

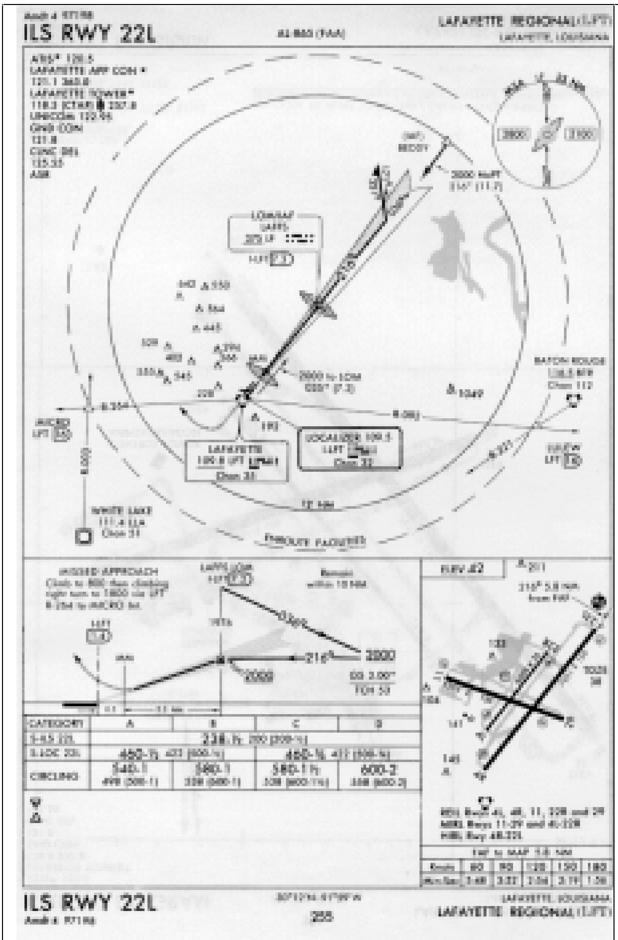
If you are getting radar vectors to final for the ILS/DME RWY 32L (**Figure 13.2**), and ATC gives you the following clearance, "Track 32, turn left heading 360, maintain 3,000 until established on the localizer, cleared the ILS/DME RWY 32L approach," then you must stay at 3,000 until established on a segment of the approach. In this example, you must remain at 3,000 feet until established on the localizer and passing 5.1 DME. Obviously, this will cause you some problems in attempting to intercept the glideslope; ATC should descend you to 2,100 before clearing you for the approach.



13.2.3. Aircraft Speed. ***Prior to reaching the initial approach fix, slow to maneuvering speed for your aircraft.*** Use holding airspeed if maneuvering airspeed is not specified for your aircraft. Establish approach configuration and airspeed before the final approach fix unless your aircraft flight manual procedures require otherwise.

13.2.4. Dead Reckoning (DR) Courses. Many IAPs utilize DR courses (**Figure 13.3**). Although course guidance is not available, the DR course should be flown as closely as possible to the depicted ground track. ***Use lead points for turns to and from the DR legs to roll out on the depicted ground track. Fly the depicted ground track by correcting for wind.***

Figure 13.3. Approach Using a DR Course.



Example

Approach with DR Segment

If you were flying the approach depicted in **Figure 13.3** from the BEDDY intersection, you should fly the 216° DR course by flying a 216° corrected for wind. Attempt to maintain the groundtrack depicted by the DR course. If necessary, use leadpoints to roll out on the DR course.

13.3. Types of Course Reversals. There are two common types of course reversals: the procedure turn (PT) and the holding pattern in lieu of procedure turn (HILO PT). Before discussing each type of course reversal in detail, here are some guidelines that apply to all course reversals:

13.3.1. Restrictions. ***Do not execute a procedure turn or HILO PT in the following situations***. (Many people use the memory aid – SNERT)

–When ATC gives you clearance for a “**S**traight-in” approach.

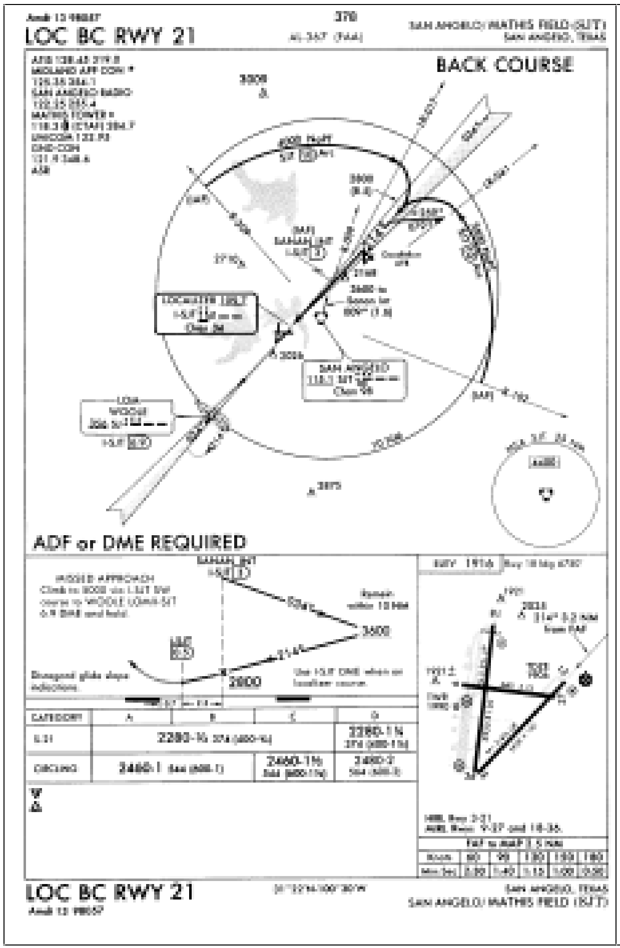
–If you are flying the approach via **N**o PT routing (**Figure 13.4**).

–When you are **E**stablished in holding, subsequently cleared the approach, and the holding course and procedure turn course are the same.

–When ATC provides **R**adar vectors to the final approach course.

–When ATC clears you for a **T**imed approach. Timed approaches are in progress when you are established in a holding pattern and given a time to depart the FAF inbound.

Figure 13.4. Example of NoPT Routing.



Example

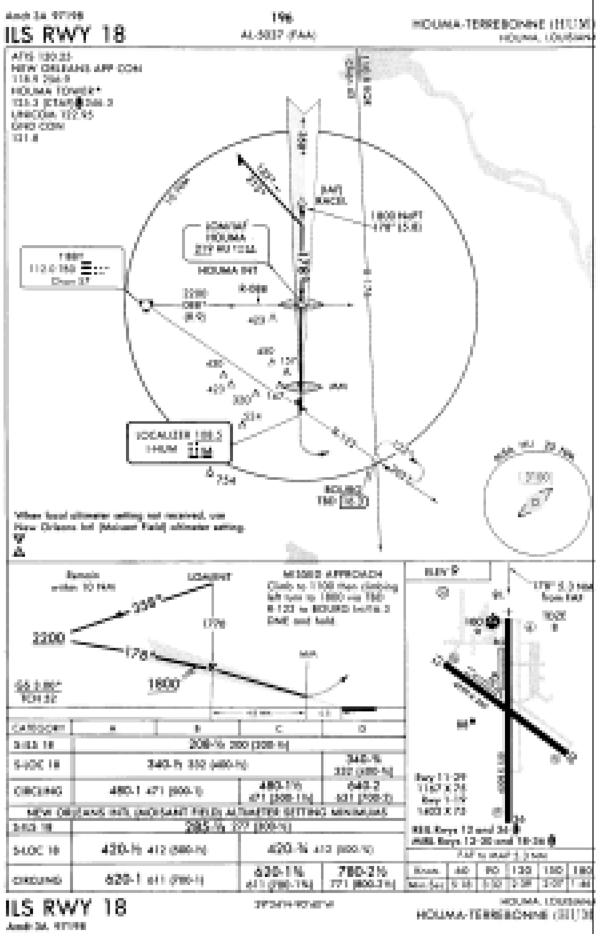
Approach with NoPT Routing

If you were flying the back course localizer approach at San Angelo (**Figure 13.4**) via the arc, you are flying on NoPT routing; therefore when cleared for the approach, ATC would not expect you to execute the procedure turn.

13.3.1.1. ***In any of the situations described in paragraph 13.3.1 above, proceed over the FAF at the published FAF altitude and continue inbound on the final approach course without making a procedure turn, holding pattern, or any other aligning maneuver before the FAF unless otherwise cleared by ATC.*** If you need to make additional circuits in a published holding pattern or to become better established on course before departing the FAF, it is your responsibility to request such maneuvering from ATC.

NOTE: Historically, these restrictions have created a lot of confusion between pilots and controllers. If you are ever in doubt about what ATC expects you to do, query the controller.

Figure 13.5. Procedure Turn Course Reversal.



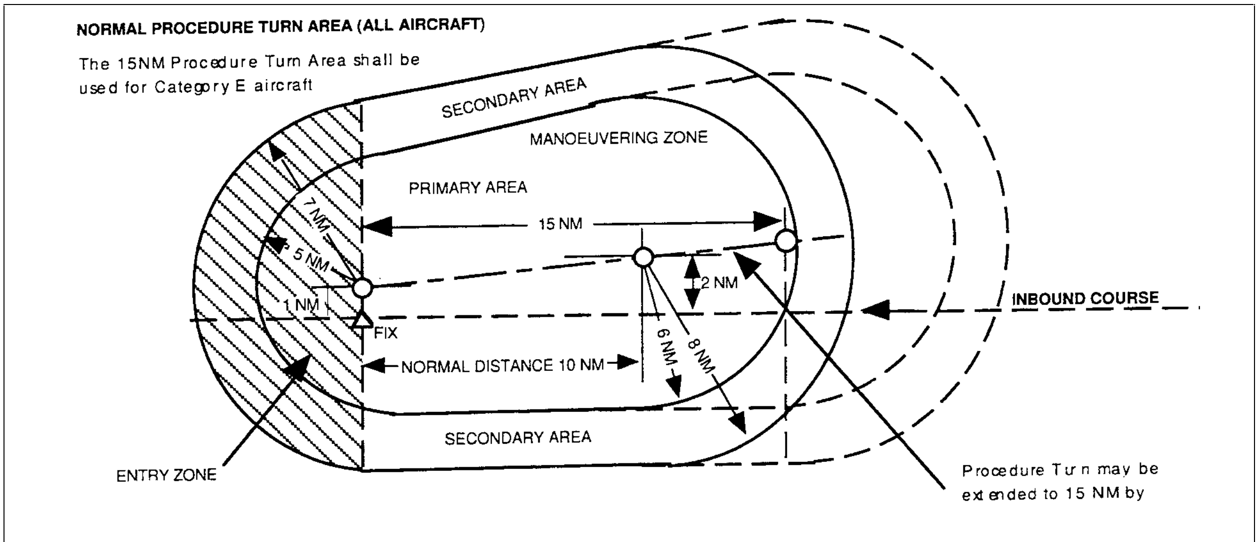
Example

Procedure Turn Course Reversal

The ILS RWY 18 approach at Houma is a procedure turn (**Figure 13.5**). Notice the barb symbol in the plan view which, in this case, indicates maneuvering should be accomplished on the west side of the procedure turn course. The procedure turn fix is the Houma Locator Outer Marker (HU) or the HOUMA intersection.

13.4. Procedure Turns. One of the most common types of low altitude course reversals is the procedure turn. Procedure turns are depicted in the plan view of U.S. government charts with a barb symbol (__↗) indicating the direction or side of the outbound course on which the procedure turn or maneuvering is to be accomplished (**Figure 13.5**). The procedure turn fix is identified on the profile view of the approach at the point where the IAP begins. To give you an idea of what the procedure turn airspace looks like, refer to **Figure 13.6**.

Figure 13.6. Procedure Turn Area.



In the diagram above, note the maneuvering side is the side above the inbound course line – the airspace is much larger. The dashed lines to the right depict the procedure turn area for Category E aircraft; it is typically 15 miles versus 10 miles for the normal area.

13.4.1. Aircraft Speed. Procedure turns may be safely flown at speeds up to 250 KIAS provided the pilot takes into consideration all factors which may affect the aircraft's turn performance (e.g., winds, TAS at altitude, bank angle, etc.).

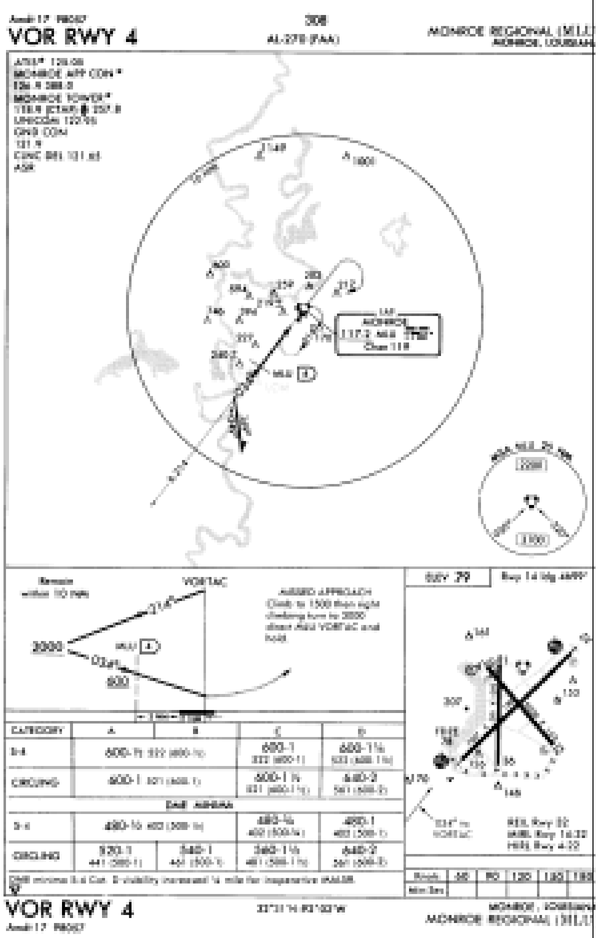
NOTE: The FAA recommends a maximum airspeed of 200 KIAS while performing procedure turn course reversals, and when possible, USAF aircraft should also observe this speed restriction. If a speed of 200 KIAS is not practical, you must exercise caution to ensure your aircraft remains in the protected airspace provided by TERPs.

13.5. Techniques for Flying Procedure Turns. There are three common techniques for executing a procedure turn course reversal: the holding technique, the 45/180, and the 80/260. Regardless of the method you choose to fly the procedure turn, take the following two notes into consideration when planning your approach:

1. Plan the outbound leg to allow enough time for configuration and any descent required prior to the FAF. ***Ensure you adjust the outbound leg length so you will stay inside the "remain within distance" noted on the profile view of the approach plate***. The remain within distance is measured from the procedure turn fix unless the IAP specifies otherwise. At the completion of the outbound leg, turn to intercept the procedure turn course inbound.
2. When the NAVAID is on the field and no FAF is depicted (**Figure 13.7**), plan the outbound leg so the descent to MDA can be completed with sufficient time to acquire the runway and position the aircraft for a normal landing. Consideration should be given to configuring on the outbound leg to minimize pilot tasking on final. When flying this type of approach, the FAF is considered to be the point when you begin your descent from the procedure turn completion altitude. Since this point is considered the FAF, you should establish approach configuration and

airspeed prior to departing procedure turn completion altitude unless your aircraft flight manual procedures require otherwise.

Figure 13.7. Procedure Turn Approach with No FAF Depicted.



Example

Procedure Turn Approach with No FAF Depicted

If you are flying the VOR RWY 4 approach at Monroe Regional (**Figure 13.7**), the NAVAID is on the field and no FAF is depicted. When flying this type of approach, plan your outbound leg so descent to MDA can be completed with enough time to see the runway and perform a normal landing. Consider configuring on the outbound leg to reduce your workload on final.

13.6. Holding Technique. ***Enter the procedure turn according to the holding procedures described in Chapter 10 with the following exceptions:***

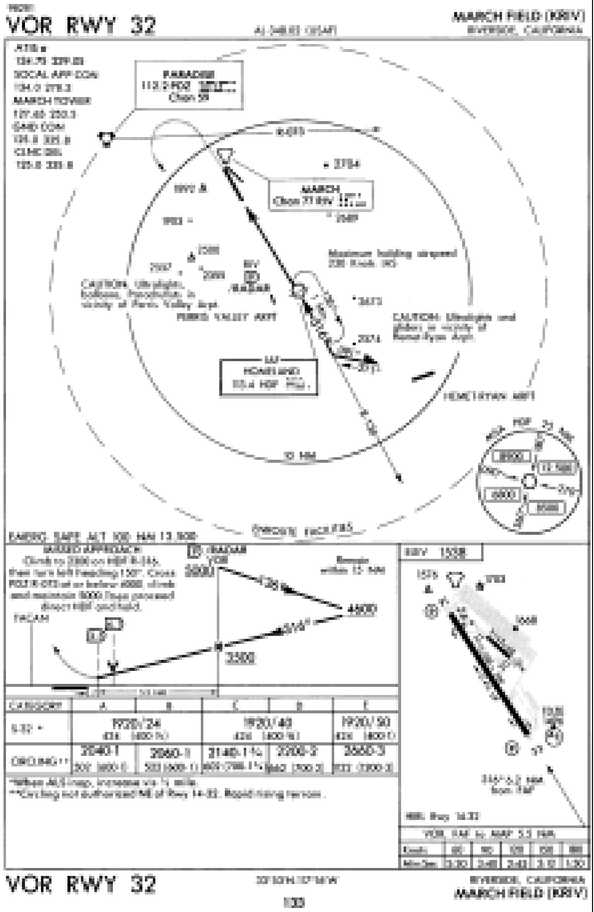
–If your heading is within 90° of the outbound procedure turn course, you may use normal lead points to intercept the procedure turn course outbound.

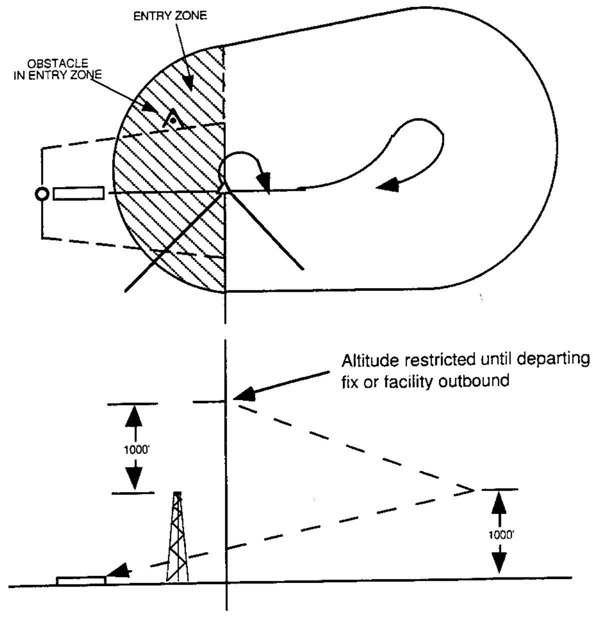
–If you elect a teardrop entry, your teardrop course must be within 30 degrees of the procedure turn course. Use course guidance if it is available.

–If the entry turn places the aircraft on the non-maneuvering side of the procedure turn course and you are flying in excess of 180 KTAS, you must correct toward the procedure turn course using an intercept angle of at least 20°.

–If you intercept the procedure turn course outbound, maintain the course for the remainder of the outbound leg, then turn toward the maneuvering side to reverse course.

Figures 13.8 and 13.9. PT Fix Altitude.





If you notice in **Figure 13.8**, the VOR RWY 32 at March Field has a PT fix altitude. The reason a PT fix altitude is depicted is because there is an obstacle in the PT entry area. You must wait until "outbound abeam" to begin your descent because of this TERPs consideration (**Figure 13.9**). If no PT fix altitude exists, then the PT entry area is "clear;" however, in the interest of good habit patterns, the "outbound abeam" restriction has been adopted as procedural for all procedure turns (para 13.6.2).

13.6.1. Timing. ***Begin timing once you are outbound abeam the procedure turn fix. If you cannot determine the abeam position while in the turn, start timing after completing the outbound turn.***

13.6.2. Descent. ***Do not descend from the procedure turn fix altitude (published or assigned) until you are abeam the procedure turn fix heading outbound. If you cannot determine when you are abeam, start your descent after completing the outbound turn. Do not descend from the procedure turn completion altitude until you are established on the inbound segment of the approach.***

13.7. The 45°/180° and the 80°/260° Course Reversals. Two other methods you may use to accomplish a procedure turn approach are the 45°/180° and the 80°/260° course reversal maneuvers (**Figure 13.10**). The procedures for flying each maneuver are identical with the exception of the actual course reversal.

–**Entry.** Upon reaching the procedure turn fix, turn in the shortest direction to intercept the procedure turn course outbound. You may use normal leadpoints if practical.

–**Proceeding Outbound.** ***Intercept and maintain the procedure turn course outbound as soon as possible after passing the procedure turn fix.***

–**Descent.** ***Do not descend from the procedure turn fix altitude (published or assigned) until you are abeam the procedure turn fix and on a parallel or intercept heading to the outbound track. Do not descend from the procedure turn completion altitude until you are established on the inbound segment of the approach.***

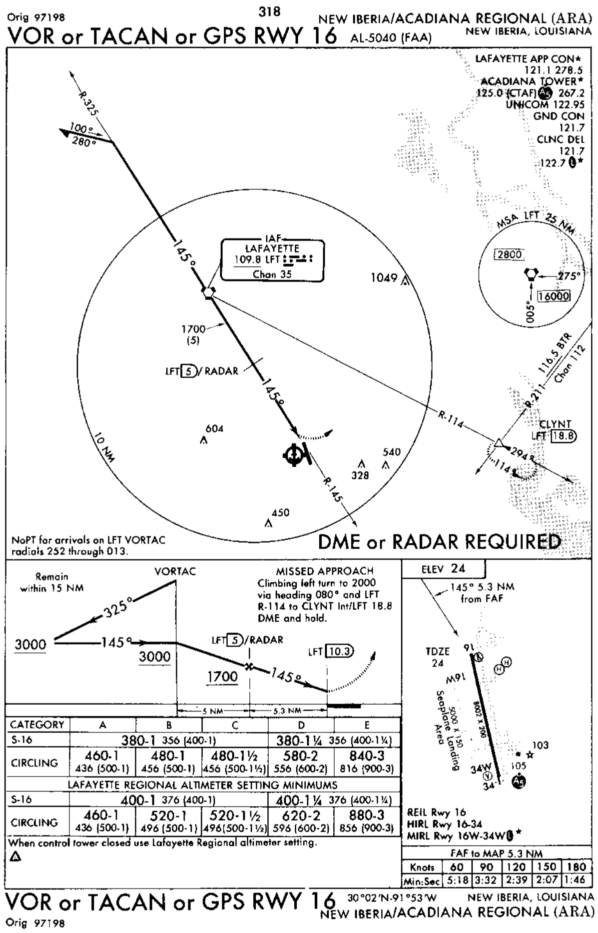
NOTE: When flying procedure turns designed in FAA airspace, there is no requirement to wait until you are on a parallel or intercept heading to begin descent from the procedure turn fix altitude; however, when flying these types of course reversals in ICAO airspace, this procedure is MANDATORY due to different TERPs criteria. In the interest of forming good habit patterns, the ICAO method has been adopted by the USAF as procedural.

13.7.1. ***Executing the Course Reversal Maneuver. At the appropriate time on the outbound leg, begin the course reversal maneuver. In both cases, comply with the published remain within distance.***

13.7.1.1. The 45°/180°. ***To begin the reversal maneuver, turn 45° away from the outbound track toward the maneuvering side.*** Begin timing upon initiating the 45° turn; time for 1 minute (Categories A and B) or 1 minute and 15 seconds (Categories C, D, and E); then begin a 180° turn in the opposite direction from the initial turn to intercept the procedure turn course inbound.

13.7.1.2. The 80°/260°. ***To begin the reversal maneuver, make an 80° turn away from the outbound track toward the maneuvering side followed by an immediate 260° turn in the opposite direction to intercept the inbound course.***

Figure 13.10. The 45°/180° and the 80°/260°.



Example

The 45°/180° and the 80°/260°

The procedure turn for Runway 16 at Acadiana (Figure 13.10) could be flown using either the 45°/180° or the 80°/260° course reversal technique. Using this approach, adjust your outbound leg to remain within 15 NM of LFT (PT fix). To do the 45/180, turn left to a heading of 280°. At the appropriate time for your aircraft, turn right to a heading of 100° and intercept the PT course inbound. To execute the 80/260, turn left to a heading of 245° followed by an immediate right turn to intercept the PT course inbound. (Be careful not to land on the seaplane runway!)

13.8. Holding Pattern in Lieu of Procedure Turn (HILO PT). The HILO PT is another common way to execute a low altitude course reversal. The HILO PT is depicted like any other holding pattern except the holding pattern track is printed with a heavy black line ( ) in the plan view (**Figures 13.11 and 13.12**). The depiction of the approach in the profile view varies depending on where the descent should begin.

13.8.1. Flying the Holding Pattern. ***Enter and fly the HILO PT holding pattern according to the holding procedures described in Chapter 10.***

13.8.2. Descent. Descent from the minimum holding altitude may be depicted in two ways: descent at the holding fix (**Figure 13.11**) or descent on the inbound leg (**Figure 13.12**). ***When a descent is depicted on the inbound leg, you must be established on the inbound segment of the approach before beginning the descent.***

Figure 13.11. HILO PT With Descent at the Holding Fix

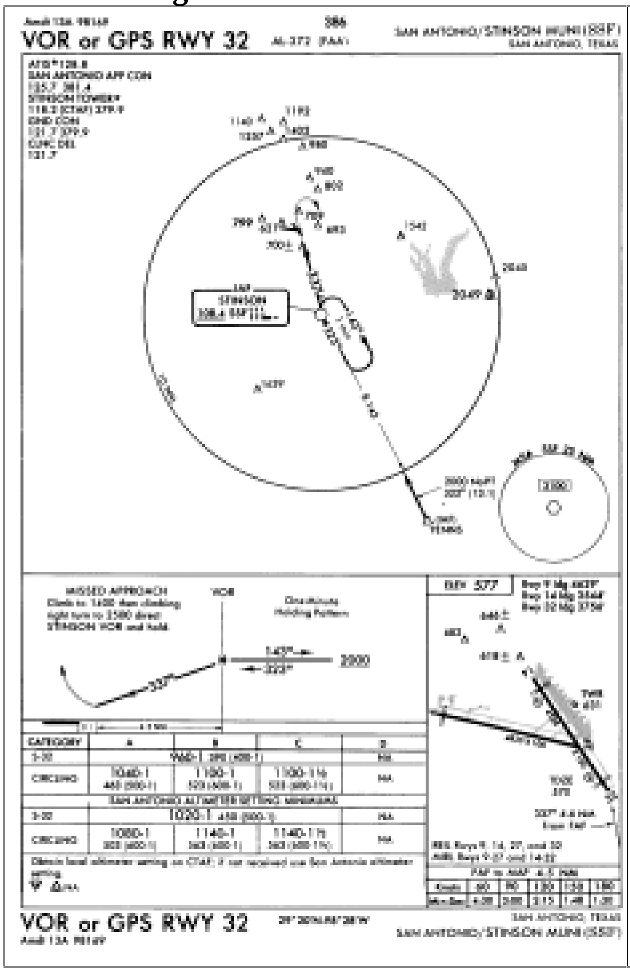
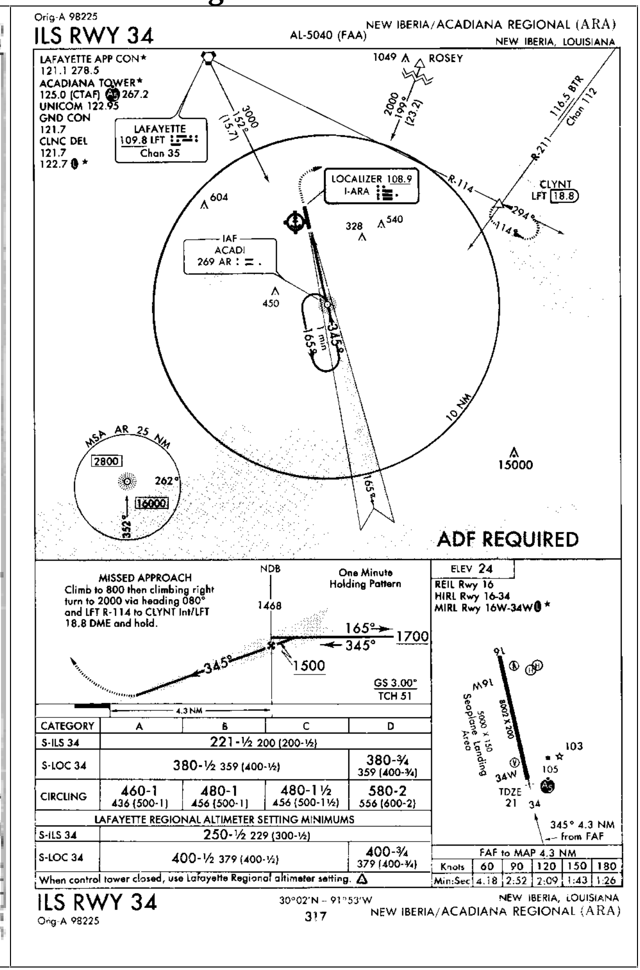


Figure 13.12. HILO PT With Descent on the Inbound Leg.



13.8.3. Additional Guidance for HILO PTs. ***If cleared for the approach while holding in a published HILO PT, complete the holding pattern and commence the approach without making additional turns in the holding pattern (altitude permitting). If an additional turn is needed to lose excessive altitude, request clearance from ATC*** since additional circuits of the holding pattern are not expected by ATC. If the aircraft is at an altitude from which the approach can be safely executed and you are ready to turn inbound immediately, you may request approval for an early turn from ATC.

13.9. Procedural Tracks.

13.9.1. Depiction. There is no specific depiction for a procedural track. It may employ arcs, radials, courses, turns, etc. When a specific flight path is required, procedural track symbology is used to depict the flight path between the IAF and FAF. The depiction used is a heavy black line showing intended aircraft ground track **(Figures 13.13 through 13.16**).

Figure 13.13. Procedure Track Approach (Straight-In).

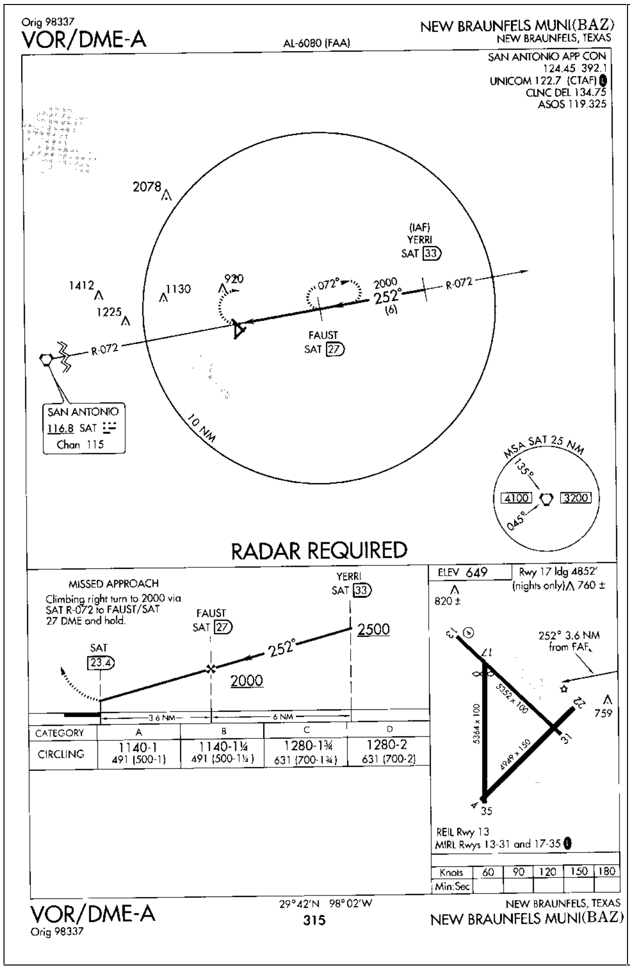
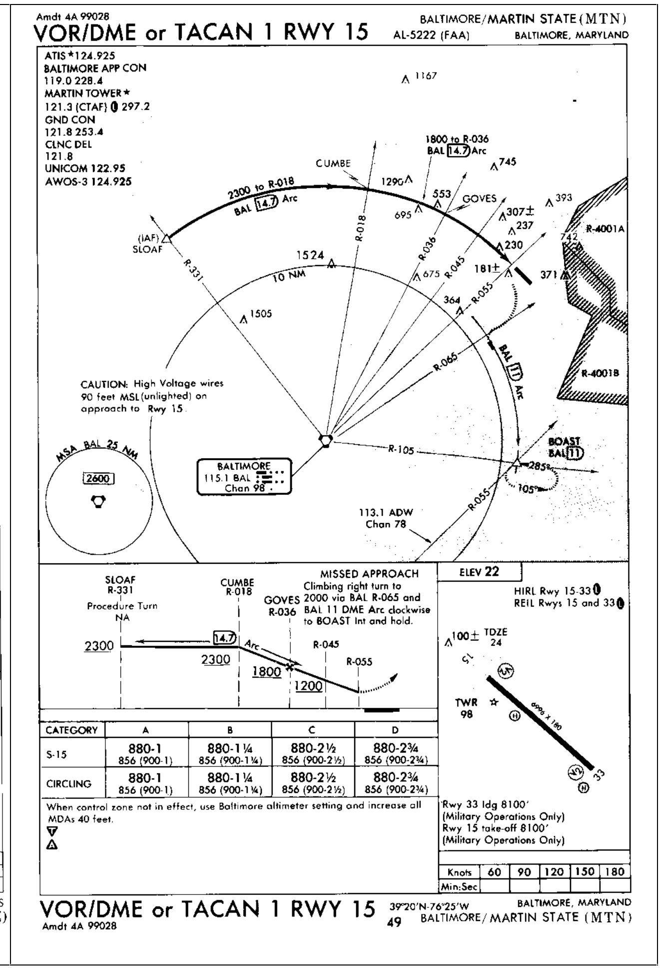


Figure 13.14. Procedure Track Approach (Arcing Final).



13.9.2. Entry. ***When over the IAF, turn immediately in the shorter direction to intercept the published track. If your heading is within 90° of the procedure track course, you may use normal lead points to intercept the course. If your heading is not within 90° of the course, overfly the fix and turn in the shorter direction to intercept the procedure track course.***

13.9.3. Maneuvering. ***Conform to the specific ground track shown on the IAP.*** Where a teardrop turn is depicted, you may turn to the inbound course at any time unless otherwise restricted by the approach plate (**Figure 13.12**). Determine when to turn by using the aircraft turn performance, winds, and the amount of descent required on the inbound course; however, ***do not exceed the published remain within distance.***

13.9.4. Descent. A descent can be depicted at any point along the procedural track.

13.9.4.1. IAF. ***When a descent is depicted at the IAF, start descent when abeam or past the IAF and on a parallel or intercept heading to the procedural track course. Except for initial descents at an IAF, be established on the appropriate segment of the procedural track before descending to the next altitude shown on the IAP.***

NOTE: Low altitude approaches may include arc-to-radial and radial-to-arc combinations (**Figure 13.16**). An arc-to-radial altitude restriction applies only while established on that segment of the IAP. Once a lead point is reached and a turn to the next segment is begun, you may consider yourself established on the next segment and descend to the next applicable altitude. ***When an altitude restriction is depicted at a fix defined as an intersection of a radial and an arc, the restriction must be complied with no later than the completion of the lead turn associated with that fix***. If the restriction is met during the lead turn, consider yourself established on the next segment, and you may continue to descend to the next applicable altitude restriction.

Figure 13.15. Procedure Track Approach (Teardrop)

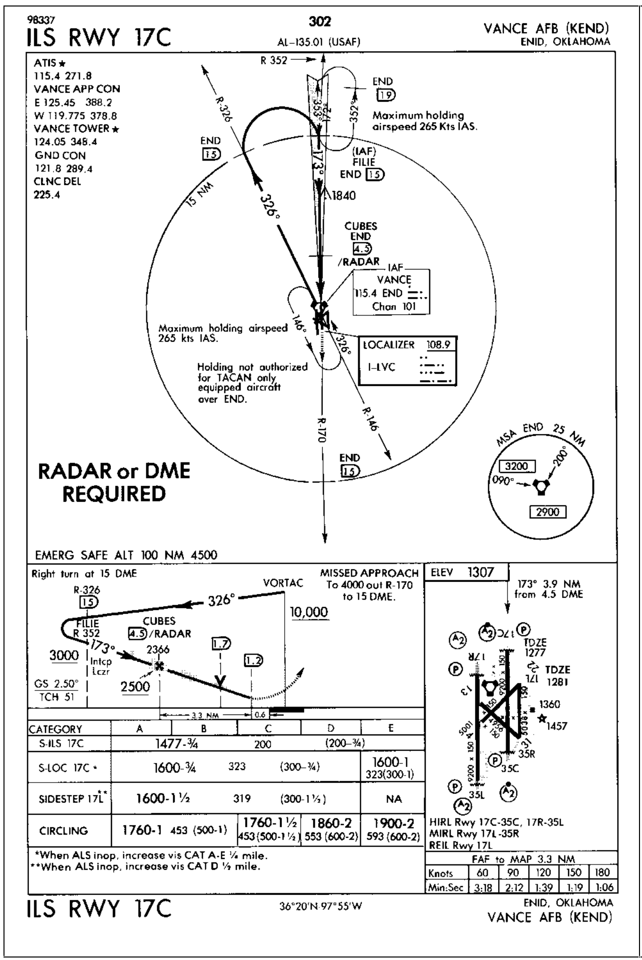
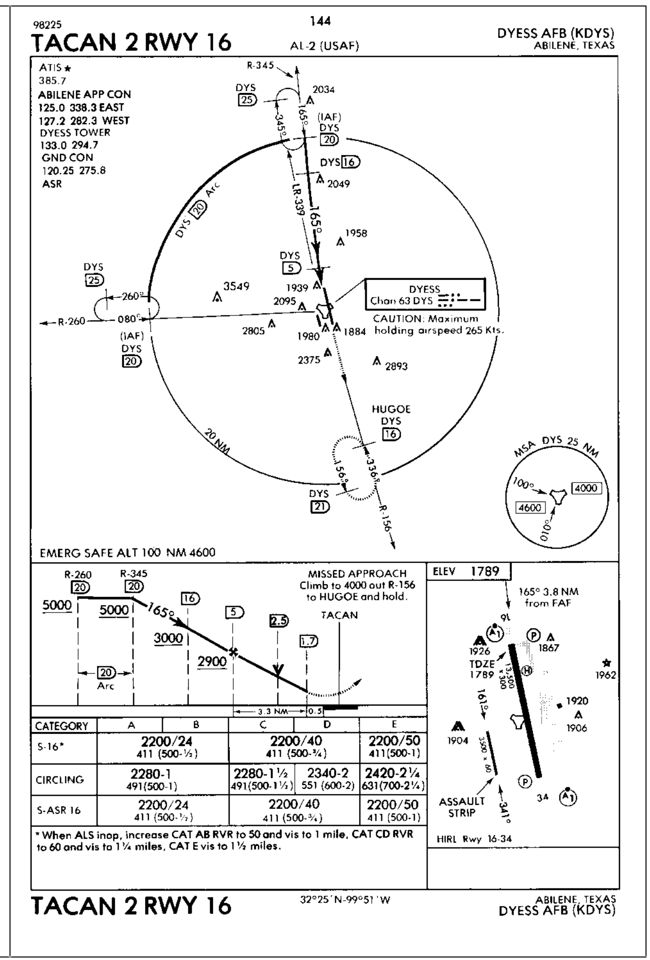


Figure 13.16. Procedure Track Approach (Arc-to-Radial).



CAUTION: Maximum designed obstacle clearance is based on the your ability to maintain the course centerline; you must use your position orientation and your judgment to determine when to descend while attempting to intercept the procedural track.

13.9.4.2. Teardrop (Figure 13.15). ***Where a teardrop is depicted, do not descend from the turn altitude until you are established on the inbound segment of the procedural track.***

Chapter 14

FINAL APPROACH

14.1. Nonradar.

14.1.1. Nonprecision (VOR, TACAN, NDB, VOR/DME, LDA, SDF, Localizer and Back Course Localizer).

14.1.1.1. Final Approach.

14.1.1.1.1. Starts. The final approach starts at the final approach fix (FAF) and ends at the missed approach point (MAP). The optimum length of the final approach is 5 miles; the maximum length is 10 miles.

14.1.1.1.2. Navigation receiver. ***Once the aircraft is inside the final approach fix, one navigation receiver must remain tuned to and display the facility that provides final approach course guidance.*** For example, if an aircraft is equipped with only one VOR receiver, that receiver cannot be retuned inside the final approach fix to another VOR station that identifies subsequent stepdown fixes and/or the missed approach point.

14.1.1.1.3. Localizer signal. The localizer signal typically has a usable range of at least 18 miles within 10° of the course centerline unless otherwise stated on the IAP. ATC may clear you to intercept the localizer course beyond 18 miles or the published limit, however, this practice is only acceptable when your aircraft is in radar contact and ATC is sharing responsibility for course guidance.

14.1.1.1.4. "Back Course" Localizer. In order to fly a back course localizer approach, ***set the published front course in the course selector window.*** The term "front course" refers to the inbound course depicted on the ILS/localizer approach for the opposite runway. On the back course approach plate, the published front course is depicted in the feather as an outbound localizer course.

14.1.1.2. Flying the Approach.

14.1.1.2.1. Descent. Avoid rapid descent requirements on final by crossing the FAF at the published altitude.

CAUTION: Nonprecision approach procedures published in conjunction with an ILS cannot always clearly depict the FAF crossing altitude. Careful review of the IAP using the following guidance is required. The minimum altitude to be maintained until crossing the fix following the glide slope intercept point (normally the FAF will be the next fix) is the published glide slope intercept altitude, altitude published at that fix, or ATC assigned altitude. For most nonprecision approaches the glide slope intercept altitude will be the minimum FAF crossing altitude.

14.1.1.2.2. Timing. Timing is required when the final approach does not terminate at a published fix, as is usually the case with VOR, NDB, and localizer. ***If timing is required to identify the missed approach point, begin timing when passing the FAF or the starting point designated in the timing block of the approach plate.*** This point is usually the FAF, but it may be a fix not co-located with the FAF such as a LOM, NDB, crossing radial, DME fix or outer marker. Time and distance tables on the approach chart are based on groundspeed; therefore, the existing wind and TAS must be considered to accurately time the final approach. If timing is published on the approach plate, then timing can also be valuable as a backup in the event of DME loss or other problems that might preclude determination of the MAP. ***If timing is not published, do not use timing to identify the missed approach point.***

NOTES:
1. If timing is not specifically depicted on the instrument approach procedure, timing is not authorized as a means of identifying the missed approach point (MAP).
2. Timing is the least precise method of identifying the missed approach point; therefore, when the use of timing is not authorized for a particular approach because of TERPs considerations, timing information will not be published.
3. If other means of identifying the MAP are published (e.g. DME), they should be used as the primary means to determine the MAP. In these situations, timing is a good backup, but it is not the primary means of identifying the MAP. For example, if you reach the published DME depicting the MAP, do not delay executing the missed approach just because you have not reached your timing.
4. ***The middle marker may never be used as the sole means of identifying the MAP.*** The middle marker may assist you in identifying the MAP on certain localizer approaches provided it is coincident with the published localizer MAP. To determine the location of the MAP, compare the distance from the FAF to MAP adjacent to the timing block. It may not be the same point as depicted in the profile view. If the MM is received while executing such an approach, and your primary indications (DME and/or timing) agree, you may consider yourself at the MAP and take appropriate action. If the middle marker is the only way to identify the MAP (i.e., timing is not published), then the approach is not authorized.

14.1.1.2.3. Turns. ***When a turn is required over the FAF, turn immediately and intercept the final approach course to ensure that obstruction clearance airspace is not exceeded.***

14.1.1.2.4. Minimum Descent Altitude. ***Do not descend to the minimum descent altitude (MDA) or step down fix altitude until passing the FAF (if published).***

14.1.1.2.5. Visual Descent Point. Arrive at MDA (MDA is determined by the barometric altimeter) with enough time and distance remaining to identify the runway environment and depart MDA from a normal visual descent point to touchdown at a rate normally used for a visual approach in your aircraft.

14.1.1.2.6. Runway Environment. ***Descent below MDA is not authorized until sufficient visual reference with the runway environment has been established and the aircraft is in a position to execute a safe landing***. Thorough preflight planning will aid you in locating the runway environment (lighting, final approach displacement from runway, etc.). The definition of runway environment for nonprecision and precision approaches is the same. ***The runway environment consists of one or more of the following elements:***

–The approach light system (except that the pilot may not descend below 100 feet above the TDZE using the approach lights as a reference unless the red termination bars or the red side row bars are also visible and identifiable)

–The threshold, threshold markings or threshold lights

–The runway end identifier lights

–The touchdown zone lights

–The runway or runway markings

–The runway lights

–The visual approach slope indicator

CAUTIONS:

1. Most non-precision approach lighting systems do not have red termination bars or red side row bars; therefor you must have at least one of the other elements of the runway environment in sight in order to descend below 100 feet above the TDZE.
2. Depending on the location of the MAP, the descent from the MDA (once the runway environment is in sight) often will have to be initiated prior to reaching the MAP in order to execute a normal (approximately 3°) descent to landing.
3. In many cases, the minimum visibility required for the approach will not allow you to see the runway environment until you are beyond the VDP. This accentuates the need to compute a VDP and determine a point along the approach when you will no longer attempt to continue for a landing. A common error is to establish a high descent rate once the runway environment is in sight. This can go unnoticed during an approach without visual glidepath guidance and may lead to a short and/or hard landing. Caution should also be used to avoid accepting a long touchdown and landing roll.

14.1.1.2.7. Alignment. Be aware that the final approach course on a nonradar final may vary from the runway heading as much as 30° (except localizer) and still be published as a straight-in approach.

14.1.1.2.8. Stepdown Fix. A stepdown fix between the FAF and the missed approach point is sometimes used. ***Descent below stepdown fix altitude is limited to aircraft capable of simultaneous reception of final approach course guidance and the stepdown fix. Regardless of the type or number of navigation facilities used to define the stepdown fix, one navigation receiver must remain tuned to and display the navigation facility that provides final approach course guidance.*** For example, aircraft equipped with a single VOR receiver will not descend below a stepdown fix altitude when that fix is defined by two VOR radials. The VOR receiver must remain tuned to and must display the facility that provides the final approach course.

NOTE: ***When fixes on the IAP are depicted as defined by radar, only ground-based radar, such as airport surveillance, precision, or air route surveillance radar, may be used to position the aircraft.***

14.1.2. Precision (ILS).

14.1.2.1. Required Components. In the United States, the glideslope, the localizer, and the outer marker are required components for an ILS. If the outer marker is inoperative or not installed, it may be replaced by DME, another NAVAID, a crossing radial, or radar provided these substitutes are depicted on the approach plate or identified by NOTAM. If the glideslope fails or is unavailable, the approach reverts to a non-precision approach system. If the localizer fails, the procedure is not authorized. If the OM (or at least one of its substitutes) is not available, then the procedure is not authorized.

14.1.2.2. Transition to the ILS Localizer Course. This is performed by using either radar vectors or a published approach procedure.

14.1.2.2.1. Tune. ***Tune the ILS as soon as practicable during the transition and monitor the identifier during the entire approach.***

14.1.2.2.2. Front Course. Set the published localizer front course in the course selector window prior to attempting localizer interception.

NOTE: If using a flight director system or flight management system, the switches should be positioned in accordance with instructions in the aircraft flight manual for intercept and final approach modes of operation. Normally, manual selection of the final approach mode would be delayed until the aircraft heading is within 15 ° of the localizer course and the CDI is within one dot of center.

14.1.2.2.3. Orientation. Use any available navigation facility (for example, TACAN) to aid in remaining position oriented in relation to the localizer course and glide slope intercept point. (The glide slope has a usable range of 10 miles.)

14.1.2.3. Accomplish the Approach.

14.1.2.3.1. Intercepting the Localizer. Once the localizer course is intercepted, reduce heading corrections as the aircraft continues inbound. Heading changes made in increments of 5° or less will usually result in more precise course control.

14.1.2.3.2. Descent. When on the localizer course, maintain glide slope intercept altitude (published or assigned) until intercepting the glide slope. Published glide slope intercept altitudes may be minimum, maximum, mandatory, or recommended altitudes and are identified by a lightning bolt (↯). When the glide slope intercept altitude is a recommended altitude, you must only comply with other IAP altitudes (FAF altitude for example) until established on the glide slope. When on glideslope, crosscheck the aircraft altitude with the published "Glideslope Altitude at Outer Marker/FAF" to ensure you are established on the correct glideslope. ***Do not descend below a descent restrictive altitude (minimum or mandatory) if the CDI indicates full scale deflection***. On approaches where the "Glideslope Altitude at outer Marker/FAF" is not published, you should use all means available to ensure you are on the proper glideslope and a normal descent rate is established (ref. Para 14.2.4.6.).

14.1.2.3.3. Glide Slope Indicator. Prepare to intercept the glide slope as the glide slope indicator (GSI) moves downward from its upper limits. Determine the approximate rate of descent to maintain the glide slope. The vertical velocity required to maintain this angle of descent will be dependent upon the aircraft groundspeed and the ILS glide slope angle. Slightly before the GSI reaches the center position, coordinate pitch and power control adjustments to establish the desired rate of descent.

14.1.2.3.3.1. Pitch Adjustments. Pitch adjustments made in increments of 2° or less will usually result in more precise glidepath control. As the approach progresses, smaller pitch and bank corrections are required for a given CDI/GSI deviation.

14.1.2.3.3.2. Over Controlling. During the latter part of the approach, pitch changes of 1° and heading corrections of 5° or less will prevent over controlling.

14.1.2.3.4. Steering Commands. If using pitch and bank steering commands supplied by a flight director system or FMS, monitor flight path and aircraft performance instruments to ensure the desired flight path is being flown and aircraft performance is within acceptable limits. A common and dangerous error when flying an ILS on the flight director is to concentrate on the steering bars and ignore flight path and aircraft performance instruments. Failure of the flight director computer (steering bars) may NOT always be accompanied by the appearance of warning flags. Steering commands must be correlated with flight path (CDI and GSI) and aircraft performance instruments.

14.1.2.3.5. Crosscheck. Maintain a complete instrument crosscheck throughout the approach, with increased emphasis on the altimeter during the latter part (DH is determined by the barometric altimeter). Establish a systematic scan for the runway environment prior to reaching DH

14.1.2.3.6. Decision Height. Decision Height (DH) is the height at which a decision must be made during a precision approach to either continue the approach or to execute a missed approach. ***Descent below DH is not authorized until sufficient visual reference with the runway environment has been established.*** Definition of runway environment is found in para 14.1.1.2.6.

CAUTION: ***The ILS/LOC approach must be discontinued if the localizer course becomes unreliable, or any time full scale deflection of the CDI occurs on final approach. Do not descend below localizer minimums if the aircraft is more than one dot (half scale) below or two dots (full scale) above the glide slope***. If the glide slope is recaptured to within the above tolerance, descent may be continued to DH.

NOTE: If making an autopilot coupled approach or landing, use the aircraft flight manual procedures for the category of ILS approach being conducted. ***When autopilot coupled operations are to be conducted, advise the ATC approach controller as soon as practical if the weather is less than circling minimums, but not later than the FAF***. This will allow time for the appropriate ILS critical area to be cleared or an advisory issued. The advisory used by controllers will be: "Localizer/glide slope signal not protected." In this case be alert for unstable or fluctuating ILS indications that may prevent an autopilot coupled approach. When aircraft equipment and crew qualification permit, the localizer and glide slope may be used for autopilot operations to the points specified in FLIP for each category of ILS approach, unless a restriction is published on the approach procedure.

14.2. Radar.

14.2.1. Precision and Surveillance Approaches. There are two basic types of approaches: the precision approach and the surveillance approach. The precision approach provides the pilot with precise course, glide slope, and range information; the surveillance approach provides course and range information and is classified as a nonprecision approach. Upon request, the controller will provide recommended altitudes on final to the last whole mile that is at or above the published MDA. Recommended altitudes are computed from the start descent point to the runway threshold. (At the MAP, the straight-in surveillance system approach error may be as much as 500 feet from the runway edges.)

14.2.2. Lost Communications.

14.2.2.1. Backup. In preparation for the radar approach, select a backup approach that is compatible with the existing weather and your aircraft. Be prepared to fly this approach in the event of radar failure or lost communications. If you experience lost communications, you are automatically cleared to fly any published approach unless the controller previously issued a specific lost communications approach.

14.2.2.2. Contact. Attempt contact with the controlling agency if no transmissions are received for approximately:

–One minute while being vectored to final,

–Fifteen seconds while on final for an ASR approach, or

–Five seconds while on final for a PAR approach.

14.2.2.3. Backup Approach. If unable to reestablish communications and unable to maintain VFR, transition to your backup approach. Intercept the approach at the nearest point that will allow a normal rate of descent and not compromise safety. ***Maintain the last assigned altitude or the minimum safe/sector altitude (emergency safe altitude if more than 25 NM from the facility), whichever is higher, until established on a segment of the published approach.***

14.2.2.4. No Backup Approach. If there are no backup approaches compatible with the weather or with your aircraft, advise the controller upon initial contact of your intentions in the event of lost communications. If local conditions dictate, the controller may specify the approach to fly if you experience lost communications. It is the pilot's responsibility to determine the adequacy of any issued lost communications instructions.

14.2.3. Voice Procedures. The radar approach is predicated entirely upon voice instructions from the approach control or radar controller. ***Repeat all headings, altitudes (departing and assigned), and altimeter settings until the final controller advises "do not acknowledge further transmissions."*** During high density radar operations, a limiting factor is the communication time available. Keep transmissions brief and specific, commensurate with safety of flight. Never sacrifice aircraft control to acknowledge receipt of instructions.

14.2.4. Transitioning to Final.

14.2.4.1. Dogleg. The transition to final segment of the approach includes all maneuvering up to a point where the aircraft is inbound and approximately 8 nautical miles from touchdown. A dogleg to final is considered to be part of the "transition to final" segment.

14.2.4.2. Complying with ATC. During the transition to final, the radar controller directs heading and altitude changes as required to position the aircraft on final approach. Turns and descents should be initiated immediately after instructed. Perform turns by establishing an angle of bank, on the attitude indicator, which will approximate a standard rate turn for the TAS flown but not to exceed 30° of bank. When the aircraft or mission characteristics dictate very low turn rates, it is advisable to inform the controller. The controller uses this information to assist in determining lead points for turns or corrections.

14.2.4.3. Weather. Weather information issued by the radar controller will include altimeter setting, ceiling, and visibility. The controller is required to issue ceiling and visibility only when the ceiling is below 1,500 feet (1,000 feet at civil airports) or below the highest circling minimum, whichever is greater, or if the visibility is less than 3 miles.

14.2.4.4. Field Conditions. The controller will furnish pertinent information on known field conditions which the controller considers necessary to the safe operation of the aircraft concerned. You should request additional information, as necessary, to make a safe approach.

14.2.4.5. Orientation. Use available navigation aids to remain position-oriented in relation to the landing runway and the glide slope intercept point. The controller will advise you of the aircraft position at least once before starting final approach.

14.2.4.6. Planning. Start the before landing checklist (landing check), review approach minimums, and tune navigation equipment to comply with lost communication instructions when practical. Determine the approximate initial descent rate required on final approach by referring to the VVI chart in the IAP books or by using one of the formulas for two of the most common glide slopes:

$$3° \text{ glideslope VVI} = \frac{\text{Groundspeed x } 10}{2}$$

$$2½° \text{ glideslope VVI} = \frac{\text{Groundspeed x } 10 - 100}{2}$$

Example: For a final approach groundspeed of 180 knots and a 3° glide slope,

$$\text{VVI} = \frac{180 \text{ x } 10}{2} = 900 \text{ fpm}$$

14.2.4.7. Establish Configuration. Establish the aircraft configuration and airspeed in accordance with the aircraft flight manual. If final approach configuration is established prior to turning onto final, avoid using excessive bank angles that could make precise aircraft control difficult.

14.2.5. Accomplishing the Approach.

14.2.5.1. Nonprecision -- Airport Surveillance Radar (ASR).

14.2.5.1.1. Controller. The controller will inform the pilot of the runway to which the approach will be made, the straight-in MDA (if a straight-in approach is being made), and the MAP location, and will issue advance notice of where the descent to MDA will begin. When the approach will terminate in a circling approach, furnish the controller with your aircraft category. The controller will then issue the circling MDA. Circling MDA for ASR approaches are found in the FLIP Terminal Book (the circling MDA found on the individual IAP refers only to non-radar approaches).

14.2.5.1.2. Descent. When the aircraft reaches the descent point, the controller will advise you to descend to MDA. If a descent restriction exists, the controller will specify the prescribed restriction altitude. When the aircraft is past the altitude limiting point, the controller will advise you to continue descent to MDA. The descent rate should be sufficient to allow the aircraft to arrive at the MDA in time to see the runway environment and make a normal descent to landing.

14.2.5.1.3. Runway Environment. Arrive at the MDA with enough time and distance remaining to identify the runway environment and descend from MDA to touchdown at a rate normally used for a visual approach in your aircraft.

NOTE: Upon request, the controller will provide recommended altitudes on final to the last whole mile that is at or above the published MDA. Due to the possible different locations of the MAP, recommended altitudes may position you at MDA at or slightly prior to the MAP. Consider this in relation to the normal visual descent point (VDP) required for your aircraft.

14.2.5.1.4. Course Guidance. The controller will issue course guidance when required and will give range information each mile while on final approach. You may be instructed to report the runway in sight. Approach guidance will be provided until aircraft is over the MAP unless you request discontinuation of guidance. The controller will inform you when you are at the MAP.

14.2.5.1.5. MDA. ***Fly the aircraft at or above MDA until arrival at the MAP or until establishing visual contact with the runway environment.*** If you do not report the runway environment in sight, missed approach instructions will be given.

CAUTION: Depending upon the location of the MAP, the descent from the MDA (once the runway environment is in sight) often will have to be initiated prior to reaching the MAP to execute a normal (approximately 3°) descent to landing.

14.2.5.2. Precision Approach Radar (PAR).

14.2.5.2.1. Starts. The precision final approach starts when the aircraft is within range of the precision radar and contact is established with the final controller. Normally this occurs at approximately 8 miles from touchdown.

14.2.5.2.2. Final Descent. Approximately 10 to 30 seconds before final descent, the controller will advise that the aircraft is approaching the glide path. When the aircraft reaches the point where final descent is to start, the controller will state "begin descent." At that point, establish the predetermined rate of descent. Adjust power or use drag devices as required to maintain desired airspeed or angle of attack. When the airspeed or angle of attack and glide path are stabilized note the power, attitude, and vertical velocity. Use these values as guides during the remainder of the approach.

14.2.5.2.3. Controller Guidance. The controller issues course and glide path guidance, and frequently informs you of any deviation from course or glide path. The controller's terminology will be: on course, on glide path; slightly/well above/below glide path; or slightly/well left/right of course. Controllers may also issue trend information to assist you in conducting a PAR approach. Examples of trend information phraseologies that may be used are: going above/below glide path, holding above/below glide path, holding left/right or course, etc. Trend information may be modified by the use of the terms rapidly or slowly as appropriate. The terms "slightly" or "well" are used in conjunction with the trend information.

14.2.5.2.4. Corrections. Corrections should be made immediately after instructions are given or when deviation from established attitude or desired performance is noted. Avoid excessive throttle, pitch, or bank changes. Normally pitch changes of one degree will be sufficient to correct back to glide path.

14.2.5.2.5. Heading Control. Accurate heading control is important for runway alignment during the final approach phase. When instructed to make heading changes, make them immediately. Heading instructions are preceded by the phrase "turn right" or "turn left." To prevent overshooting, the angle of bank should approximate the number of degrees to be turned, not to exceed a one-half standard rate turn. At high final approach speeds, a large angle of bank may be required to prevent a prolonged correction. In any case, do not exceed the one-half standard rate turn. After a new heading is directed, the controller assumes it is being maintained. Additional heading corrections will be based on the last assigned heading.

14.2.5.2.6. Decision Height. Decision Height (DH) is the height at which a decision must be made during a precision approach to either continue the approach or to execute a missed approach. ***Descent below DH is not authorized until sufficient visual reference with the runway environment has been established.*** Definition of runway environment is found in para 14.1.1.2.6. The controller will advise the pilot when the aircraft reaches the published DH. DH is determined in the cockpit either as read on the altimeter or when advised by the controller, whichever occurs first. The controller will continue to provide advisory course and glide path information until the aircraft passes over the landing threshold at which time the controller will advise "over landing threshold." To provide a smooth transition from instrument to visual conditions, a systematic scan for runway environment should be integrated into the crosscheck prior to reaching DH.

14.2.5.3. No-Gyro Approach (Heading Indicator Inoperative).

14.2.5.3.1. Advise controller. If the heading indicator should fail during flight, advise the radar controller and request a no-gyro approach. The final approach may be either precision or surveillance.

14.2.5.3.2. Turns. Perform turns during the transition to final by establishing an angle of bank on the attitude indicator that will approximate a standard rate turn, not to exceed 30° of bank. Perform turns on final by establishing an angle of bank on the attitude indicator that will approximate a half-standard rate turn. If unable to comply with these turn rates, advise the controller so that the controller may determine lead points for turn and heading corrections. Initiate turns immediately upon hearing the words "turn right" or "turn left." Stop the turn on receipt of the words "stop turn." ***Acknowledge the controller's commands to start and stop turns until advised not to acknowledge further transmissions.***

NOTE: Do not begin using half-standard rate turns on final until the controller tells you. The controller may want standard rate turns even on final if abnormal conditions exist (i.e., strong crosswinds, turbulence, etc.).

14.3. Visual Approach. Visual approaches reduce pilot/controller work load and expedite traffic by shortening flight paths to the airport. A visual approach is conducted on an IFR flight plan and authorizes the pilot to proceed visually and clear of clouds to the airport. ***The pilot must have either the airport or the preceding identified aircraft in sight, and the approach must be authorized and controlled by the appropriate ATC facility.***

14.3.1. Conditions Required to Conduct Visual Approaches. Before a visual approach can be authorized, several conditions must be met:

14.3.1.1. 1,000 and 3 at the Airport. The reported weather at the airport must have a ceiling at or above 1,000 feet and visibility 3 miles or greater.

14.3.1.2. Operational Benefit. ATC will authorize visual approaches when it will be operationally beneficial.

14.3.1.3. Cloud Clearance Requirements. Visual approaches are IFR procedures conducted under IFR in visual meteorological conditions (VMC) with one exception -- cloud clearance requirements described in AFI 11-202, Vol 3, para 7.3, are not applicable. Pilots must be able to proceed visually while remaining clear of clouds.

14.3.1.4. Airport or Preceding Aircraft in Sight. ATC will not issue clearance for a visual approach until the pilot has the airport or the preceding aircraft in sight. If the pilot has the airport in sight but cannot see the preceding aircraft, ATC may still clear the aircraft for a visual approach; however, ATC retains both aircraft separation and wake separation responsibility. When visually following a preceding aircraft, acceptance of the visual approach clearance constitutes acceptance of pilot responsibility for maintaining a safe approach interval and adequate wake turbulence separation.

14.3.2. A Visual Approach is an IFR Approach. Although you are cleared for a “visual” approach, you are still operating under IFR. ***Do not cancel your IFR clearance when cleared for a visual approach.*** Be aware that radar service is automatically terminated (without advising the pilot) when the pilot is instructed to change to advisory frequency.

14.3.3. What ATC Expects You to Do When Cleared for a Visual Approach. After being cleared for a visual approach, ATC expects you to proceed visually and clear of clouds to the airport in the most direct and safe manner to establish the aircraft on a normal straight-in final approach. Clearance for a visual approach does not authorize you to do an overhead/VFR traffic pattern.

14.3.4. Visual Approaches Have No Missed Approach Segment. A visual approach is not an instrument approach procedure and therefore does not have a missed approach segment. If a go-around is necessary for any reason, aircraft operating at controlled airports will be issued an appropriate advisory, clearance, or instruction by the tower. At uncontrolled airports, aircraft are expected to remain clear of clouds and complete a landing as soon as possible. If a landing cannot be accomplished, the aircraft is expected to remain clear of clouds and contact ATC as soon as possible for further clearance (separation from other IFR aircraft will be maintained under these circumstances).

14.3.5. Pilot Responsibilities During Visual Approaches. When cleared for a visual approach, the pilot has the following responsibilities:

14.3.5.1. ***Advise ATC as soon as possible if a visual approach is not desired.***

14.3.5.2. ***Comply with controller’s instructions for vectors toward the airport of intended landing or to a visual position behind a preceding aircraft.***

14.3.5.3. ***After being cleared for a visual approach, proceed visually and clear of clouds to the airport in the most direct and safe manner to establish the aircraft on a normal final approach. You must have the airport or the preceding aircraft in sight.***

14.3.5.4. ***If instructed by ATC to follow another aircraft, notify the controller if you do not see it, are unable to maintain visual contact with it, or for any other reason you cannot accept the responsibility for visual separation under these conditions.***

14.4. Contact Approach. An approach where an aircraft on an IFR fight plan, operating clear of clouds with at least 1 mile flight visibility and having an ATC authorization, may deviate from the instrument approach procedure and proceed to the airport of destination by visual reference to the ground. This approach will only be authorized when requested by the pilot and the reported ground visibility at the destination is at least 1 statute mile.

NOTE: Being cleared for a visual or contact approach does not authorize the pilot to fly a 360° overhead traffic pattern. An aircraft conducting an overhead maneuver is VFR and the instrument flight rules (IFR) flight plan is canceled when the aircraft reaches the "initial point." ***Aircraft operating at an airport without a functioning control tower must initiate cancellation of the IFR flight plan prior to executing the overhead maneuver or after landing***.

14.5. IAP with Visual Segment.

14.5.1. Published Visual Segment. In isolated cases, due to procedure design peculiarities, an IAP procedure may contain a published visual segment (**Figure 14.1**). The words "fly visual to airport" will appear in the profile view of the IAP. The depicted ground track associated with the visual segment should be flown as "DR" course. ***When executing the visual segment, remain clear of clouds and proceed to the airport maintaining visual contact with the ground.***

14.5.2. MAP. Since missed approach obstacle clearance is assured only if the missed approach is commenced at the published MAP or above the MDA, the pilot should have preplanned climbout options based on aircraft performance and terrain features.

CAUTION: Be aware that obstacle clearance becomes the sole responsibility of the aircrew when the approach is continued beyond the MAP.

14.6. Charted Visual Flight Procedures (CVFPs). A published visual approach where an aircraft on an IFR flight plan, operating in VMC when authorized by air traffic control, may proceed to the destination airport under VFR via the route depicted on the CVFP (**Figure 14.2**). ***When informed CVFPs are in use, the pilot must advise the arrival controller on initial contact if unable to accept the CVFP.***

14.6.1. Characteristics. CVFPs are established for noise abatement purposes to a specific runway equipped with a visual or electronic vertical guidance system. These procedures are used only in a radar environment at airports with an operating control tower. The CVFPs depict prominent landmarks, courses, and altitudes, and most depict some NAVAID information for supplemental navigational guidance only.

14.6.2. Altitudes. Unless indicating a Class B airspace floor, all depicted altitudes are for noise abatement purposes and are recommended only. Pilots are not prohibited from flying other than recommended altitudes if operational requirements dictate. Weather minimums for CVFPs provide VFR cloud clearance at minimum vectoring altitudes. Therefore, clearance for a CVFP is possible at MVA, which may be below the depicted altitudes.

14.6.3. Clearance. CVFPs usually begin within 20 miles from the airport. When landmarks used for navigation are not visible at night, the approach will be annotated "PROCEDURE NOT AUTHORIZED AT NIGHT." ATC will clear aircraft for a CVFP after the pilot reports sighting a charted landmark or a preceding aircraft. If instructed to follow a preceding aircraft, pilots are responsible for maintaining a safe approach interval and wake turbulence separation. ***Pilots should advise ATC if at any point they are unable to continue an approach or lose sight of a preceding aircraft.***

14.6.4. Climb-outs. CVFPs are not instrument approaches and do not have missed approach segments. Missed approaches are handled as a go-around (IAW FLIP, GP). The pilot should have preplanned climb-out options based on aircraft performance and terrain features. (See paragraphs 14.3 and 14.5 for additional visual approach guidance.)

Figure 14.1. IAP with Visual Segment (para 14.5.1).

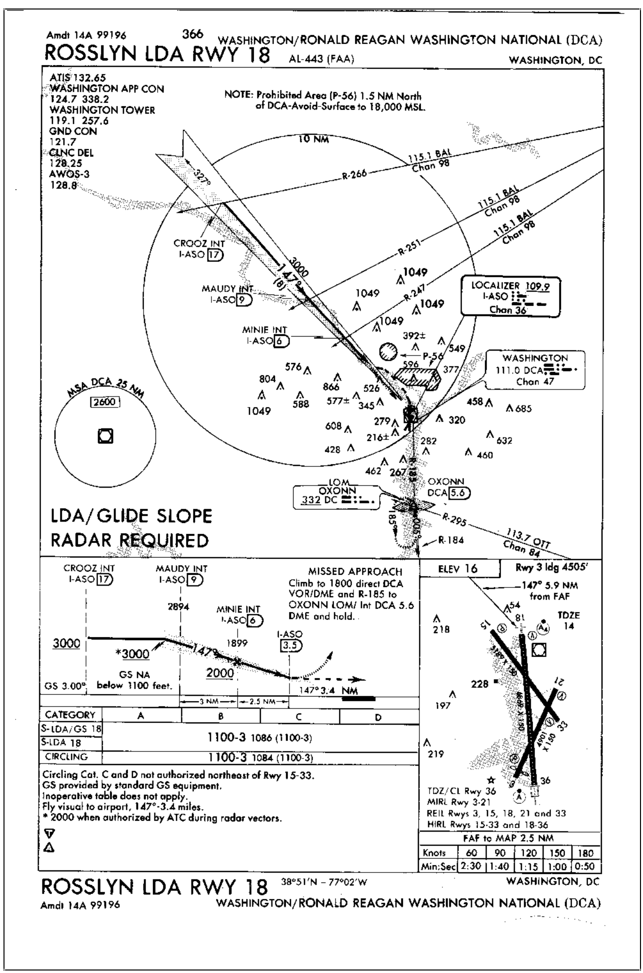
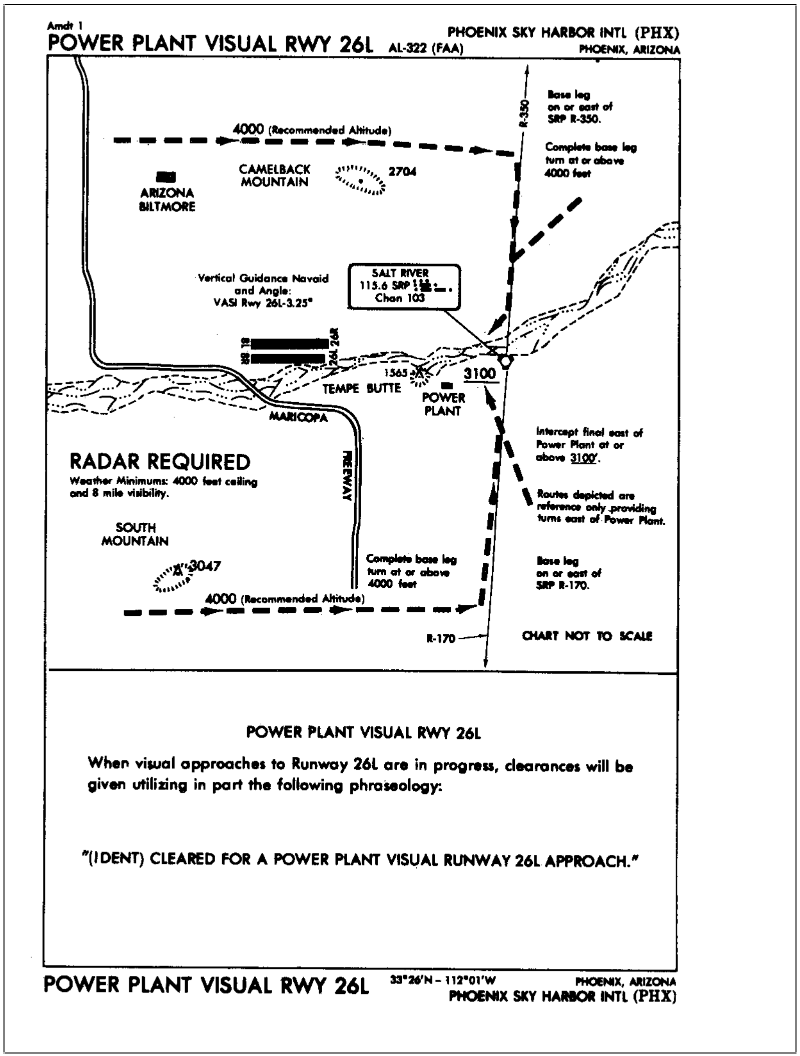


Figure 14.2. Charted Visual Flight Procedure (CVFP, para 14.6).



14.7. Converging Approaches (Figure 14.3). Converging approaches provide procedures for conducting simultaneous precision instrument approaches (normally ILS) to converging runways. Converging runways are defined as runways having a 15° to 100° angle between them. In simpler terms, if the runways are pointed at each other (extended centerlines intersect) they are converging runways and procedures must be established to de-conflict possible simultaneous missed approaches.

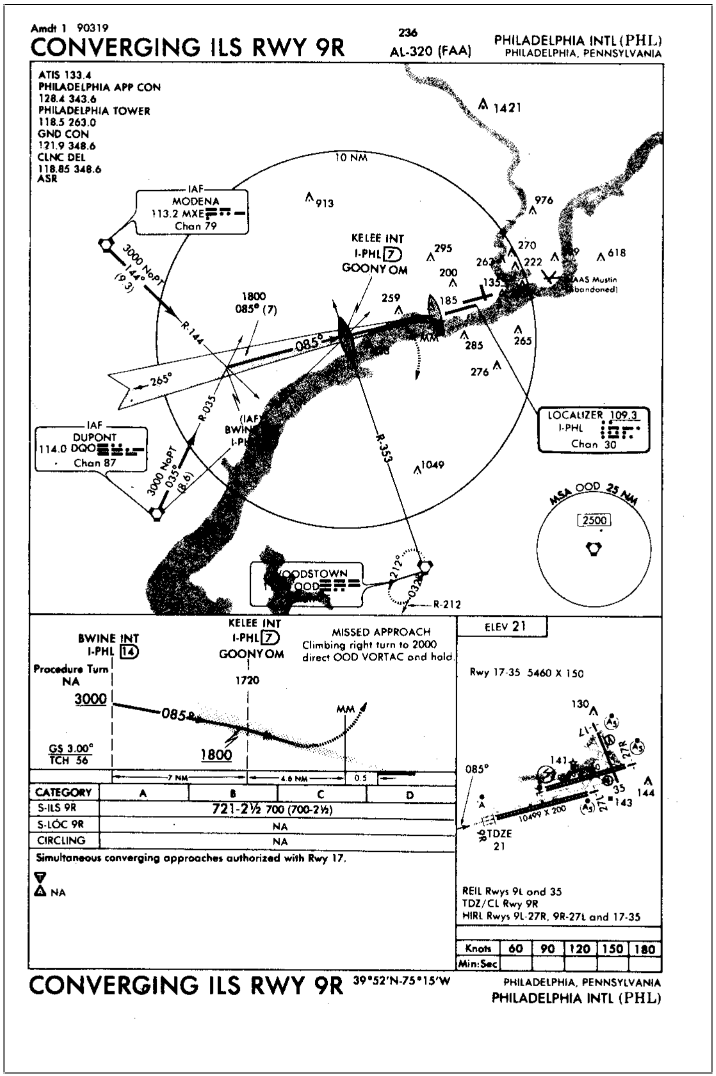
14.7.1. Procedures. Converging approaches are implemented when the volume and complexity of aircraft operations require the use of simultaneous converging instrument approaches. These approaches are specifically designed to ensure traffic deconfliction during all phases of the arrival procedure. Converging approaches are labeled as "converging" and ATC clearance must specify this type of approach. Theoretically no operational hardships on users and control facilities will result from these operations.

14.7.2. Differences. There are two subtle differences found in converging approaches that a pilot must be aware of. The missed approach departure instruction printed on the approach is the procedure the controller expects to be flown during a missed approach and it will not normally be modified. Although missed approach departure instructions for regular approaches are based primarily on obstacle clearance, converging approaches also include the deconfliction of aircraft on the other converging approach's missed approach. This is often done by moving the MAPs of each converging approach further out from the runway and turning the aircraft away from each other.

14.7.3. Missed Approach. ***Beginning the missed approach departure instruction no later than the published missed approach point is mandatory.*** If a pilot delays beginning the missed approach, clearance from an aircraft on the other converging approach may decrease such as to cause a traffic conflict. For this reason, anytime a pilot continues flight beyond the MAP the pilot must be highly confident of completing the landing since traffic deconfliction can not be assured for missed approaches initiated beyond the MAP.

14.7.4. Decision Height. Since converging approaches must provide precision approach guidance (normally ILS) the only way to adjust the missed approach point is to increase the decision height. Therefore, normally the primary difference between the converging approach and the regular approach to the same runway will be the approach minimums and the missed approach departure instruction. This increase in approach minimums will also result in an increase in the weather minimums required for the approach.

Figure 14.3. Converging ILS Approach (para 14.7).



Chapter 15

LANDING FROM INSTRUMENT APPROACHES

15.1. Planning the Approach and Landing.

15.1.1. Begin Before Flight. A successful approach and landing in marginal weather conditions requires considerable planning, which should begin before the flight. Checking the forecast weather, winds, NOTAMs, and runway conditions at your destination and alternate will normally help you determine the runway and type of approach that is likely to be used. A study of the instrument approach procedure for the destination airport will show the approach as well as the runway layout, obstructions, type of lighting installed, and minimum data.

15.1.2. Mental Picture. When planning, try to form a mental picture of the airfield layout as well as the location of prominent landmarks. Be familiar with the types of lighting installed on the landing runway. This means knowing more than just the type of lighting system installed. A picture of what the lighting system looks like should be firmly implanted in your mind. When viewing only a part of the lighting system, you should be able to determine aircraft position relative to the runway. Note the distance to the airfield from available NAVAIDs in the immediate area. There is no substitute for proper and thorough planning as this will help prepare you for the transition from instrument to visual conditions.

15.2. Transitioning From Instrument to Visual Flight Conditions. The transition from instrument to visual flight conditions varies with each approach. Pilots seldom experience a distinct transition from instrument to visual conditions during an approach in obscured weather. Obscured conditions present you with a number of problems not encountered during an approach that is either hooded or has a cloud base ceiling. At the point where the hood is pulled or the aircraft breaks out below the ceiling, the visual cues used to control the aircraft are usually clear and distinct, and there is instantaneous recognition of the position of the aircraft in relation to the runway. With obscured ceilings or partially obscured conditions, the reverse is usually true; visual cues are indistinct and easily lost, and it is difficult to discern aircraft position laterally and vertically in relation to the runway. Consider every factor that might have a bearing on the final stages of an approach and landing. The visibility, type of weather, expected visual cues, and even crew procedures and coordination are some of the tangibles requiring careful consideration. Preparation and understanding are the keys that will make the transition smooth and precise. Only through a thorough understanding of the weather environment and how it affects the availability and use of visual cues will you be prepared to transition safely and routinely. The following information deals with some of the conditions you may encounter during this phase of flight.

15.2.1. Straight-In. When flying a straight-in approach in VMC, the pilot has almost unlimited peripheral visual cues available for depth perception, vertical positioning, and motion sensing. Even so, varying length and width of unfamiliar runways can lead to erroneous perception of aircraft height above the runway surface. A relatively wide runway may give the illusion that the aircraft is below a normal glide path; conversely, a relatively narrow runway may give the illusion of being high. With an awareness of these illusions under unlimited visibility conditions, it becomes easy to appreciate a pilot's problems in a landing situation in which the approach lights and runway lights are the only visual cues available.

15.2.2. No vertical Guidance. Instrument approach lights do not provide adequate vertical guidance to the pilot during low visibility instrument approaches. In poor visibility, especially when the runway surface is not visible, or in good visibility at night, there simply are not enough visual cues available to adequately determine vertical position or vertical motion. Studies have shown that the sudden appearance of runway lights when the aircraft is at or near minimums in conditions of limited visibility often gives the pilot the illusion of being high. They have also shown that when the approach lights become visible, pilots tend to abandon the established glide path, ignore their flight instruments and instead rely on the poor visual cues. Another similar situation occurs when a pilot flies into ground fog from above. If the pilot initially sees the runway or approach lights, these cues will tend to disappear as the pilot enters the fog bank. The loss of these visual cues will often induce the illusion or sensation of climbing. These situations of erroneous visual cues convincing the pilot that the aircraft is above normal glide path generally result in a pushover reaction, an increase in the rate of descent, and a short or hard landing.

15.2.3. Descent Rate. Since approach lights are usually sighted close to the ground in limited visibility, an increase in the rate of descent during the final approach when the aircraft is very close to the ground may create a situation in which sufficient lift cannot be generated to break the rate of descent when the pilot realizes he or she will land short.

15.2.4. Crosscheck. A recommended method to ensure against a dangerously high rate of descent and a short or hard landing is to maintain continuous crosscheck of the GSI or flight director and pay continuous attention to PAR controller instructions as well as VVI and ADI indications. The pilot should establish predetermined limitations on maximum rates of descent for the aircraft that he or she will accept when landing out of a low visibility approach. Exceeding these limits during the transition to landing should result in a go-around and missed approach in the interest of aircraft and aircrew safety. Knowing that visual cues can be extremely erroneous, the pilot must continue to crosscheck instruments and listen to the PAR controller's advisories even after runway and/or approach lights have come into view. Most pilots find it extremely difficult to continue to crosscheck their flight instruments once the transition to the visual segment has been made, as their natural tendency is to believe the accuracy of what they are seeing, or they continue to look outside in an effort to gain more visual cues. To successfully continue reference to VVI and/or GSI when approach lights come into view, a scan for outside references should be incorporated into the crosscheck at an early stage of the approach, even though restrictions to visibility may preclude the pilot from seeing any visual cues. If such a scan is developed into the crosscheck, it will facilitate the recheck of flight instruments for reassurances of glide path orientation once visual cues come into view and the visual transition is begun. The following information deals with some of the conditions you may encounter during this phase of flight.

15.2.4.1. Restrictions to Visibility. There are many phenomena, such as rain, smoke, snow, and haze, which may restrict visibility. When surface visibility restrictions do exist and the sky or clouds are totally hidden from the observer, the sky is considered totally obscured and the ceiling is the vertical visibility from the ground. If you are executing an approach in an obscured condition, you will not normally see the approach lights or runway condition as you pass the level of the obscured ceiling. You should be able to see the ground directly below; however, the transition from instrument to visual flight will occur at an altitude considerably lower than the reported vertical visibility. In partially obscured conditions, vertical visibility is not reported since the ground observer can see the sky through the obscuration. When clouds are visible with a partial obscuration, their heights and amounts are reported. The amounts (in 10ths) of the sky or clouds obscured by a partial obscuration is included in the remarks section of weather reports. Although this may help clarify the reported conditions in many cases, it still does not provide an idea of the height at which visual cues will be sighted or the slant range visibility. In some cases the partial obscuration can be associated with shallow patchy fog so you can expect to lose visual references once the fog condition is entered. Also of concern is the visual range at which you will be able to discern visual cues for runway alignment and flare. Be aware that the runway visibility or runway visual range (RVR) may not be representative of the range at which you will sight the runway. In fact, slant range visibility may be considerably less than the reported RVR. Knowledge of these various factors will aid you in making a safe, smooth transition from instrument to visual flight.

15.2.4.1.1. Shallow Fog. Fog that extends no more than 200 feet in height is considered shallow fog and is normally reported as a partial obscuration. Since the fog may be patchy, it is possible that the visual segment may vary considerably during the approach and rollout. RVR may not be representative of actual conditions in this situation if measured by transmissometer located in an area of good visibility. One of the most serious problems with this type of fog stems from the abundance of cues available at the start of the approach. You may see the approach lighting system and possibly even some of the runway during the early stages of the approach. However, as the fog level is entered, most or all the cues become confused and disoriented. In these conditions, you should not rely entirely on visual cues for guidance. They can be brought into the crosscheck to confirm position, but instrument flight must be maintained until visual cues can be kept in view and the runway environment can provide sufficient references for alignment and flare.

15.2.4.1.2. Deep Fog. Fog that extends to a height of several hundred feet usually forms a total obscuration. You will not normally see cues during the early portion of an approach. Most likely, you will pick up cues from only the last 1,000 feet of the approach lighting system. From a US standard approach lighting system, in rapid succession you will probably see cues from the 1,000-foot bar, the last 1,000 feet of the centerline approach lights, red terminating bar, red wing lights, green threshold lights, and the high intensity runway edge lights. If operating at night and the strobe lights are on, these may produce a blinding effect. Care should be taken with the use of landing lights as they also may cause a blinding effect at night. The transition from an approach in a total obscuration involves the integration of visual cues within the crosscheck during the latter portion of the approach. Again, be thoroughly familiar with the approach lighting system to develop the proper perspective between these cues and the runway environment.

15.2.4.1.3. Fog Below Clouds. This fog is usually reported as a partial obscuration below a cloud ceiling. After penetrating through a ceiling, visibility usually increases when you descend below the cloud ceiling. Therefore, the transition from instrument to visual flight is sharper, with more pronounced use of visual cues after passing the ceiling. However, with fog below clouds all of the problems mentioned above with shallow fog and deep fog may be found. Night approaches may produce the sensation that the aircraft is high once the cloud base is passed. You should continue on instruments, cross-checking visual cues to confirm runway alignment. During the flare you may experience a sensation of descending below the surface of the runway. This will be especially pronounced at facilities with 300-foot wide runways. In either case, avoid abrupt or large attitude changes.

15.2.4.1.4. Advection Fog. Advection fog can present wind and turbulence problems not normally associated with other types of fog. Advection fog may possess characteristics similar to shallow, deep, or cloud base fog. It may be more difficult to maintain precise instrument flight because of turbulence. The characteristics of advection fog will be related to the wind speed increases. Wind greater than 15 knots usually lifts the fog and it forms a cloud base. The best procedure is to be aware of the conditions that might be encountered and to integrate visual cues within the crosscheck during the later portion of the approach. Also closely monitor airspeed because of the effects of turbulence and crosswinds.

15.2.4.1.5. Ice Fog. This type of fog is most common to the Arctic region; however, it can occur in other areas if the air temperature is below approximately 0° C (32° F). It consists of a suspension of ice crystals in the air and is more common around airports and cities. Condensation nuclei caused by human activity often cause the fog to form. When there is little or no wind, it is possible for an aircraft to generate enough fog during landing or takeoff to cover the runway and a portion of the field. Depending on the atmospheric conditions, ice fogs may last for several minutes or days. The piloting hazards and procedures are basically the same as with other fogs.

15.2.4.1.6. Rain. Approaches and the ensuing transition to visual flight can be very hazardous since moderate to heavy rain conditions can seriously affect the use of visual cues. Night approaches in these conditions can be even more critical as you may be distracted by flashing strobes or runway end identifier lights. Transition to visual flight can be severely hampered by the inability to adequately maintain aircraft control and interpret the instruments as a result of gusty or turbulent conditions. The moderate or heavy rain conditions can also render the rain removal equipment ineffective, causing obscuration of visual cues at a critical time during the transition. In these conditions, be prepared for an alternate course of action and act without hesitation to prevent the development of an unsafe situation.

15.2.4.1.7. Snow. Blowing snow is accompanied by many of the same hazards as rain, such as turbulence, difficulties in reading the flight instruments, obscured visual cues, and aircraft control problems. Of special interest will be a lack of visual cues for runway identification for the visual portion of the approach. The approach and runway lights will provide some identification; however, runway markings and the contrast with relation to its surroundings may be lost in the whiteness. Therefore, depth perception may be difficult, requiring more emphasis on instruments for attitude control. It is extremely important to avoid large attitude changes during approaches in snow.

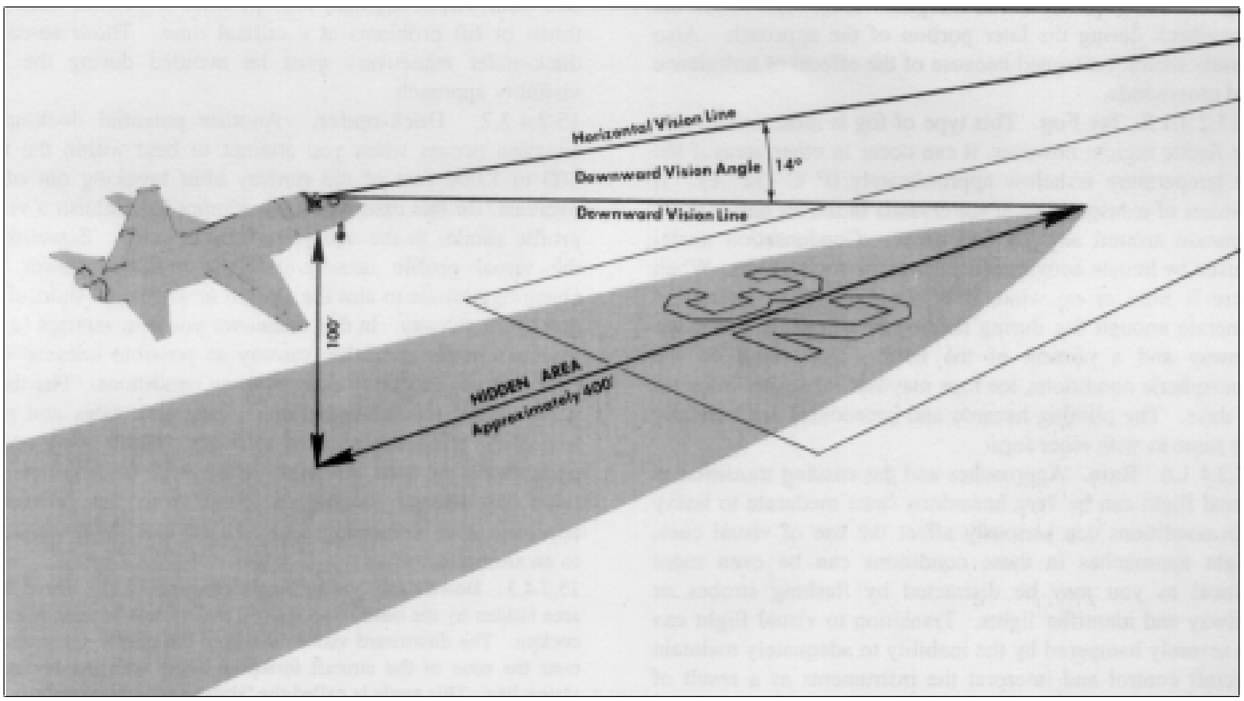
15.2.4.2. Visual Cues.

15.2.4.2.1. Runway Contact Point. Approach lights, runway markings, lights, and contrasts are the primary sources of visual cues. At some facilities, touchdown zone and centerline lights may also be available. Become familiar with the lighting and marking patterns at your destination and correlate them with the weather so you will be prepared to transition to visual flight. In minimum visibility conditions, the visual cues and references for flare and runway alignment are extremely limited compared to the normal references used during a visual approach. Therefore, the aircraft's projected runway contact point may not be within your visual segment until considerably below published minimums.

WARNING: Any abrupt attitude changes to attempt to bring the projected touchdown point into your visual segment may produce high sink rates and thrust or lift problems at a critical time. Those so-called duck-under maneuvers must be avoided during the low visibility approach.

15.2.4.2.2. Duck-under. Another potential duck-under situation occurs when you attempt to land within the first 500 to 1,000 feet of the runway after breaking out of an overcast. In this case, you may attempt to establish a visual profile similar to the one you use most often. Establishing the visual profile usually involves reducing power and changing attitude to aim the aircraft at some spot short of the end of the runway. In this maneuver you may attempt to use as much of the available runway as possible because of a short runway or due to poor braking conditions. The duck-under is not recommended since high sink rates and poor thrust/lift relationships can develop which may cause undershoots or hard landings. Base your landing decision upon the normal touchdown point from the instrument approach, and if stopping distances are insufficient, proceed to an alternate.

Figure 15.1. Downward Vision Angle (para 15.2.4.3).



15.2.4.3. Downward Vision Angle (Figure 15.1). There is an area hidden by the nose of an aircraft that cannot be seen from the cockpit. The downward vision line from the pilot's eye projected over the nose of the aircraft forms an angle with the horizontal vision line. This angle is called the "downward vision angle." The area hidden from the pilot's view can then be determined from a trigonometric relationship based on aircraft elevation and downward vision angle. An aircraft with a 14° downward vision angle 100 feet above the surface will conceal about 400 feet beneath its nose. Consider an approach in 1,600-foot visibility. This means your visual segment at 100-foot elevation with a 14° downward vision will be reduced to about 1,200 feet. Other factors, such as a nose-high pitch attitude and a slant range visibility less than the RVR, can further reduce your visual segment.

15.2.4.4. Pilot Reaction Time. At 100-foot elevation and a 3° glide slope, an aircraft is approximately 1,900 feet from the runway point of intercept (RPI). If your aircraft's final approach speed is 130 knots (215 feet per second), you have about 9 seconds to bring visual cues into the crosscheck, ascertain lateral and vertical position, determine a visual flight path, and establish appropriate corrections. More than likely, 3 to 4 seconds will be spent integrating visual cues before making a necessary control input. By this time, the aircraft will be 600 to 800 feet closer to the RPI, 40 to 60 feet lower, and possibly well into the flare. Therefore, it is absolutely essential to be prepared to use visual cues properly and with discretion during the final stages of a low visibility approach. Prior to total reliance on visual information, confirm that the instrument indications support the visual perspective.

15.2.4.5. Crew Procedures.

15.2.4.5.1. Copilot. A copilot can assist the pilot in a number of ways. The copilot can fly the approach, control airspeed, be responsible for communications, direct the checklist, perform the missed approach, establish aircraft configurations, or perform any other duties assigned by the pilot. However, the copilot must understand exactly what those duties and responsibilities are before the approach.

15.2.4.5.2. Technique One. One technique that has proven quite successful has been to allow highly qualified copilots to fly the approach, while the pilot makes the decision to continue or go-around at decision height (DH). The pilot assumes control if a landing is to be made; if not, the copilot executes the go-around. This procedure puts fewer burdens on the pilot, allowing more time to obtain information from the visual cues for landing. If the approach is unsatisfactory or insufficient visual references are available to continue the approach at DH, the copilot, since the aircraft is on instruments, is prepared to execute a missed approach on command. If the pilot executes the approach, the copilot may be allowed to control power or airspeed until DH where the pilot assumes control for the landing or missed approach.

15.2.4.5.3. Technique Two. Another technique is to have the pilot not flying the approach continue to monitor flight instruments from DH or minimum descent altitude to touchdown and notify the pilot flying the approach of excessive deviations in rates of descent, glide slope, course, or airspeed. This technique will help detect duck-under maneuvers and will prevent both pilots from being deceived by a visual illusion that may be present.

15.2.4.5.4. Technique Three. A final technique is to have the autopilot fly the approach to the DH or MDA and then have the pilot assume control to either land or execute the go-around as required. This technique can be quite helpful especially after a long duty day and/or with instrument conditions.

15.3. Approach Lighting Systems.

15.3.1. Types of Approach Lighting Systems.

15.3.1.1. Visual Aids. Approach lighting systems are visual aids used during instrument conditions to supplement the guidance information of electronic aids such as VOR, TACAN, PAR, and ILS. The approach lights are designated high intensity (the basic type of installation) and medium intensity, according to candle power output.

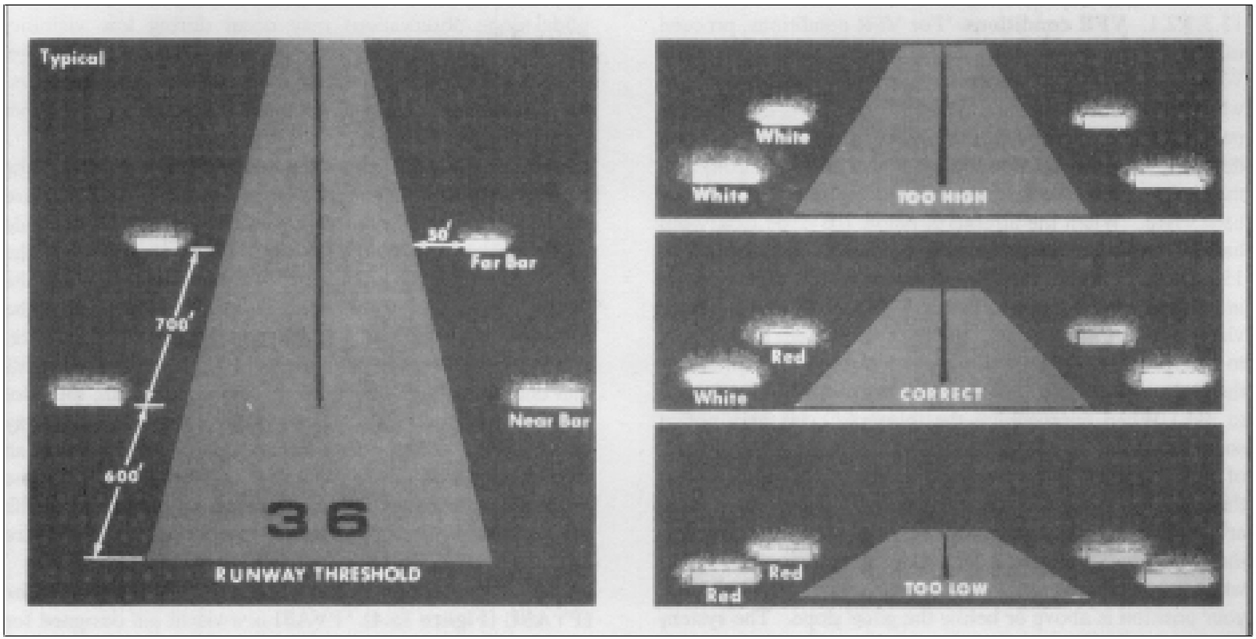
15.3.1.2. Adjustment. Most runway and approach light systems allow the tower controller to adjust the lamp brightness for different visibility conditions, or at a pilot's request. The extreme brilliance of high intensity lights penetrate fog, smoke, precipitation, etc., but may cause excessive glare under some conditions.

15.3.1.3. Depiction. The approach lighting systems now in use, along with their standard lengths, appear in the Flight Information Handbook. Each IAP chart indicates the type of approach lighting system by a circled letter on the airport sketch. Actual length is shown on the airport diagram for any system, or portion thereof, that is not of standard length. The IFR Supplement indicates availability of airfield, runway, approach, sequenced flashing, runway end identification lights, runway centerline lights, and visual approach slope indicator (VASI).

15.3.1.4. Pilot Activation. Some airports are installing airport lighting systems that can be activated by the pilot "keying the microphone" on selected frequencies. Information concerning these systems can be found in the Flight Information Handbook and Terminal FLIP.

15.3.2. Runway End Identifier Lights (REIL). Runway end identifier lights are installed at many airfields to help identify the approach end of the runway. The system consists of two synchronized flashing lights, one of which is located laterally on each side of the runway threshold facing the approach area. They are effective for identifying a runway that lacks contrast with the surrounding terrain or which is surrounded by other lighting, and for approaches during reduced visibility.

Figure 15.2. Visual Approach Slope Indicator (VASI) (para 15.3.3).



15.3.3. Visual Approach Slope Indicator (VASI) (Figure 15.2).

15.3.3.1. Description and Functions.

15.3.3.1.1. Visual Glide Path. The VASI provides a color-coded visual glide path using a system of lights positioned along the runway, near the touchdown point. The system is for final approach only.

15.3.3.1.2. VASI Angles. VASI glide slope angles are normally adjusted to coincide with ILS and (or) PAR glide slopes servicing the same runway. If the glide slope angles differ, such deviations should be noted in the IFR Supplement.

NOTE: There are also nonstandard VASI installations that will take the aircraft to some point other than the normal ILS/ PAR glide path intercept point (usually short of the runway). Nonstandard VASIs will be depicted on the IAP.

15.3.3.1.3. Obstruction Clearance. The VASI functions equally well during day or night conditions for all types of aircraft. No special airborne equipment is necessary. The VASI ensures safety by providing a visual glide path that clears all obstructions in the VASI final approach area.

15.3.3.1.4. Descent Guidance. The VASI is especially effective during approaches over water or featureless terrain where other sources of visual reference are lacking or misleading. It provides optimum descent guidance for landing to a selected touchdown point.

15.3.3.1.5. Transition. During an instrument approach, the VASI can assist in the transition from instrument conditions to visual flight. Maintaining a descent on the VASI will bring the aircraft safely to a point from which a normal landing can be made within the first portion of a runway.

15.3.3.1.6. Operations. United States Air Force and Navy VASI facilities operate continuously on the active runway unless noted otherwise in the IFR or VFR Supplement. The intensity of VASI at civil facilities can be adjusted by the tower controller at the pilot's request. Air Force and Navy installations are automatically adjusted by a photoelectric cell.

NOTE: The VASI provides obstruction clearance in the VASI final approach area only; therefore, use of the system is limited to glide slope information during the final approach phase of flight. Since the VASI provides only glide slope information, other facilities must be used to align the aircraft with the runway.

15.3.3.1.7. Runway diagram. To determine if the base of intended landing is equipped with VASI, consult the runway diagram in the lower right corner of the Terminal FLIP approach chart. The VASI is portrayed by the symbol (V) at the approach end of the landing runway.

NOTE: Three-bar VASI systems are being installed at some airfields to accommodate jumbo aircraft; for example, C-5s and Boeing 747s. Pilots of these aircraft will use the two far bars in the same manner as pilots fly the standard two bar system. Pilots of other aircraft should ignore the additional bar and fly the first two (nearest) bars just like a standard VASI.

15.3.3.2. Flight Procedures.

15.3.3.2.1. VFR Conditions. For VFR conditions, proceed inbound maintaining the normal traffic pattern altitude. When the near bars transition from red through pink to white, commence descent. When the aircraft is on the glide path, you are, in effect, overshooting the bars near the threshold and undershooting the bars farther from the threshold. Thus, the far bars will indicate red and the near bars white. When the aircraft is below the glide path, both bars are red; when above the glide path, both are white.

15.3.3.2.2. Guidance. Departure from the glide path is indicated by color changes from red through pink to white or vice versa. (A movement to the high side causes the far bars to change from red through pink to white. A descent below the glide path changes the near bars from white through pink to red.) When approaching the threshold, you may notice some deterioration of system guidance because of the spread of light sources. However, the VASI will bring the pilot through a "window" at a threshold where you may accomplish a normal flare and landing.

NOTE: Although the VASI will indicate a deviation from the glide slope, white-over-white or red-over-red indications show only that your position is above or below the glide slope. The system has no capability to indicate how far the aircraft is above or below the glide slope. Pilots must, therefore, employ other available references to ensure a positive position.

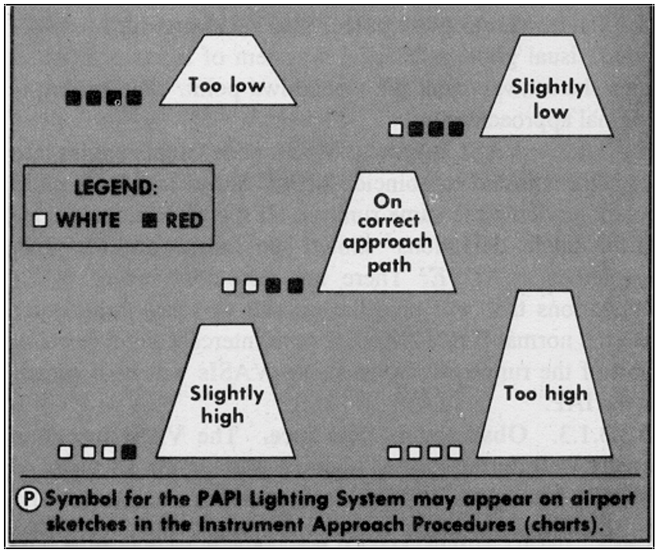
15.3.3.2.3. Blends with IMC. Although the VASI is basically for VFR only, it blends well with instrument approaches. For example, when on a precision glide slope it permits a smooth transition from instrument to visual flight. Since the VASI and precision glide slopes are normally aligned with each other, the transition from one glide slope reference to another can be made without aircraft power or pitch changes; merely continue with the same attitude and power to the runway threshold. During a nonprecision approach, after having descended out of the instrument conditions, follow the same glide slope interception as previously described for VFR conditions.

15.3.3.2.4. Variables. Many variables will affect the decision to initiate a missed approach while using VASI. Some of the variables to be considered are: terrain, obstacles, weather, distance from the runway, runway lighting, approach lighting, aircraft or pilot capabilities, and the runway glide path intercept point. Other available references may include ILS glide slope, PAR glide slope, altimeter, vertical velocity indicator, and DME. Since each approach may provide any or all of these factors, consider the individual situation and make your decisions based upon all of the available information. However, once transition has been made to the VASI for a visual approach to landing, you must confirm your exact position above or below the glide slope by reference to the runway environment.

15.3.3.2.5. Erroneous Indications. Some caution should be exercised when using VASI facilities that are associated with runway threshold bar lights. Further, some erroneous glide slope observations may occur during low visibility periods from reflection of the light beams. Therefore, remember that VASI is an approach aid and should be used in conjunction with, and cross-checked against, all other available aids.

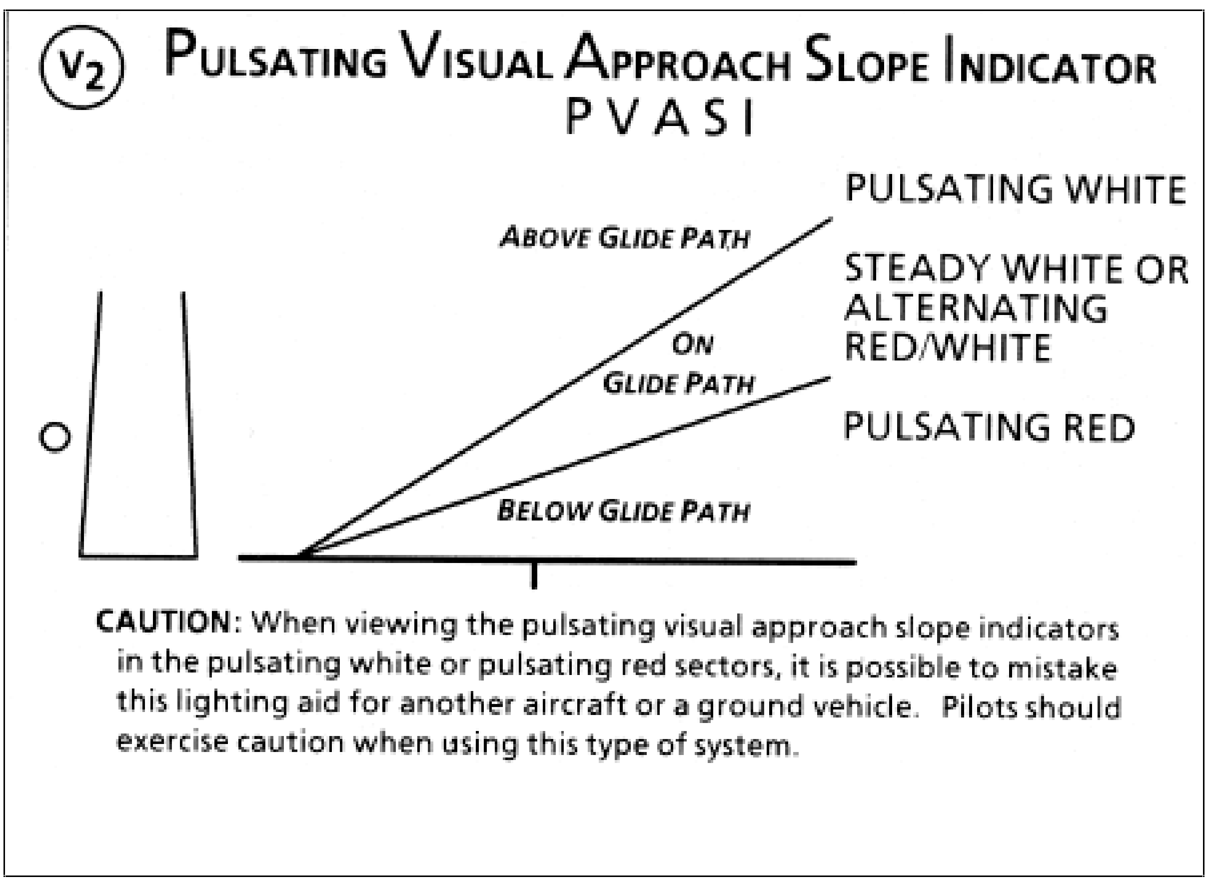
15.3.4. Precision Approach Path Indicator (PAPI). The PAPI consists of four light boxes, similar to the standard VASI light boxes, installed in a horizontal row on one side of the runway, usually the left side. When on glide path, the pilot will see two red lights and two white lights. When the aircraft deviates from the nominal glide path, the combination of red and white lights changes. For instance, when 0.2° below glide path, the pilot will see three red lights and one white light, and for 0.4° below glide path, the pilot will see four red lights. The system works the same way when going above the nominal glide path except an increasing number of white lights will be seen. At some locations, light boxes may be installed on both sides of the runway. This does not affect the system operation (**Figure 15.3**).

Figure 15.3. Visual Signals Produced by PAPI (para 15.3.4).



15.3.5. Pulsating Visual Approach Slope Indicator (PVASI) (Figure 15.4). PVASI is a visual aid designed for use in VMC. The system normally consists of a single light unit projecting a two-color visual approach path into the final approach area of the runway upon which the indicator is installed.

Figure 15.4. Pulsating Visual Approach Slope Indicator (PVASI) (para 15.3.5).



15.3.5.1. On glide path. The on glide path indication is either a steady white light or an alternating red and white light depending upon the system installed.

15.3.5.2. Above glide path. If the aircraft is above the glide path, the pilot will see a pulsing white light. The further the aircraft deviates from the glide path, the faster the pulses appear to the pilot. As the pilot corrects the approach and nears the glide path, the pulse of the white light appears to become slower until the pilot intercepts the glide path and sees one continuous white light.

15.3.5.3. Below glide path. If slightly below glide path, the pilot will see a "steady" red light.

15.3.5.4. Well below glide-path. If the aircraft goes further below the glide path, the pilot will see a pulsing red light. The further the aircraft deviates from the glide path, the faster the pulses appear to the pilot. As the pilot corrects the approach and nears the glide path, the pulse of the red light appears to become slower until the pilot intercepts the glide path.

15.3.5.5. Angular wedge. The on-glide path light is an angular wedge of one-third of a degree. This translates to approximately 1/2 dot above or below the glide path on an ILS glide slope indicator.

15.3.5.6. Hazards associated with PVASI.

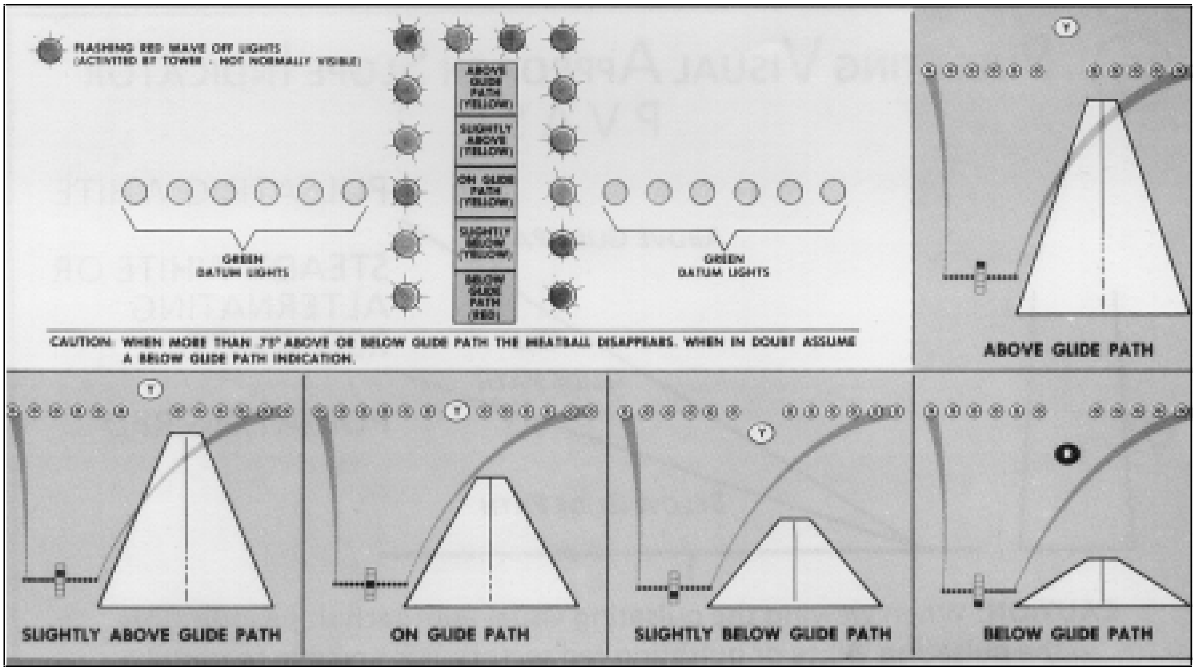
15.3.5.6.1. First look reliability. On the basis of the specific installation, PVASI can be confused with other lights in the vicinity of the runway (i.e., runway lights, aircraft landing/taxi lights, anti-collision beacons, emergency vehicle lights, RSU lights, barrier system lights, REILs, etc.). During low visibility/low ceiling conditions, the ability to pick out the PVASI, especially with runway lights at a higher intensity, can be difficult with a solid white PVASI (on glide path) indication. When breaking out of the weather, the first look reliability of the system may not be present.

15.3.5.6.2. Dual Installations. Some fields may have a dual PVASI installation. The system was not designed for a dual installation. The left and right side units are independent systems. The pulsing of the left and right side lights cannot be synchronized. Often there are differences in signals between the left and right side (one side solid, the other pulsing). This causes a dilemma for the pilot as to which side to believe.

CAUTION: When viewing the pulsating visual approach slope indicators in the pulsating white or pulsating red sectors, it is possible to mistake this lighting aid for another aircraft or ground vehicle. Pilots should exercise caution when using this system.

15.3.6. Fresnel Lens Optical Landing System (FLOLS). This system is an electro-optical pilot landing aid. It was designed primarily for use by Navy aboard ship. However, most Naval Air Stations also have the FLOLS installed (**Figure 15.5**).

Figure 15.5. Fresnel Lens Optical Landing System (FLOLS) (para 15.3.6).



15.3.6.1. Purpose. The purpose of the system is to provide a visual indication of relative position with respect to a prescribed glide slope. This glide slope is normally coincident with the precision approach glide slope and designed to touch the aircraft down at a suitable distance prior to the arresting gear.

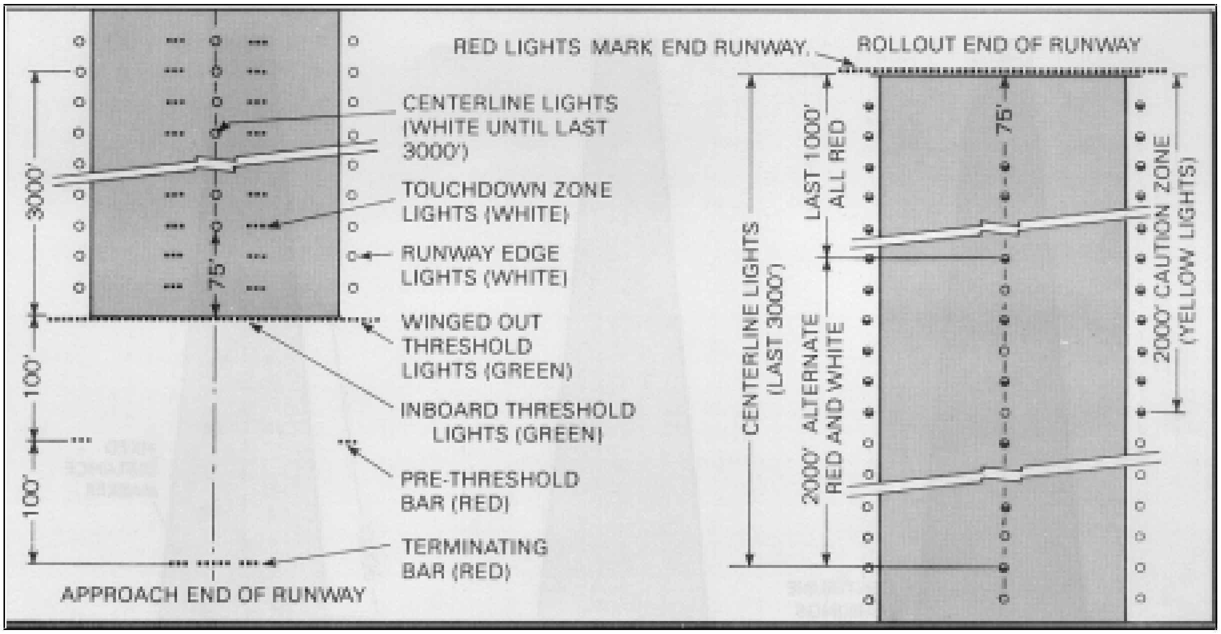
15.3.6.2. Basics. Basically, the FLOLS appears as two sets of green (datum) lights arranged horizontally on either side of a large yellow light (the meatball). When above the glide slope, the meatball will appear to be above the green line formed by the datum lights. When below glide slope, the meatball will appear below the datum lights. At the lowest limit of the FLOLS glide slope envelope, the meatball turns red. The object is to line up the meatball with the datum lights. The five meatball lights are framed by red wave off lights. These will not normally be visible, but when activated by tower, they will flash red and command a go-around.

WARNING: When more than 0.75 (¾) degrees above or below the glide slope, the meatball will disappear. When in doubt, assume you are below the glide slope.

15.4. Runway Lighting Systems. Two basic runway lighting systems are used to aid the pilot in defining the usable landing area of the runway. These systems are Runway Edge Lights and Runway Centerline and Touchdown Zone Lights.

15.4.1. Runway Edge Lighting. The runway edge lighting system is a configuration of lights that defines the limits of the usable landing area. The lateral limits are defined by a row of white lights on either side of the runway. The longitudinal limits are defined at each end by the threshold lighting configuration. This configuration includes threshold lights, a pre-threshold light bar, and a terminating bar. The threshold lights emit green light toward the approach end of the runway and red light toward the rollout end of the runway. The pre-threshold wing light bars and the terminating light bar emit red light toward the approach area (**Figure 15.6**).

Figure 15.6. Runway Lighting Systems (para 15.4.1).



15.4.1.1. HIRL. The High Intensity Runway Lighting (HIRL) system is the basic type of installation used by the Air Force. These elevated bi-directional lights, which extend the length of the runway, emit a white light the entire length of the runway at some military fields. Most military and all civil field HIRLs also emit a white light except in the caution zone, which is the last 2,000 feet (610m) of an instrument runway or one-half the runway length, whichever is less. The lights in the caution zone emit a yellow light in the direction of the approach end and white light in the opposite direction. The yellow lights are intended for rollout information after landing and are sometimes used in place of runway remaining markers.

15.4.1.2. MIRL. The Medium Intensity Runway Lighting (MIRL) system, which consists of elevated, omnidirectional lights, may be installed on runways that are not to be used under IMC due to impaired clearance, short length, or other factors.

15.4.2. Runway Centerline and Touchdown Zone Lighting. The runway centerline and touchdown zone lighting systems are designed to facilitate landings, rollouts, and takeoffs under adverse day and night low visibility conditions. The touchdown zone lights, which define the touchdown area, are primarily a landing aid while the centerline lights are most effective for rollout and takeoff (**Figure 15.6**).

15.4.2.1. Touchdown Zone Lighting. The touchdown zone lighting system consists of two rows of high intensity light bars arranged on either side of the runway centerline. Each bar consists of three unidirectional white lights toward the approach area. The two rows of light bars are 3,000 feet long and extend from the threshold of the runway toward the rollout end of the runway.

15.4.2.2. Runway Centerline Lighting. The runway centerline lighting system is a straight line of lights located along the runway centerline. The system starts 75 feet (23m) from the threshold and extends down the runway to within 75 feet of the rollout end of the runway. The last 3,000 feet are color coded for landing rollout information. The last 3,000-foot to 1,000-foot section displays alternate red and white lights, while the last 1,000-foot section displays all red lights.

15.5. Runway Markings. Runway markings are designed to make the landing area more conspicuous and to add a third dimension for night and low visibility operations (**Figure 15.7**). When visual contact has been established, runway markings aid the pilot in aligning the aircraft with the runway and determining if a safe landing is possible. Serviceable runways are marked and classified according to the instrument approach facilities serving them. The classifications are precision instrument runways that are served by precision approach facilities, nonprecision instrument runways to which a straight-in nonprecision approach has been approved, and basic runways that are used for visual flight operations and circling nonprecision approaches. Standard runway markings in most cases are in reflective white, while markings of non-traffic areas, such as blast pads and overruns, are in reflective yellow.

15.5.1. Basic Runways. Basic runway markings consist of a runway direction number and centerline marking. In addition, any of the elements of the nonprecision and precision instrument runway markings may be used.

15.5.2. Nonprecision Instrument Runways. The markings used on nonprecision instrument runways are the runway direction number, centerline, and threshold markings. Additional elements of the precision instrument runway markings may be added.

15.5.3. Precision Instrument Runways. The precision instrument runway markings consist of a runway direction number, centerline, threshold, touchdown zone, and side stripe markings.

15.5.4. Runway Touchdown Zone Marking. The runway touchdown zone marking pattern consists of groups of rectangular markings to outline the touchdown zone and to provide distance coded information by means of the "3-3-2-2-1-1" marking pattern. Groups of rectangular markings begin 500 feet from the threshold and are spaced at 500-foot intervals up to 3,000 feet from the threshold. Fixed distance markings begin 1,000 feet from the threshold and provide an aiming point for touchdown.

15.5.5. Runway Direction Numbers. All runways are marked with a runway direction number. This number is the number nearest the 10° increment of the magnetic azimuth of the centerline of the runway. Single numbers are not preceded by a zero. To differentiate between two parallel runways, the runway direction number has a letter "L" or "R" following it. With three parallel runways, the center runway has the letter "C" added to the runway direction number.

15.5.6. Associated Runway Area Markings.

15.5.6.1. Overruns. Overruns (called stopways at civil airfields) are areas beyond the takeoff runway designated by the airport authorities for use in decelerating an airplane during an aborted takeoff. Air Force overruns are marked by a series of equally spaced yellow chevrons. The apex of the chevrons is on the centerline extension of the runway and points to and terminates at the threshold of the usable runway. A pilot should not taxi on an overrun or stopway except in an emergency or an aborted takeoff, unless it is designated for taxiing and takeoff. (See 15.5.6.2 below.)

15.5.6.2. Displaced threshold. Where it has been necessary to position the landing threshold up the runway from the end of the paving, it is known as a displaced threshold. Two methods of marking this area are used (**Figure 15.8**). When the paved area on the approach side of the displaced threshold can be used for taxiing and takeoff, it will be marked with a series of large white arrows. The arrows are placed along the centerline on the approach side of the displaced threshold and point to the landing area. Where the paved area on the approach side of the displaced threshold is not to be used for taxiing or takeoff, the area is marked in the same manner as the overrun or blast pad areas previously discussed. In all cases, a white stripe across the width of the full strength runway precedes the threshold markings.

Figure 15.7. Runway Markings (para 15.5).

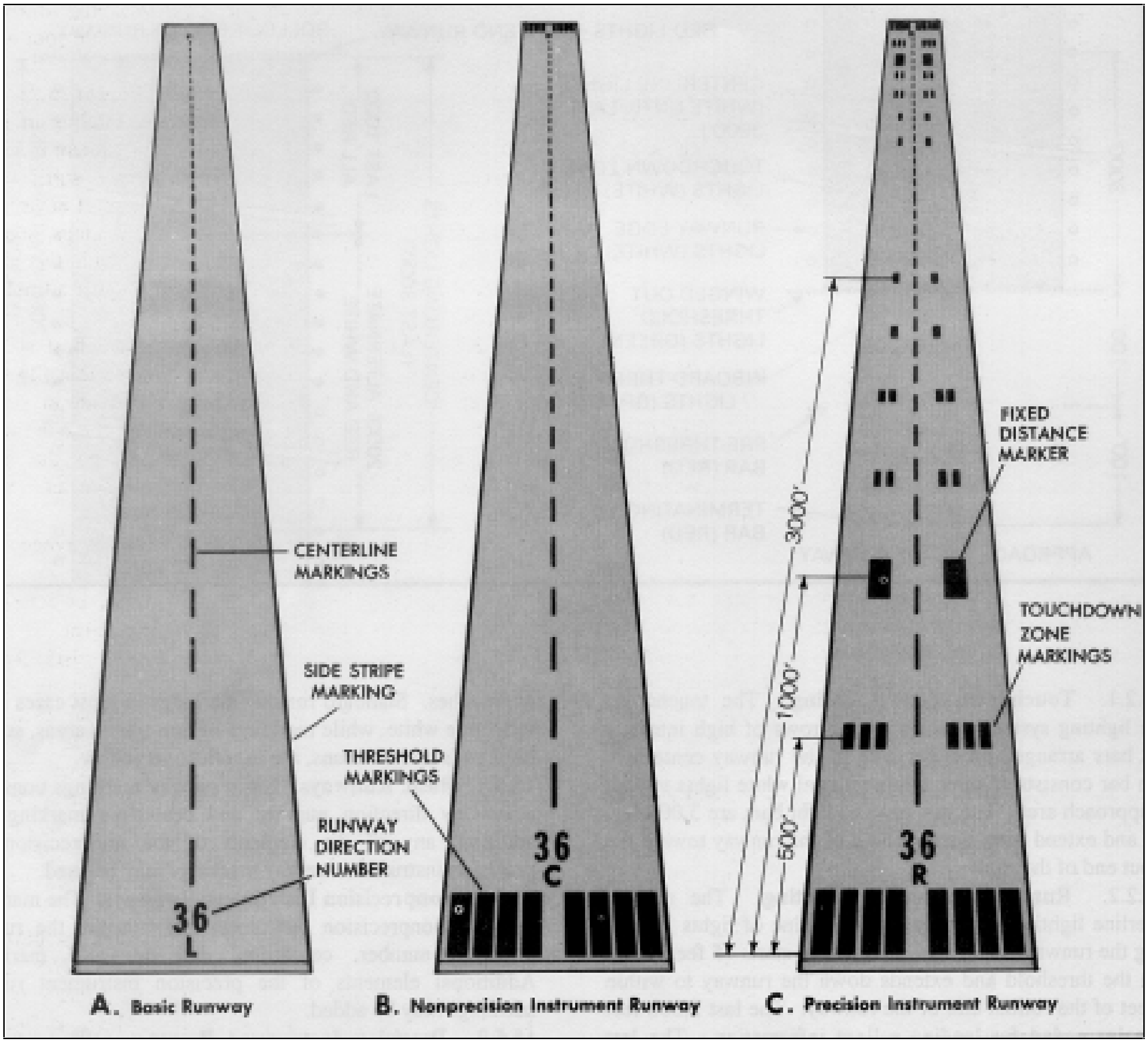
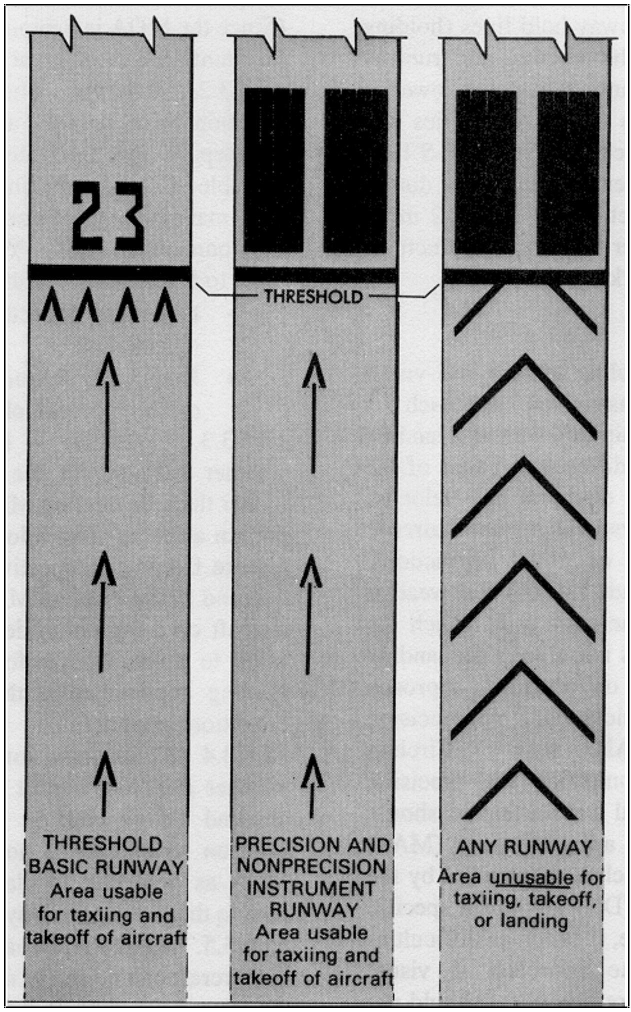


Figure 15.8. Displaced Threshold Markings (para 15.5.6.2).



15.5.6.3. Side Stripe Markings. Side stripe markings are required on precision approach runways that are 150 feet or wider and on all runways where there is a lack of contrast between runway edges and shoulders or surrounding terrain. The distance between the inner edges of the stripes is 140 feet for runways 150 feet or wider. This distance will be less for runways less than 150 feet wide. Runway shoulders that have been stabilized with materials that give the appearance of paving but are not intended for use by aircraft are marked with a series of partial yellow chevrons. When a center section of a runway has been strengthened, the unstrengthened sections on either side are marked in the same manner as stabilized runway shoulders.

15.5.6.4. Runway Hold Lines. Runway hold lines (holding position markers) indicate where the taxiway and runway intersect. Do not cross without clearance from the tower to proceed onto the runway. Airfields with ILS facilities will have instrument hold lines (Air Force) or CAT II ILS hold lines. These markings ensure proper ILS operation during weather conditions less than 800 feet ceiling and/or 2 miles visibility. The airport control tower will issue instructions for aircraft to hold short of these markings.

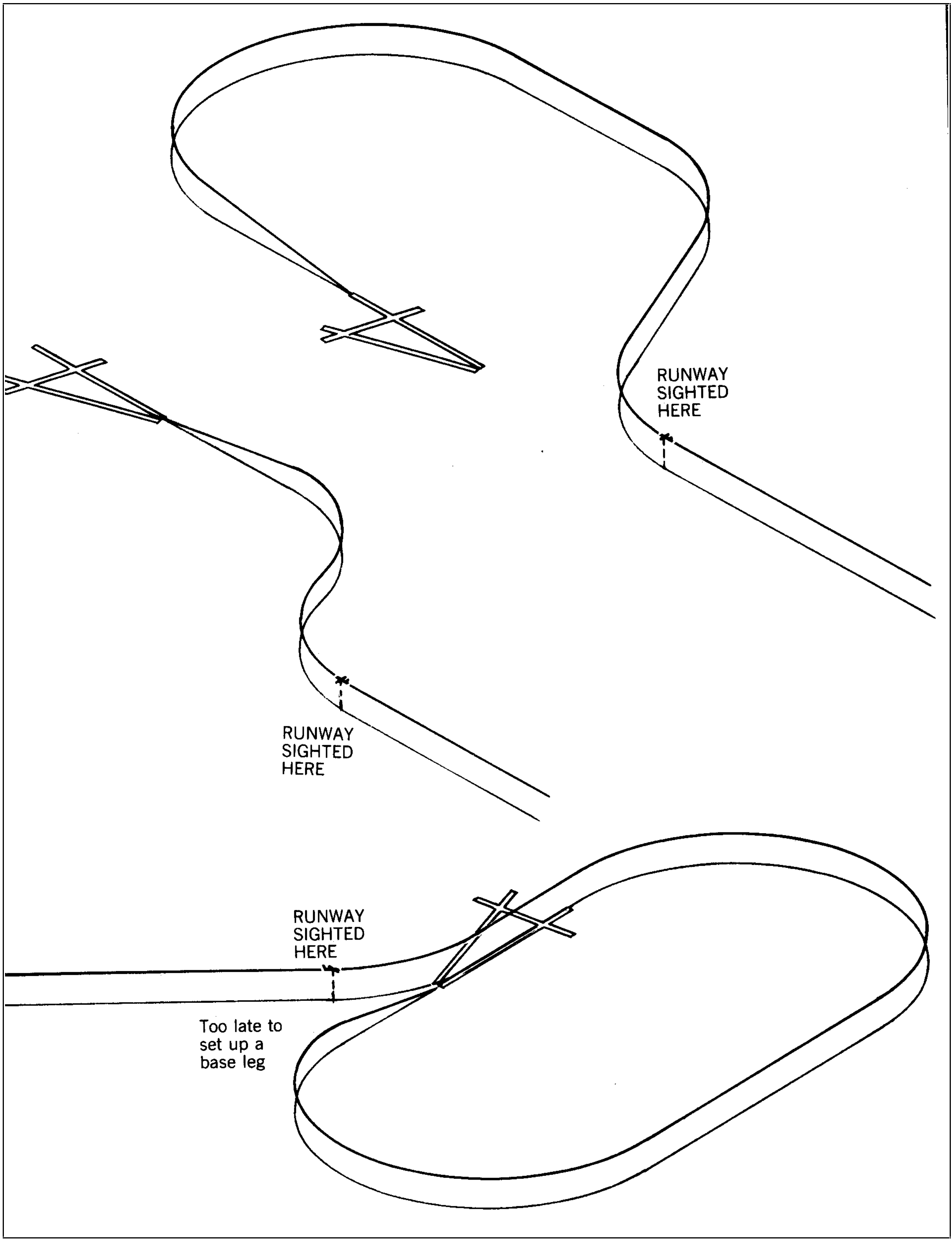
15.6. Circling Approaches.

15.6.1. General Procedures. Circling to land is a visual flight maneuver. When the instrument approach is completed, it is used to align the aircraft with the landing runway. Each landing situation is different because of the variables of ceiling visibility, wind direction and velocity, obstructions, final approach course alignment, aircraft performance, cockpit visibility, and controller instructions. The circling minimum descent altitude (MDA) and weather minima to be used are those for the runway to which the instrument approach is flown (this is not always the landing runway). The circling minima listed on instrument approach procedures (IAPs) apply to nonradar nonprecision approaches (LOC, VOR, TACAN, etc.). Circling procedures and techniques are not compatible with precision approach criteria, and under normal circumstances, should not be attempted. Since the missed approach point (MAP) associated with the precision approach is determined by the pilot in terms of a decision height (DH) and not a specific point along the final approach course, it becomes difficult to ascertain when to discontinue the approach if visual conditions are not encountered. Therefore, pilots should not plan to circle from a precision approach.

15.6.2. Instructions. If the controller has a requirement to specify the direction of the circling maneuver in relation to the airport or runway, the controller will issue instructions in the following manner: "Circle (direction given as one of eight cardinal compass points) of the airport/runway for a right/left base/downwind to runway (number)." For example, "Circle west of the airport for a right base to runway one eight."

NOTE: Obstruction clearance areas are determined by aircraft category. Maneuver the aircraft to remain within the circling area for your aircraft category (see **Figure 20.5** for radii of circling approaches). If it is necessary to maneuver at speeds in excess of the upper limit of the speed range authorized for your aircraft's category, use the landing minima for the category appropriate to the maneuvering speed. When you request circling MDA from the controller for a circling ASR approach, state your aircraft category.

Figure 15.9. The Circling Approach (para 15.6.3).



15.6.3. Accomplishing the Approach (Figure 15.9).

15.6.3.1. Descent. After descending to circling minimum descent altitude and when the airport environment is in sight, determine if the ceiling and visibility are sufficient for performing the circling maneuver. The airport environment is considered the runways, its lights and markings, taxiways, hangars, and other buildings associated with the airport. (Since the MDA is a minimum altitude, a higher altitude may be maintained throughout the maneuver.)

15.6.3.2. Pattern. Choose a pattern that best suits the situation. Maneuver the aircraft to a position that allows you to keep as much of the airport environment in sight as possible. Consider making your turn to final into the wind if this maneuvering allows you to also keep the airport environment in sight. You may make either left or right turns to final unless you are:

Directed. Directed by the controlling agency to do otherwise.
Required. Required to do otherwise by restrictions on the approach chart or IFR Supplement.

15.6.3.3. Weather -- High Ceiling/Good Visibility. If weather permits, fly the circling approach at an altitude higher than the circling MDA, up to your normal VFR traffic pattern altitude. This allows the maneuver to be flown with a more familiar perspective and better visual cues. Do not descend below circling MDA until in a position to place the aircraft on a normal glide path to the landing runway. (In order to prepare pilots for the worst situation fly practice circling approaches at the circling MDA if feasible and conditions permit.)

15.6.3.4. Weather -- Low Ceiling/Restricted visibility. If weather does not permit circling above the MDA, do not descend below circling MDA until the aircraft is in a position to execute a normal landing. Descend from the MDA as necessary to place the aircraft on a normal glide path to the landing runway.

15.6.3.5. Missed Approach. If there is any doubt whether the aircraft can be safely maneuvered to touchdown, execute the missed approach.

WARNING: Be aware of the common tendency to maneuver too close to the runway at altitudes lower than your normal VFR pattern altitude. This is caused by using the same visual cues that you use from normal VFR pattern altitudes. Select a pattern that displaces you far enough from the runway that will allow you to turn to final without overbanking or overshooting final.

15.7. Side-Step Maneuver Procedures. Where a side-step procedure is published, aircraft may make an instrument approach to a runway or airport and then visually maneuver to land on an alternate runway specified in the procedure. Landing minimums to the adjacent runway will be higher than the minimums to the primary runway, but will normally be lower than the published circling minimums.

15.7.1. Phraseology. Examples of ATC phraseology used to clear aircraft for these procedures are: "Cleared for ILS runway seven left approach. Side-step to runway seven right."

15.7.2. Begin Side-step. Pilots will not begin the side-step maneuver until past the FAF with the side-step runway or side-step runway environment is in sight. The side-step MDA will be maintained until reaching the point at which a normal descent to land on the side-step runway can be started.

15.7.3. Lose Visual. As in a circling approach, if you lose visual reference during the maneuver, follow the missed approach specified for the approach procedure just flown, unless otherwise directed. An initial climbing turn toward the landing runway will ensure that the aircraft remains within the obstruction clearance area.

Chapter 16

MISSED APPROACH

16.1. Planning. Performing a missed approach successfully is the result of thorough planning. You should familiarize yourself with the missed approach departure instructions during preflight planning. The missed approach departure instruction is designed to return the aircraft to an altitude providing en route obstruction clearance. In some cases the aircraft may be returned to the initial segment of the approach.

16.2. Missed Approach Point (MAP). The missed approach point for a nonprecision straight-in approach is located along the final approach course and no farther from the FAF than the runway threshold (or over an on-airport navigation facility for a no-FAF procedure and some selected FAF procedures). To determine the location of the MAP, compare the distance from the FAF to the MAP adjacent to the timing block. It may not be the same point as depicted in the profile view. If there is not a timing block, the MAP should be clearly portrayed on the IAP.

NOTE: The MAP depicted on the IAP is for the non-radar approach with the lowest HAT. For example, on an ILS approach designed by the FAA, the MAP printed will be for the ILS decision height (DH). The MAP for the localizer will probably be at the approach end of the runway and the only way to determine this is by the distance listed on the timing block.

16.2.1. Circling. The MAP for a circling approach is also located along the final approach course. It will be no farther from the FAF than the first portion of the usable landing surface (or over an on-airport navigation facility for a no-FAF procedure).

16.2.2. Precision. The missed approach point for any precision approach is the point at which the decision height is reached. This is normally the point depicted on the IAP as the start of a climbing dashed line.

16.2.3. Obstacle Clearance. The obstacle clearance area provided for the missed approach is predicated upon the missed approach being started at the MAP.

16.2.4. Initiation. ***When the missed approach is initiated prior to the MAP, proceed to the MAP along the final approach course and then via the route and altitudes specified in the published missed approach departure instruction.***

16.2.5. Delayed Decision. If the decision to execute the missed approach is delayed beyond the MAP, you may be below the missed approach obstacle clearance surface or outside the missed approach obstacle clearance area.

16.2.6. Radar Approach. When flying a radar approach, missed approach departure instructions will be given if weather reports indicate that any portion of the final approach will be conducted in IFR conditions. At USAF bases where missed approach instructions are published in base flying regulations, controllers may not issue missed approach instructions to locally assigned aircraft.

16.3. Missed Approach/Departure Instructions. A clearance for an approach includes clearance for the missed approach published on the IAP, unless ATC issues verbal missed approach/departure instructions.

16.3.1. Multiple Approaches. The controller is required to issue, prior to the FAF, appropriate departure instructions to be followed upon completion of approaches that are not to full stop landings. The pilot should tell the controller how the approach will terminate prior to beginning the approach. The controller will state, "After completion of your low approach/touch-and-go/stop-and-go/option, climb and maintain (altitude), turn right/left heading (degrees)." These instructions are verbally issued missed approach/departure instructions (often referred to as "climbout instructions"). They supersede published missed approach/departure instructions and constitute an air traffic control (ATC) clearance. ***Even if you must execute an actual missed approach, you must comply with the verbally issued missed approach/departure instructions when able***. These instructions are designed to return you to the traffic pattern. Unless otherwise instructed, you may initiate an immediate climb to the assigned altitude. ***Delay any turns until past the departure end of the runway, if visible and 400 feet above touchdown zone elevation (TDZE). If the departure end is not visible, climb on runway heading until 400 feet above TDZE before beginning your turn.*** ATC may direct a turn at another point.

16.3.2. Circling Approaches. Executing the verbally issued missed approach/departure instructions in conjunction with a circling approach is more complicated. ***If upon reaching the missed approach point the airport environment is not in sight, execute the verbally issued missed approach/departure instructions from the missed approach point. If the circling maneuver has begun and the airport environment is visually lost, begin an initial climbing turn toward the landing runway to ensure the aircraft remains within the obstruction clearance area. Continue this turn until established on the verbally issued missed approach/departure instructions***.

NOTES: Use the following guidelines:

1. Verbally issued missed approach/departure instructions supersede published missed approach departure instructions and constitute an ATC clearance.
2. If able, comply with the verbally issued missed approach/departure instructions (your last ATC clearance).
3. ***Delay any turns until past the departure end of the runway, if visible, and 400 feet above TDZE. If the departure end is not visible, climb on runway heading until 400 feet above TDZE before beginning your turn.***
4. ***If you cannot comply with your last ATC clearance, ATC must be advised.***

16.4. Actual Missed Approach. ***If you must execute an actual missed approach and are not able to accomplish the verbally issued missed approach/departure instructions, follow the published missed approach/departure instructions. Immediately advise ATC that you have missed the approach, are unable to accomplish the verbally issued missed approach/departure instructions, and are complying with the published missed approach/departure instructions***. This will ensure ATC is aware of your intentions and can issue a radar vector if necessary.

16.4.1. Important Guidelines. If you have been cleared to land (full stop), it is important to remember ATC expects you to land; therefore, ***if you have been cleared to land and must subsequently execute a missed approach, notify ATC as soon as possible and execute the published missed approach unless you have been issued verbal missed approach/departure instructions***. Keep in mind that beginning the missed approach departure instruction from other than the missed approach point will not guarantee obstacle clearance.

16.4.2. ATC Radar Vectors. ATC radar vectors (heading and altitude) issued during the initiation of the missed approach take precedence over the published or verbally issued missed approach/departure instructions.

16.4.2.1. Various Terms. There are various terms in the missed approach departure instruction written on the IAP that have specific meanings with respect to climbing to an altitude, executing a turn for obstruction avoidance and other reasons. Here are some examples:

–"Climb and maintain" means a normal climb along the prescribed course.
–"Climb and maintain (altitude), turn right (heading)" means climbing right turn as soon as safety permits, normally to clear obstructions. This instruction may be given with the turn direction stated first.
–"Climb and maintain 2,400" means climb to 2,400 feet before ATC will issue a turn instruction, normally to clear obstructions. ATC may state: "Climb and maintain 2,400, then turn right (heading)," to accomplish the same.

16.5. Accomplishing the Missed Approach.

16.5.1. When to do the Missed Approach. ***Perform the missed approach when the missed approach point or decision height (DH) is reached and any of the 3 following conditions exists:***

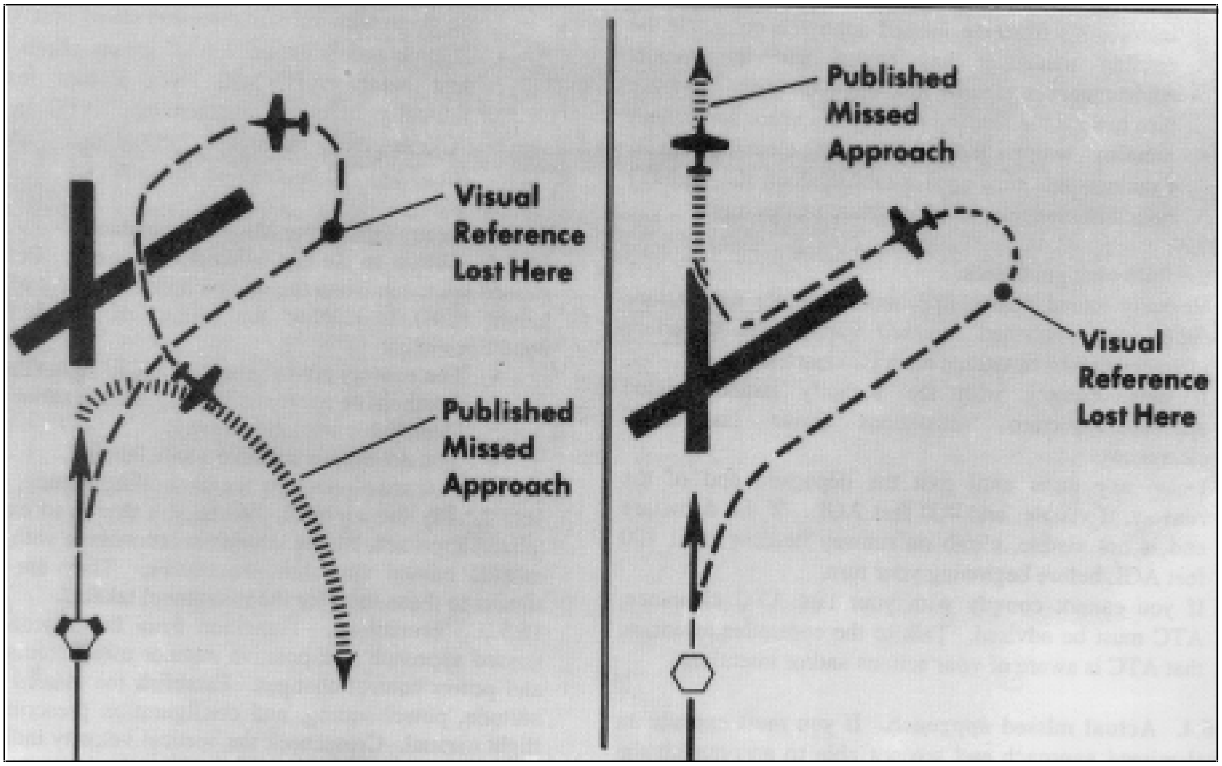
–The runway environment is not in sight
–You are unable to make a safe landing.
–You are directed by the controlling agency.

16.5.2. Fly the Aircraft. When you decide to execute the missed approach, fly the aircraft in accordance with the flight manual missed approach procedures. They are normally similar to those used for the instrument takeoff.

16.5.3. Transition. Transition from the approach to the missed approach in a positive manner using precise attitude and power control changes. Establish the missed approach attitude, power setting, and configuration prescribed in the flight manual. Crosscheck the vertical velocity indicator and altimeter for positive climb indications before retracting the gear and wing flaps. Since aircraft control will require almost total attention, you should have the first heading, course, and altitude in mind before reaching the missed approach point.

16.5.4. Lose Visual Reference. ***If you lose visual reference while circling to land, follow the missed approach specified for the approach procedure just flown, unless otherwise directed. An initial climbing turn toward the landing runway will ensure that the aircraft remains within the circling obstruction clearance area. Continue to turn until established on the missed approach course (Figure 16.1). An immediate climb must be initiated to ensure climb gradient requirements are met.***

Figure 16.1. Missed Approach from the Circling Approach (para 16.3.4.6.4).



16.5.5. Climb Gradient. ***Ensure your aircraft can achieve the published climb gradient. When the gradient is not published, climb at least 152 feet per nautical mile in order to clear obstructions.***

16.5.6. Request clearance. As soon as practical after initiating the missed approach, advise ATC and request clearance for specific action; that is, to an alternate airport, another approach, or holding. Do not sacrifice aircraft control for the sake of a voice transmission.

16.5.7. Obstacle Clearance. Terrain clearance is provided within established boundaries of the approach course and the missed approach path. It is essential that you follow the procedure depicted on the IAP chart or the instructions issued by the controller. Be aware of the minimum safe altitudes found on the IAP charts. Remember that the missed approach climb gradient begins at the published MAP.

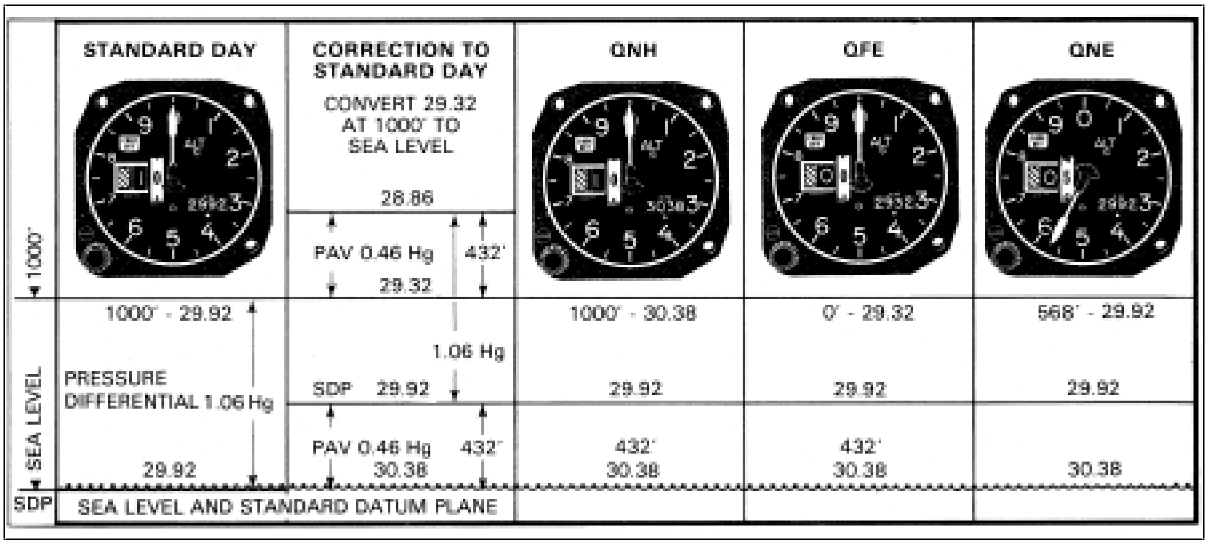
Chapter 20

ADDITIONAL INFORMATION AND GUIDANCE

20.1. Altimeter Information.

20.1.1. Altimeter Settings (Figure 20.1). There are three different altimeter settings (QNH, QFE, and QNE) referenced in Flight Information Publications (FLIP). To fully understand these different settings, an explanation of how altimeter settings are computed is necessary:

Figure 20.1. Altimeter Settings (para 20.1.1).



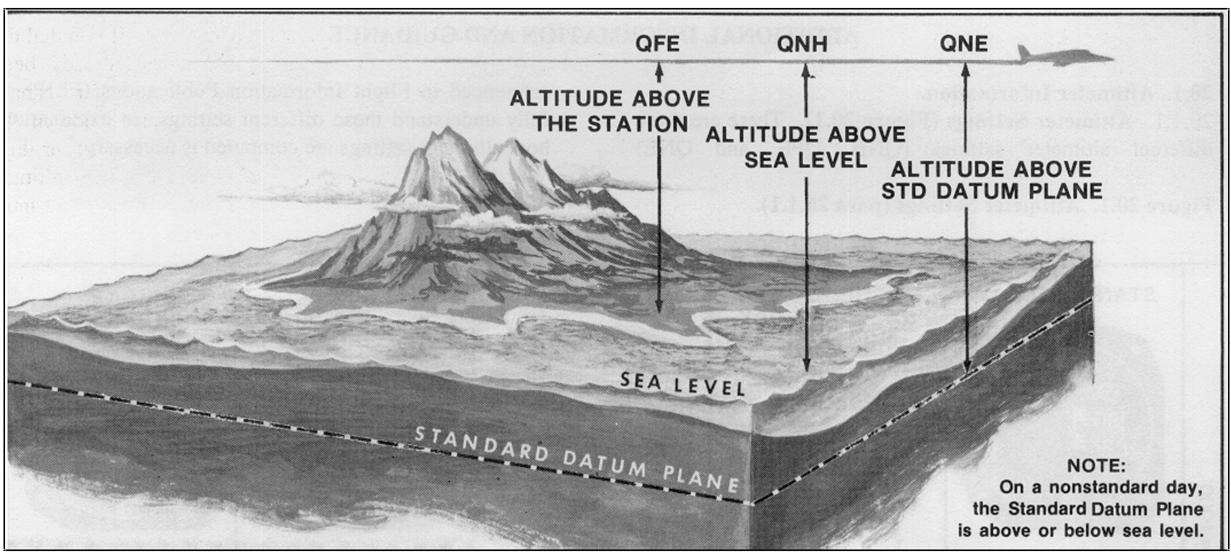
20.1.1.1. QNH Altimeter Setting. Set QNH when descending through and operating below the transition level. This setting is obtained by measuring the existing surface pressure and converting it to a pressure that would theoretically exist at sea level at that point. This is accomplished by adding the pressure change for elevation above sea level on a standard day. To illustrate this, consider an airport with an elevation of 1,000 feet (standard atmospheric value 28.86) and an actual observed surface pressure of 29.32 inches of mercury that is a pressure altitude variation (PAV) of 0.46 inches or 432 feet. To obtain the QNH altimeter setting, the pressure differential of 1.06" Hg (29.92"-28.86") is added to the observed surface pressure (29.32" + 1.06") resulting in an altimeter setting of 30.38" Hg. Theoretically, the altimeter will indicate 1,000 feet when 30.38" is set on the barometric scale. This QNH altimeter setting is standard throughout most of the world. Some nations however report QFE.

20.1.1.2. QFE Altimeter Setting. This setting is the actual surface pressure and is not corrected to sea level. Using the previous example, if 29.32 inches of mercury were set on the barometric scale, the altimeter would indicate zero feet although field elevation is 1,000 feet. This is because there is no pressure difference between the altimeter reference on the barometric scale and the existing surface pressure that is sensed by the static system. The QNH altimeter setting results in the altimeter indicating height above mean sea level (MSL), while QFE altimeter setting results in the altimeter indicating height above field elevation.

20.1.1.3. QNE Altimeter Setting. Set QNE when operating at, climbing through, or operating above the transition altitude. This setting is always 29.92 inches of mercury and results in the altimeter indicating height above the standard datum plane or pressure altitude. This altimeter setting is used at and above transition altitude. Many nations use this altimeter setting for all flights above a specific transition altitude. In these cases, the minimum en route altitude for airways is based on the lowest barometric pressures ever recorded and obstacle height.

NOTE: Altimeter setting accuracy varies with the distance from where the surface pressure is measured and is considered reliable only when in the vicinity of where it was measured. Local pressure disturbances from wind flow around large buildings may also affect the accuracy of the altimeter. Both QNH and QFE settings may be reported in millibars or hectopascals (one millibar is equivalent to one hectopascal) of pressure rather than inches of mercury. You must then correct this setting to inches of mercury using the conversion tables found in FLIP.

Figure 20.2. Types of Altitude (para 20.1.2).



20.1.2. Types of Altitude (Figure 20.2).

20.1.2.1. Absolute Altitude. The altitude above the terrain directly below the aircraft.

20.1.2.2. Pressure Altitude. The altitude above the standard datum plane (SDP). SDP is the pressure plane where air pressure is 29.92” Hg, corrected to plus 15°C.

20.1.2.3. Density Altitude. The pressure altitude corrected for temperature. Pressure and density altitudes are the same when conditions are standard (refer to standard atmosphere table). As the temperature rises above standard, the density of the air decreases resulting in an increase in density altitude.

20.1.2.4. Indicated Altitude. The altitude displayed on the altimeter.

20.1.2.5. Calibrated Altitude. The indicated altitude corrected for installation error.

20.1.2.6. True Altitude. The calibrated altitude corrected for nonstandard atmospheric conditions. It is the actual height above mean sea level.

20.1.2.7. Flight Level. A surface of constant atmospheric pressure related to the SDP. In practice, it is calibrated altitude with 29.92' Hg reference on the barometric scale.

20.1.3. AIMS. AIMS is an acronym for:

Air Traffic Control Radar Beacon System
Identification Friend or Foe
Mark XII Identification
System

Basically, AIMS is a system that provides altitude reporting and several selective identification features. The equipment is capable of automatically reporting a coded altitude and aircraft identification signal to ground stations upon interrogation. This information provides selective identification and altitude readout for control of air traffic. Two types of AIMS systems presently being used in Air Force aircraft are the servo/pneumatic system and the altitude encoder system.

20.1.3.1. Servo/Pneumatic AIMS System.

20.1.3.1.1. Parts. The servo/pneumatic type system generally consists of an identification, friend or foe and selective identification feature (IFF/SIF) transponder, precision pressure altimeter, servo-mechanism, altitude computer, controls, and other associated equipment. In this system, pitot and static pressures are provided to an altitude computer that is designed to apply a correction for installation error. The computer supplies calibrated altitude information to the transponder for altitude reporting and to the servoed altimeter for display to the pilot.

20.1.3.1.2. Modes. The AAU-19 servo/pneumatic counter-drum-pointer altimeter has two modes of operation: the primary or servoed mode (reset) and the secondary or nonservoed mode (standby). In the primary (servoed) mode, the altimeter displays calibrated altitude. The installation error correction is applied to the barometric altitude by a servo-mechanism using electrical signals supplied by the altitude computer. A secondary (nonservoed) mode is provided in the event of malfunction. The altimeter display then operates directly from static air pressure, and the appropriate altimeter installation error correction must be applied to ensure the aircraft is at the proper altitude. (As long as the altitude computer is operating properly, it will supply an altitude reporting signal to the air traffic control radars, regardless of the mode displayed on the pilot's altimeter.)

20.1.4. Altitude Encoder AIMS System. The altitude encoder type system is found in aircraft with small or negligible installation error. It generally consists of an IFF/SIF transponder, precision pressure altimeter and an altitude encoder. In this system, the altimeter and altitude encoder are a single unit. The encoder portion of the unit simply takes the barometric altitude measured by the altimeter and converts it to signals for altitude reporting. (The appropriate altimeter installation error correction must be applied at all times to ensure the aircraft is at the proper altitude.)

20.1.5. Altitude Reporting. AIMS systems report altitude based on the standard datum plane (29.92" Hg), regardless of the value set in the altimeter barometric scale. When aircraft are flying below the lowest usable flight level, ground station computers automatically apply the local altimeter setting to display accurate altitude to the air traffic controller. In order for cockpit altimeters to reflect the correct altitude as displayed to the controller, the proper value must be set in the altimeter barometric scale.

NOTE: "Code of P' and "standby" flags on AIMS altimeters do not always mean that altitude reporting has been lost. If a warning flag appears, verify that your altitude is being reported to the air traffic controller.

20.1.6. Altimeter Tolerances. Refer to your aircraft flight manual for specific operating guidance and altimeter tolerances.

20.2. Automated Radar Terminal System (ARTS).

20.2.1. Purpose. ARTS is designed to provide controllers with an alphanumeric display of aircraft identification and groundspeed on aircraft equipped with transponders, along with altitude readout on those aircraft capable of automatic altitude reporting (Mode C). This information is displayed on the controller's radar display as a data block and automatically tracks those as aircraft. ARTS is installed in many, but not all, terminal areas.

20.2.2. Advantages. ARTS equipment has simplified coordination with the terminal ATC facilities and significantly reduced the pilot and controller radio calls. This reduction in communications allows the controller to concentrate more attention on control decisions and planning.

20.3. Flight Considerations. While the Federal Aviation Administration (FAA) has provided automated ground equipment, the benefit to individual aircraft operation is dependent on the status of the airborne transponder equipment. The following are recommendations to assist pilots in obtaining optimum use of transponder equipment.

20.3.1. Aircraft with Transponders. Aircraft with transponders having altitude reporting capability should have them turned on before takeoff and contacting approach control.

20.3.2. Discrete Code. When you are assigned a discrete code (four digits) and you are not sure of the number, ask for a repeat. It is important to dial the correct code as it is a discrete code specified for your aircraft alone. If you dial the wrong code, there is a chance that it has already been assigned to another aircraft. The computer cannot distinguish between two aircraft on the same code in the same radar coverage area.

NOTE: Squawking a four-digit code does not supply the ground equipment with altitude readout. Altitude reporting is a separate function and must be specifically selected on the transponder.

20.3.3. Beacon Code. When dialing in the assigned beacon code, delay in the selection of each digit of the assigned beacon code can result in the transmission and recognition by the computer of a code assigned to a different aircraft. As noted above, the computer cannot distinguish between two aircraft on the same code in the same radar coverage area. Consistent with safe aircraft control, avoid hesitating between selection of each digit.

20.3.4. Automatic Altitude. For controllers to use your automatic altitude report, they must first verify your altitude. In order to use the automatic altitude data, it must not have an error of 300 feet or more of the pilot's reported altitude. Actual altitude reports will permit the controller to verify the automated altitude report transmitted by your transponder. (There are several ways the controller can verify altitude without directly asking you; therefore, you are not always aware that your altitude has been verified.)

20.4. Terminal Instrument Procedures (TERPs). AFJM 11-226 prescribes standardized instrument procedures.

20.4.1. Safe Procedures. The primary purpose of TERPs is to provide safe terminal procedures for aircraft operating to and from military and civil airports. The main considerations include criteria for obstacle clearance, descent gradients, and landing minimums.

20.4.2. Applications. TERPS criteria applies to the design of instrument approach procedures (IAPs) at any location over which a United States agency exercises jurisdiction.

20.4.2.1. Design. Outside of the United States, IAPs may not have been designed by a US agency. Therefore, the designing country or agency is noted in parentheses at the top of the IAP page.

20.4.2.2. Review. If the IAP is published in FLIP, it has been reviewed by an appropriate US agency, meets US TERPs criteria (or its equivalent) and is approved for use.

20.4.3. Typical Approach Designs. An instrument approach is composed of up to four segments. They are initial, intermediate, final, and missed approach segments. All segments may not be identifiable to the pilot since some begin or end at points where no navigation fixes are available. The purpose of the segments is to provide adequate maneuvering area and obstacle clearance altitude, proper alignment, and optimum descent gradients. The flight procedures prescribed for instrument approaches are predicated upon the specifications stated in TERPS and, if used, should keep the aircraft within the allocated airspace. **Figures 20.3 and 20.4** illustrate typical instrument approach designs and are informative only.

20.4.3.1. Nonprecision Approach.

20.4.3.1.1. Obstacle clearance. Required obstacle clearance in the final segment must be provided throughout the entire segment.

20.4.3.1.2. Descent gradient. The final segment descent gradient on straight-in procedures is computed using the distance from the FAF to the runway threshold and the altitude between the FAF altitude and the touchdown zone elevation. The descent gradient will not exceed 400 feet per nautical mile.

20.4.3.2. Precision Approach.

20.4.3.2.1. Angle. Normally, the glide slope angle is 2½° to 3°.

20.4.3.2.2. Obstacle clearance. Required obstacle clearance (ROC) in the final segment is constantly reduced as the aircraft approaches the runway.

20.4.3.2.3. Threshold crossing height. Optimum threshold crossing height (TCH) is 50 feet, but may be as high as 60 feet or as low as 32 feet.

20.4.3.3. Circling Approach. Circling approach obstruction clearance areas by aircraft approach category are depicted in **Figure 20.5**.

Figure 20.3. Segments of Typical Straight-In Instrument Approach with Required Obstacle Clearance (ROC) (para 20.4.3).

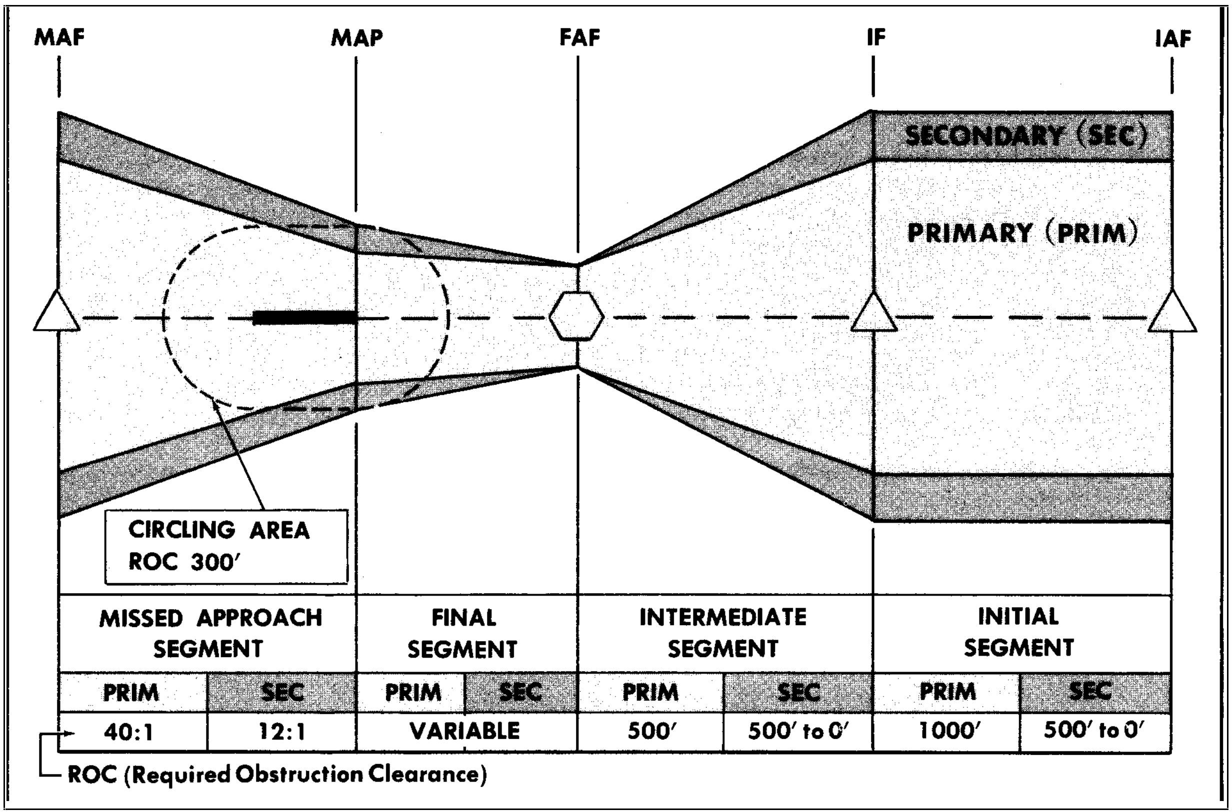
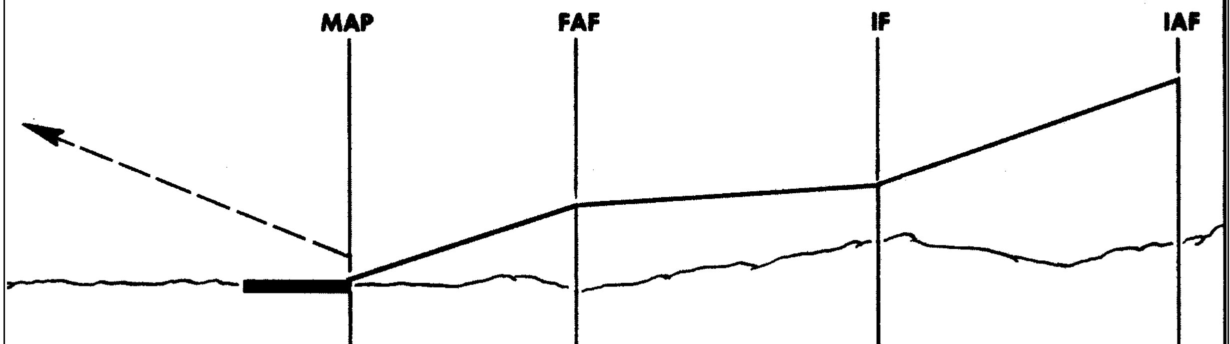


Figure 20.4. Descent Gradients by Segment for Typical Straight-In Instrument Approach (para 20.4.3).

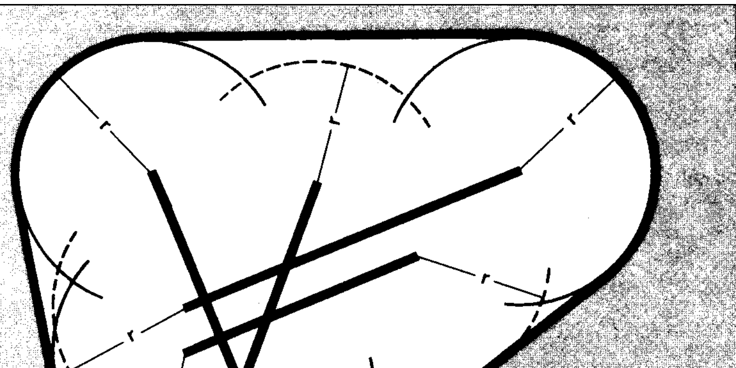


MISSED APPROACH	FINAL		INTERMEDIATE		INITIAL	
	OPT	MAX	OPT	MAX	OPT	MAX
Gradient/NM	300′	400′	150′	300′	(HI) 800′	1000′
					(LO) 250′	500′

NOTE: The final segment descent gradient is computed using the distance from the FAF to the runway threshold and the altitude between the FAF altitude and the touchdown zone elevation.

Figure 20.5. Obstruction Clearance Radius for Circling Approaches (para 20.4.3.3).

AIRCRAFT CATEGORY	OBSTRUCTION CLEARANCE RADIUS
A	1.3 NM
B	1.5 NM
C	1.7 NM
D	2.3 NM
E	4.5 NM



20.4.3.4. Missed Approaches. Missed approach obstruction clearance is provided only for the category minima listed in the approach minima blocks. The airspeeds and turning performance for the various aircraft categories are as shown in **Figure 20.6**.

Figure 20.6. Flight Path Radius for Missed Approaches (para 20.4.3.4).

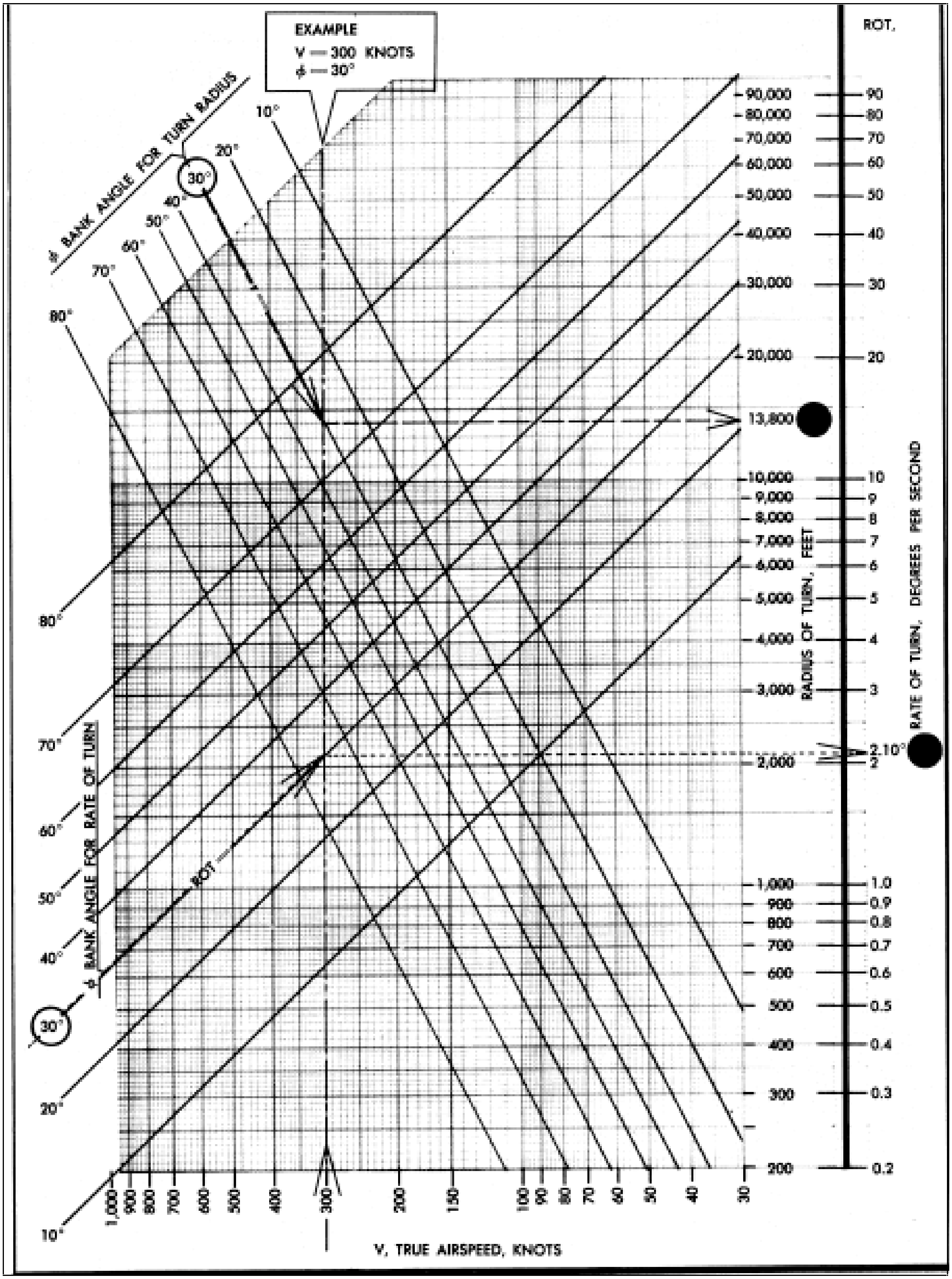
Aircraft Category	Flight Path Radius	Maximum True Airspeed
A	1.30	220
B	1.40	230
C	1.50	240
D	1.75	260
E	2.50	310

20.5. Turning Performance.

20.5.1. Turn Rate and Radius. When an aircraft is flown in a steady, coordinated turn at specific values of bank angle and velocity, the turn rate and turn radius is fixed and independent of aircraft type. As an example, an aircraft in a steady, coordinated turn at a bank angle of 30° and a velocity of 300 knots (TAS) would have a rate of turn of 2.10° per second and a turn radius of 13,800 feet or approximately 2 nautical miles (**Figure 20.7**).

20.5.2. Aircraft Turning Performance. It is a good idea to learn the approximate turning performance for your aircraft at normal operating airspeeds and angles of bank. A desired rate of turn is best flown by establishing a specific angle of bank on the attitude indicator. Therefore, it is desirable to know the approximate angle of bank required. Also, a knowledge of turn radius will aid in planning turns requiring accurate aircraft positioning. (See turning performance chart, **Figure 20.7**.)

Figure 20.7. General Turning Performance (Constant Altitude, Steady Turn) (para 20.5).



Chapter 21

AIRCRAFT EQUIPMENT

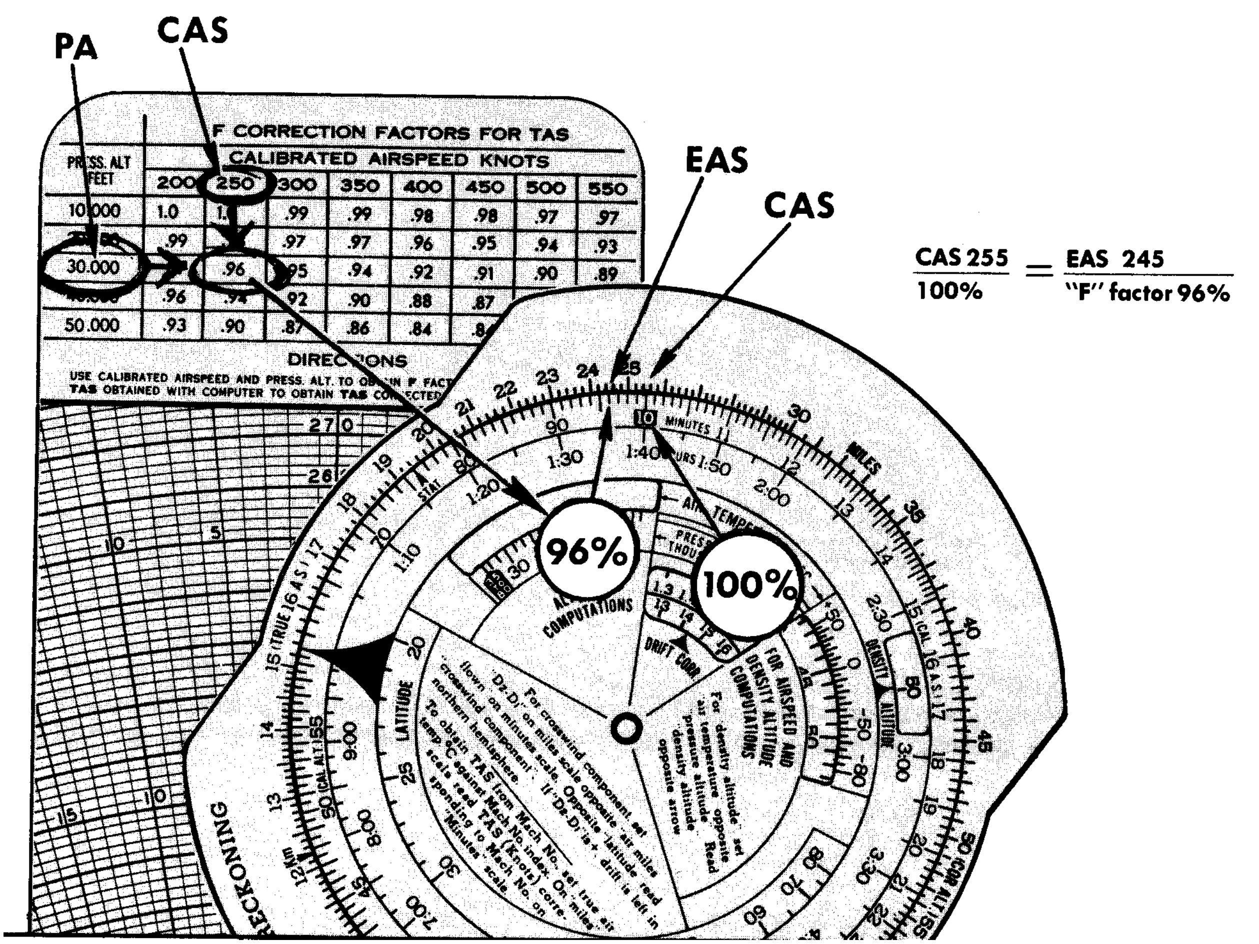
21.1. Pressure Instruments.

21.1.1. Pitot and Static Systems. Speed, altitude, and vertical velocity are measured by sensing the pressures surrounding an aircraft. These pressures are furnished either directly to the instruments or to a central air data computer (CADC) by pitot and the static systems.

21.1.2. Pitot and Static Sensing Errors. Both the pitot and the static systems have inherent characteristics that affect the pressures supplied to the instruments. Examples are:

21.1.2.1. Compressibility Error. For simplicity of design, the airspeed indicator is built to operate in air that is incompressible. Since air is compressible, the error introduced is called compressibility error. The error is zero at sea level density, regardless of airspeed, and increases with altitude as density decreases. It is negligible below 10,000 feet and 250 knots calibrated airspeed (CAS). Above sea level, CAS is always equal to or greater than equivalent airspeed. To correct for compressibility error, refer to the performance data in the aircraft flight manual or apply the "F" factor found on most dead reckoning (DR) computers (**Figure 21.1**). The error applies only to standard airspeed indicators that are calibrated by the manufacturer to read correctly at sea level conditions. It does not apply to mach or true airspeed indicators as compressibility is considered in the calibration of the indicator.

Figure 21.l. Correction for Compressibility on DR Computer (para 21.1.2.1).



21.1.2.2. Installation Error.

21.1.2.2.1. Cause. Installation error is caused by static ports supplying erroneous static pressure to the instruments. The slip stream airflow causes disturbances at the static ports, introducing an error in atmospheric pressure measurement. It varies with type of aircraft, airspeed, angle of attack, and configuration. The amount and direction of this error is determined by flight test and is found in the performance section of the aircraft flight manual. Since this is a static pressure sensing error, it affects the indications of airspeed, mach, and altitude; it does not appreciably affect vertical velocity indications. The vertical velocity indicator will initially show this pressure change, then stabilizes with the proper indication.

21.1.2.2.2. Correction. The appropriate altimeter installation error correction must be applied at all times to ensure the aircraft is flying the proper attitude or flight level. (For example, a B-52 may have an error of - 1,500 feet cruising at FL250. You will have to fly at an indicated altitude of FL235 because of installation error.) This error must be applied whether flying instrument flight rules (IFR) or visual flight rules (VFR) to ensure proper altitude separation between aircraft.

21.1.2.2.3. Direction. The direction (positive or negative) of this error is found in the performance charts, but the directions for applying the error are sometimes confusing. Ensure that it is completely understood whether the correction value to be applied is to be added to or subtracted from the altimeter readout.

NOTE: Altimeter corrections for installation error are not required on aircraft equipped with a servo/pneumatic AIMS system unless operating in the standby mode.

21.1.2.3. Reversal Error. This error is caused by a momentary static pressure change when the aircraft- pitch attitude is changed. Examples are:

21.1.2.3.1. Rotation. When an aircraft is rotated for takeoff, the instruments may indicate a temporary descent and loss of altitude and airspeed due to a momentary higher pressure being sensed by the static system. The effects of this error can be minimized by smooth pitch changes.

21.1.2.3.2. Power. When power (collective) is applied for helicopter takeoff, the instruments may indicate a temporary descent and loss of altitude due to a momentary higher pressure being sensed by the static system. The effects of this error can be reduced by smooth power inputs.

21.1.3. Alternate Static System.

21.1.3.1. With Alternate System. An alternate static system is provided in some aircraft in the event the normal system fails or becomes obstructed by ice. The alternate static ports are usually located at a point within the airframe that is not susceptible to icing conditions. There is normally a pressure difference between the alternate and normal systems that will change the indications of airspeed, mach, and altitude. If the amount and direction of this error is not available in the flight manual, you should familiarize yourself with the differences in cruise, letdown, and especially the approach configurations.

21.1.3.2. Without Alternate System. For aircraft that do not have an alternate static system, there are other actions that may be taken:

21.1.3.2.1. Icing. If the failure is due to icing, use the attitude indicator as the primary reference and establish a known power setting. (Check angle of attack.) Depart the icing conditions as soon as possible.

21.1.3.2.2. Making Alternate System. If an alternate static source is not available, you can make one in the cockpit by gently breaking the glass seal of any differential pressure instrument, such as the VVI, altimeter, airspeed indicator, mach indicator, etc. Select one that is not mandatory for recovery, such as the mach indicator, or one of the copilot's less important instruments. If it becomes necessary to use an alternate static source, don't forget that you will have to depressurize the cockpit. You may, as a result, have to descend to comply with AFI 11-206 oxygen requirements.

NOTE: When using an alternate static source, indicated readings may be higher than actual due to the venturi effect. The direction and magnitude of the error will vary with type of aircraft.

21.1.4. Central Air Data Computer (CADC). Many aircraft use electrically operated vertical tape instruments as well as electrically driven round dial counter-drum-pointer altimeters. To provide the necessary electrical signals to drive these instruments, a CADC or an altitude computer is used. These computers correct instrument displays for installation and scale errors.

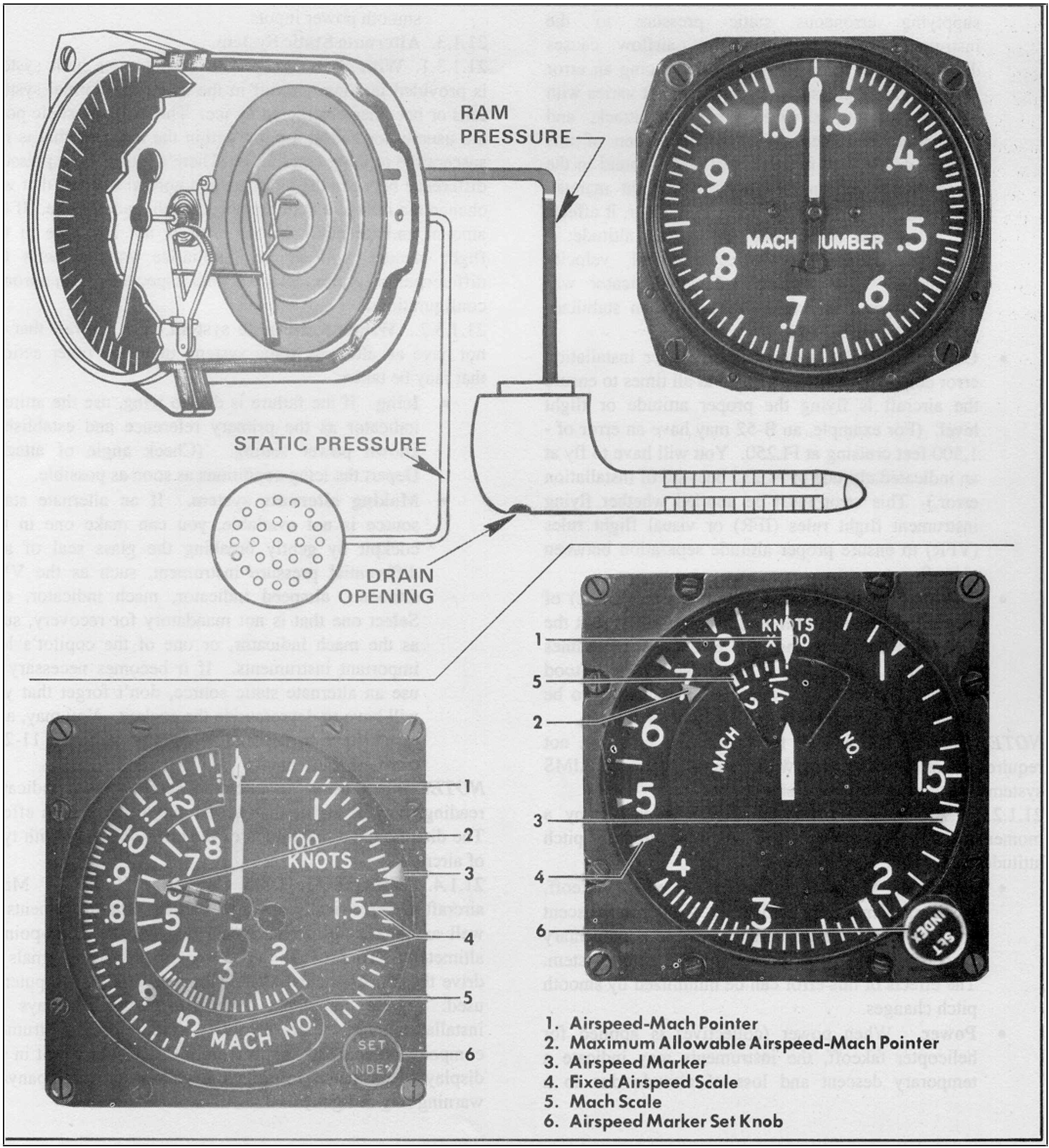
CAUTION: Failure of instrument components receiving inputs from a CADC can result in the display of erroneous information without an accompanying warning flag or light.

21.1.5. Speed Measurement (Figure 21.2).

21.1.5.1. Airspeed. Airspeed measurements are a comparison of pitot (ram) pressure to static (ambient) pressure. The difference between these two pressures is differential (dynamic) pressure. The airspeed indicator measures this dynamic pressure by supplying pitot pressure to a flexible metallic diaphragm and static pressure to the airtight chamber that surrounds the diaphragm. When the pitot system is blocked by something, such as ice, the ram pressure is trapped and the static pressure is not, the airspeed indicator then acts as an altimeter. As the aircraft climbs, airspeed indications increase. On most supersonic aircraft, the static source is located on the pitot boom, so if the boom ices over, probably both systems are blocked. In this case the airspeed will remain constant, indicating the speed it had when blockage occurred. On subsonic aircraft the static ports are located somewhere on the aircraft not significantly influenced by the airstream. If the static source is blocked and the pitot boom is not, the airspeed will decrease as the aircraft climbs. This situation is possible even with the pitot heat operating, since most aircraft do not have static port heaters. Many aircraft have an alternate static source located in the cockpit for this occurrence.

21.1.5.2. Establish Known Pitch. The most important action you should take if you suspect an airspeed error is to establish a known pitch attitude and power setting. Check the pitot heat on, and if it is on, recheck the circuit breakers. Check the attitude indicator against the standby attitude indicator or against the other pilot's attitude indicator. Crosscheck the angle of attack indicator (if available).

Figure 21.2. Airspeed Measurement (para 21.1.5).



21.1.5.3. Types of Airspeed.

21.1.5.3.1. Indicated Airspeed (IAS). The airspeed displayed by the airspeed indicator. (This airspeed is uncorrected for all errors associated with airspeed measurement.)

21.1.5.3.2. Calibrated Airspeed (CAS). The indicated airspeed corrected for installation error.

21.1.5.3.3. Equivalent Airspeed (EAS). The calibrated airspeed corrected for compressibility effect.

21.1.5.3.4. True Airspeed (TAS). The equivalent airspeed corrected for air density.

21.1.5.3.5. Groundspeed (GS). The true airspeed corrected for wind.

21.1.5.3.6. Indicated Mach Number (IMN). The Mach number displayed on the mach indicator.

21.1.5.3.7. True Mach Number (TMN). The indicated Mach number corrected for installation error.

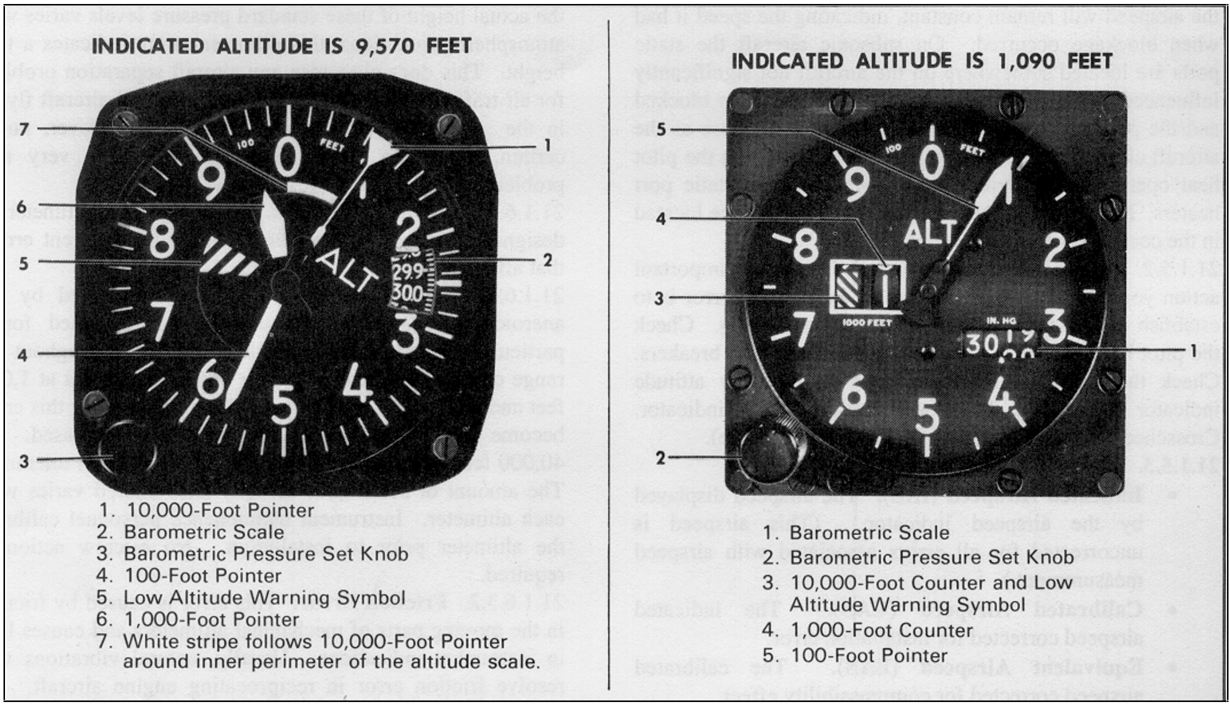
NOTE: Calibrated and equivalent airspeeds and true mach number can be determined by referring to the performance data section of the aircraft flight manual.

21.1.6. **Altitude Measurement (Figure 21.3).**

21.1.6.1. Barometric Altimeter. There are many ways to measure the altitude of an aircraft; probably the simplest is with a barometric altimeter. The pressure of the Earth's atmosphere decreases as height above the Earth increases. If this pressure difference is measured by some mechanical means, it can be directly related to height in feet, meters, or other linear measurement. The height at which a particular pressure is sensed varies with atmospheric conditions.

21.1.6.2. Atmosphere Chart. A standard atmosphere chart provides a reference for altitude measurement. Barometric altimeters are designed to display altitude relative to the pressure difference shown on the chart. For example, if the barometric scale is referenced to 29.92" Hg (sea level, standard conditions) and the instrument is supplied with a static pressure of 20.58" Hg (pressure at 10,000 feet, standard conditions), the altimeter should indicate 10,000 feet. The pressure difference between the sea level and 10,000 feet on a standard day is 9.34 inches of mercury. Any time the altimeter senses this pressure difference between the barometric scale setting and the actual static pressure supplied to the instrument, it will indicate 10,000 feet. Since the actual height of these standard pressure levels varies with atmospheric conditions, the altimeter rarely indicates a true height. This does not cause any aircraft separation problem for air traffic control (ATC) purposes since all aircraft flying in the same area are similarly affected. However, under certain conditions, terrain clearance can be a very real problem.

Figure 21.3. Altimeters (para 21.1.6).



21.1.6.3. Altimeter Errors. Although the altimeter is designed to very close tolerances, there are inherent errors that affect its accuracy. These are:

21.1.6.3.1. Scale Error. This error is caused by the aneroids not assuming the precise size designed for a particular pressure difference. It is irregular throughout the range of the instrument; that is, it might be -30 feet at 1,000 feet and +50 feet at 10,000 feet. The tolerances for this error become larger as the measured altitude is increased. At 40,000 feet an error of ±200 feet would be within tolerance. The amount of scale error actually encountered varies with each altimeter. Instrument maintenance personnel calibrate the altimeter prior to installation. No aircrew action is required.

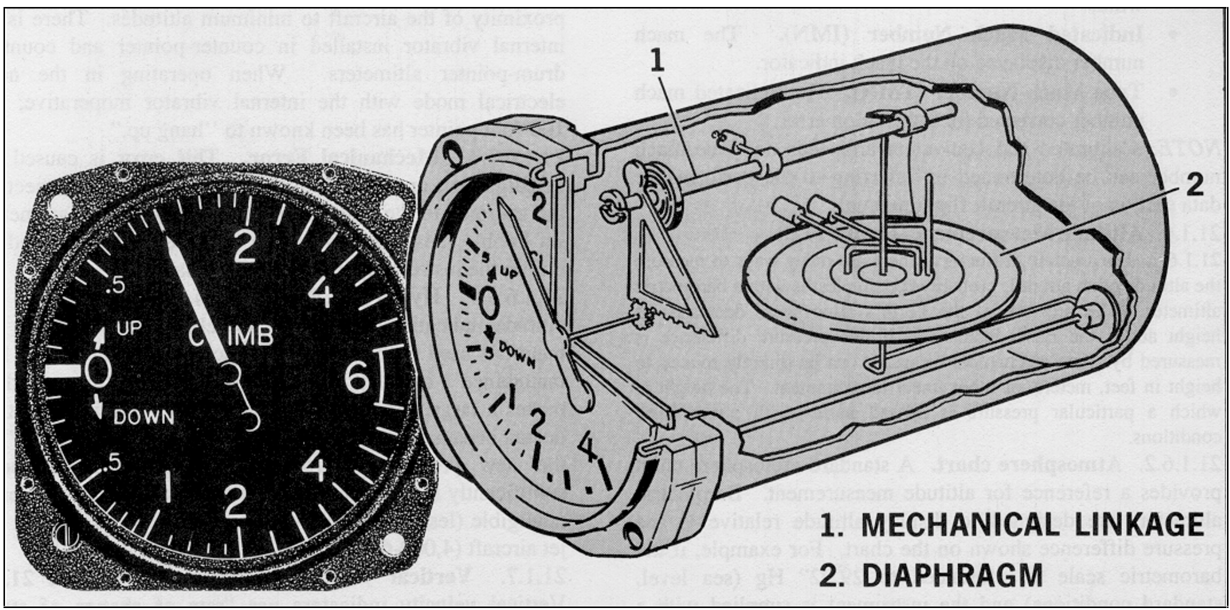
21.1.6.3.2. Friction Error. This error is caused by friction in the moving parts of mechanical altimeters and causes lags in instrument indications. Usually, natural vibrations will resolve friction error in reciprocating engine aircraft. Jet engine aircraft usually have instrument panel vibrators installed to eliminate this error. If the vibrator is inoperative, lightly tapping the instrument at certain intervals may be necessary. These intervals must be determined by the proximity of the aircraft to minimum altitudes. There is an internal vibrator installed in counter-pointer and counter-drum-pointer altimeters. When operating in the non-electrical mode with the internal vibrator inoperative, the 100-foot pointer has been known to ‘‘hang up.”

21.1.6.3.3. Mechanical Error. This error is caused by misalignment or slippage in the gears or linkage connecting the aneroids to the pointers or in the shaft of the barometric set knob. It is checked by the altimeter setting procedure during the instrument cockpit check (chapter 8).

21.1.6.3.4. Hysteresis Error. This error is a lag in the altitude indications caused by the elastic properties of the materials used in the aneroids. It occurs after an aircraft has maintained a constant altitude for a period of time and then makes a large, rapid altitude change. The lag in indication occurs because it takes time for the aneroids to “catch up” to the new pressure environment. This error has been significantly reduced in modern altimeters and is considered negligible (less than 100 feet) at normal rates of descent for jet aircraft (4,000-6,000 fpm).

21.1.7. Vertical Velocity Measurement (Figure 21.4). Vertical velocity indicators use "rate of change of static pressure" for measuring vertical rate. The rate of change of static pressure is obtained by supplying static pressure directly to a thin metallic diaphragm and through a calibrated orifice to an airtight case surrounding the diaphragm. As the aircraft climbs, the static pressure in the case is momentarily "trapped" by the calibrated orifice and the static pressure in the diaphragm is allowed to decrease immediately. This decrease causes the diaphragm to contract and, through a mechanical linkage, the pointer indicates a climb. In a descent, the opposite is true. Case static pressure is momentarily "trapped" at the lower static pressure while the diaphragm expands because of the higher static pressure furnished, and this expansion causes the pointer to indicate a descent. Because of this "delay" or "lag" caused by the calibrated orifice, it requires up to 9 seconds for the indications to stabilize. However, immediate trend information is available. Many of the "instantaneous" types of indicators use either a pitch gyro signal or an accelerometer signal for the initial indication and then stabilize the indication with barometric information.

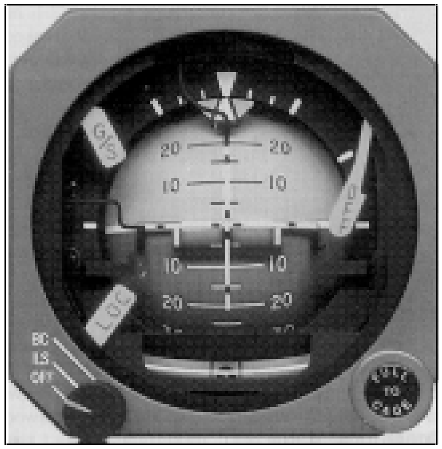
Figure 21.4. Vertical Velocity Indicator (VVI) (para 21.1.7).



21.2. Attitude Instruments.

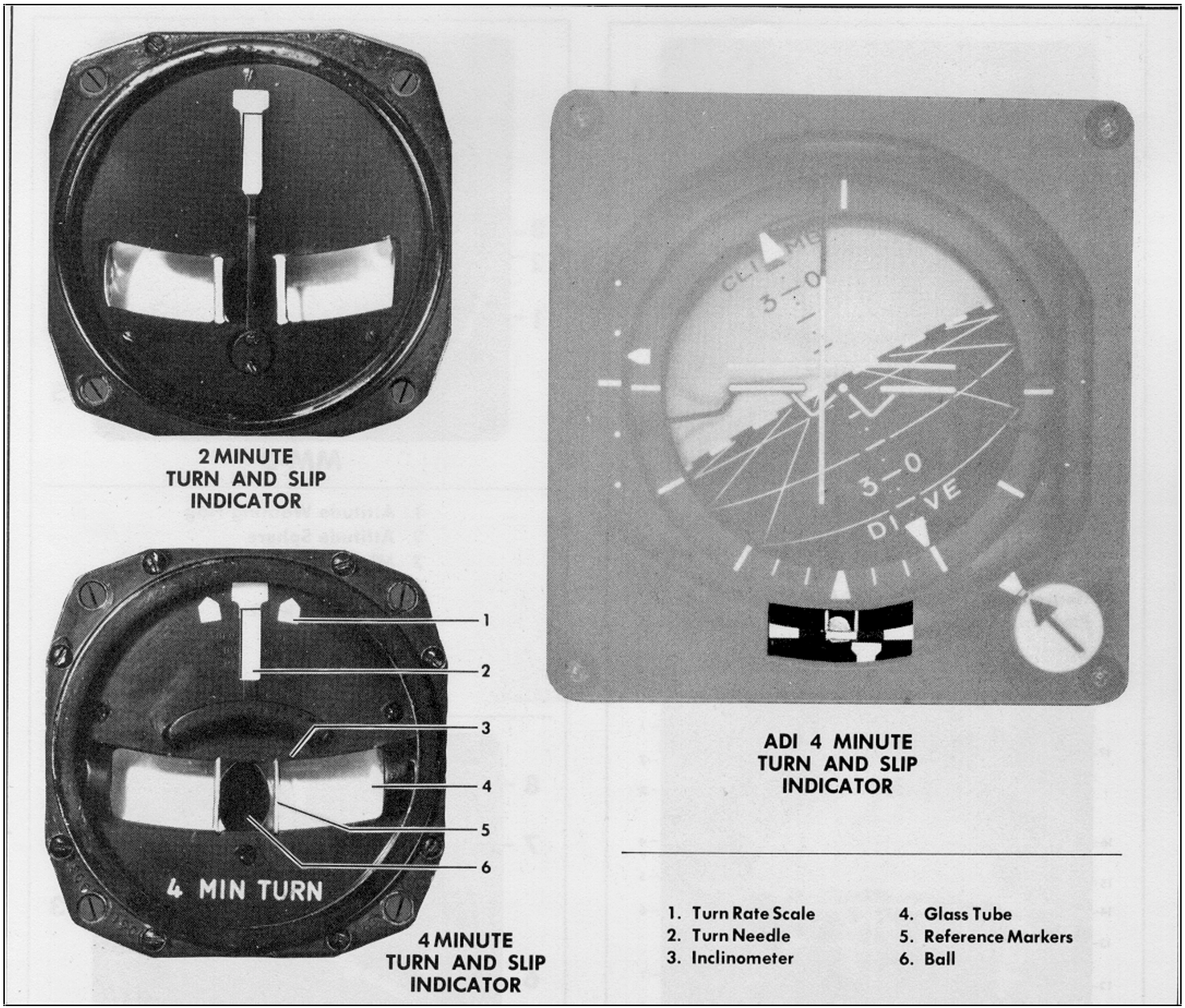
21.2.1. Attitude Indicator (Figures 21.5). This indicator provides you with a substitute for the Earth's horizon to maintain a desired aircraft attitude during instrument flight. This is accomplished by displaying an attitude sphere positioned by a self-contained gyro, remote gyros, or an inertial platform.

Figure 21.5. Three-Axis Attitude Director Indicator (ADI) (para 21.2.1).



21.2.2. Turn and Slip Indicator (Figure 21.8). The principal functions of the turn and slip indicator are to provide an alternate source of bank control and to indicate a need for a yaw trim. One needle-width deflection on the turn indicator provides for a 360° turn in either 2 minutes (3°/sec) for a 2-minute indicator, or 4 minutes (1½°/sec) for a 4-minute indicator.

Figure 21.8. Turn and Slip Indicators (para 21.2.2).



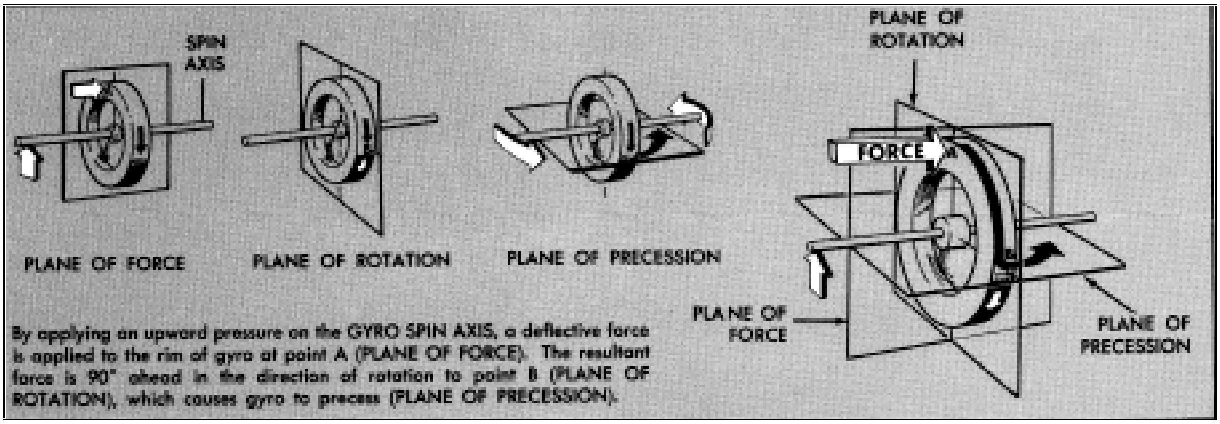
NOTE: A standard-rate turn is 3° per second and a half standard-rate turn is 1½° per second.

21.2.3. Precession. To serve as an attitude reference, the gyroscope spin axis must remain aligned with relation to the Earth's surface. Any movement (real or apparent) of the spin axis is called:

21.2.3.1. Apparent Precession. As the Earth rotates or as a gyro is flown from one position on the Earth to another, the spin axis remains fixed in space. However, to an observer on the surface of the Earth, the spin axis appears to change its orientation in space. Either the Earth's rotation (Earth rate precession) or transportation of the gyro from one geographical fix to another (Earth transport precession) may cause apparent precession.

21.2.3.2. Real Precession. Movement of the gyro spin axis from its original alignment in space is real precession. It is caused by a force applied to the spin axis (**Figure 21.9**). This force may be unintentional force such as rotor imbalance or bearing friction, or an intentional force applied by the erection mechanism or torque motor.

Figure 21.9. Precession of Gyroscope Resulting from Applied Deflective Force (para 21.2.3.2).



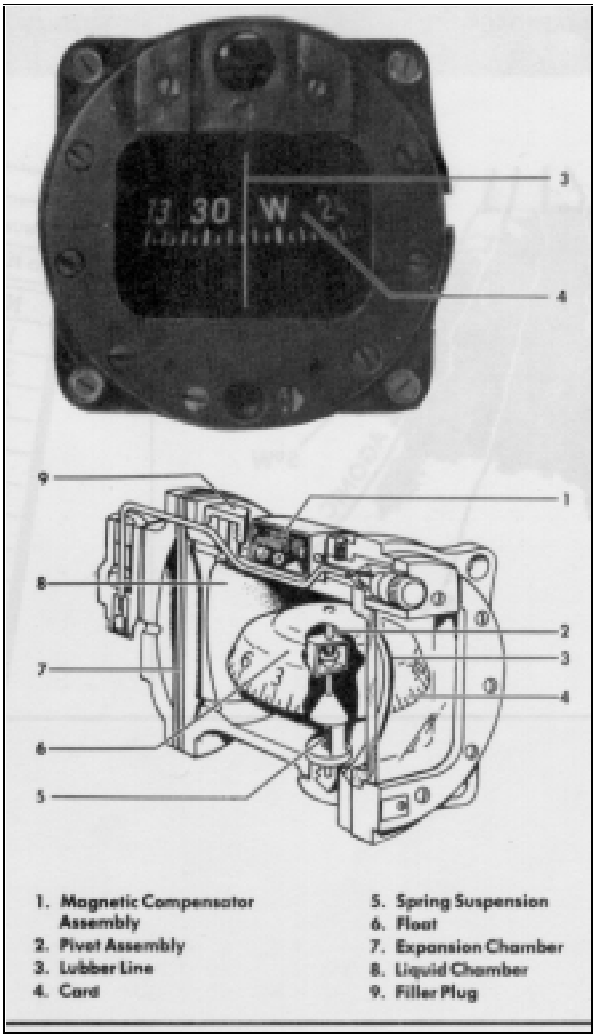
21.2.3.3. Erection Mechanisms. The erection mechanisms compensate for precession by keeping the gyros aligned with the Earth's surface.

21.3. Heading Systems.

21.3.1. Heading Information. Heading information is usually obtained by using the Earth's magnetic lines of force. The magnetic compass, one of the first to convert the magnetic lines of force to aircraft heading information, is a self-contained instrument that operates independently of the electrical system. Other heading systems require electrical power to convert magnetic lines of force to aircraft heading.

21.3.2. Magnetic Compass (Figure 21.10). The magnetic compass indicates the heading of the aircraft with reference to magnetic north. Since the compass requires no electrical power for operation, use it to check other heading systems and as an emergency heading system. However, because the magnetic compass is normally aligned with electrical power applied to the aircraft, in an electrical failure situation, the magnetic compass may be 20° to 30° in error.

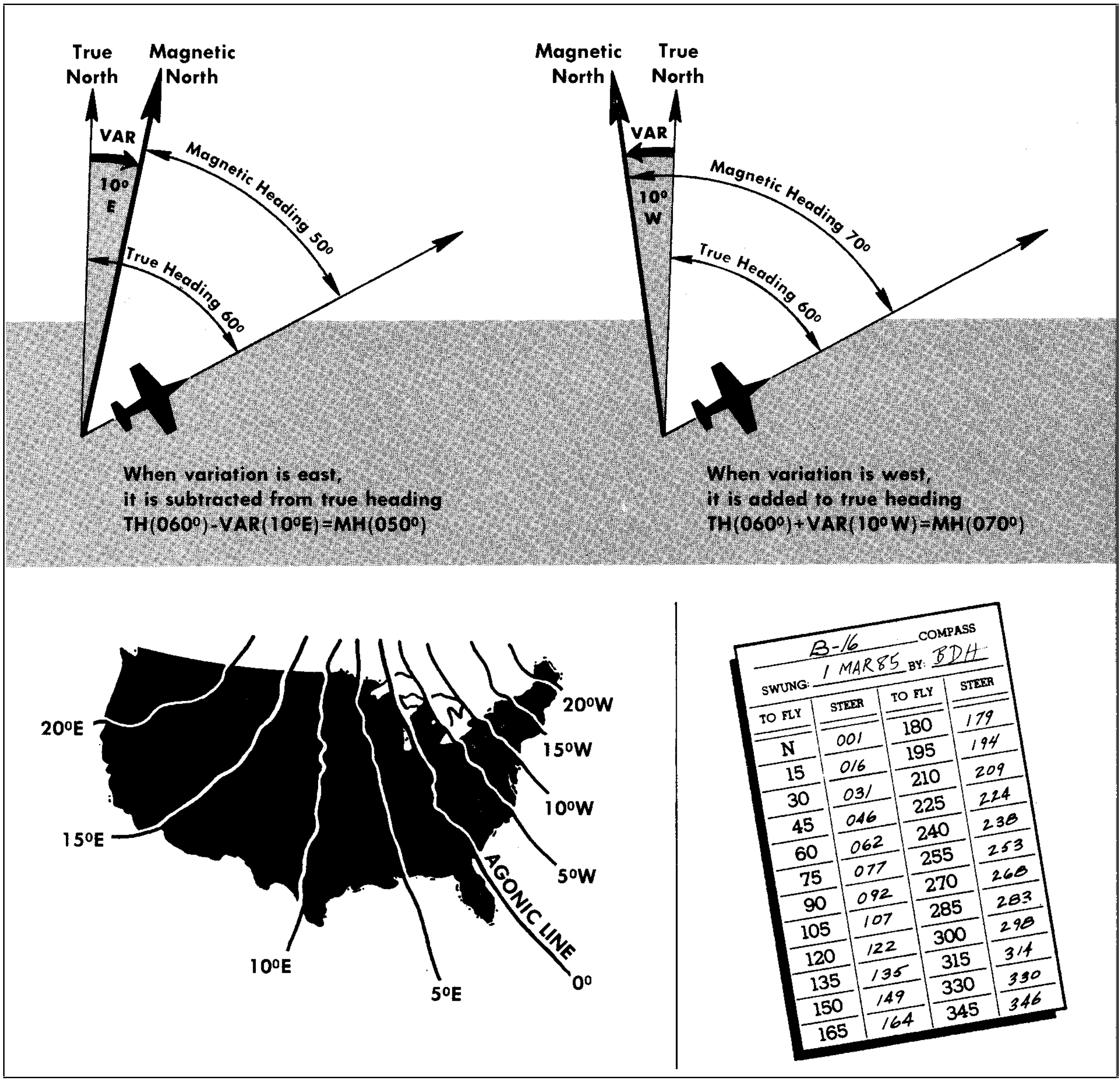
Figure 21.10. Magnetic Compass (para 21.3.2).



21.3.2.1. Variation (Figure 21.11). The magnetic compass points to magnetic north. The angular difference between true and magnetic north is known as variation and it changes for different locations on the Earth. Variations must be considered when converting true courses, true headings, or true winds to magnetic direction.

21.3.2.2. Deviation. This is an error in compass indications caused by magnetic disturbances originating within the aircraft. The magnitude of deviation varies with operation of different electrical equipment. Periodically, the compass is checked and compensations are made to reduce the amount of deviation. Deviation errors remaining after the compass has been checked are recorded on a compass correction card in the cockpit (**Figure 21.11**). The STEER column on the compass correction card is the compass heading you should indicate to maintain the TO FLY magnetic heading.

Figure 21.11. Magnetic Compass Variations and Correction Card (para 21.3.2.1).



21.3.2.3. Limitation. The magnetic compass is relatively unstable and should be read only when the aircraft is in wings level, unaccelerated flight. Timed turns are recommended when making heading changes with this compass.

21.3.3. Types of Heading Systems. There are many types of heading systems, but each may be classified as either slaved or nonslaved. The nonslaved system uses a gyro to supply the directional reference, while the slaved system uses the signals from a remote compass transmitter to orient the system to magnetic north. In both systems the gyro acts as a stabilizing component to reduce the inherent errors.

21.3.4. Heading System Errors. All heading systems are subject to errors produced by real and apparent precession. If provisions for correction are incorporated in the design of the system, these errors will be negligible.

21.3.4.1. Real Precession. During turns and periods of acceleration and deceleration, forces are produced which combine with the force of gravity causing the erection mechanism and the remote compass transmitter to induce errors in the heading system. However, once wings-level, unaccelerated flight is resumed, the remote compass transmitter and the erection mechanism sense true gravity and correct any errors.

21.3.4.2. Apparent Precession. As discussed earlier, apparent precession is caused by two factors: the rotation of the Earth; and transportation of the gyro from one location on the Earth to another. The gyro is kept horizontal by the erection mechanism.

21.4. Angle of Attack System. Angle of attack information is obtained by comparing the relative wind to the chord line of the wing. Its primary use in instrument flight is during the final phase of an instrument approach. Maintaining the computed final approach airspeed during unaccelerated (1G) flight should also maintain the approach angle of attack. The information can be used in the same manner as airspeed. This allows either angle of attack or airspeed to be flown while using the other indication as a backup. (Refer to the aircraft flight manual for specific guidance on the use of angle of attack.)

21.5. Radar Altimeters.

21.5.1. Description. Equipment used to measure the height of the aircraft above the terrain directly below it. A radar altimeter has the following restrictions:

21.5.1.1. Accuracy. Most are accurate only in straight and level flight over landmasses. Altitude readouts over areas covered by water, ice, and snow may be unreliable.

21.5.1.2. Restriction One. It cannot be used as a warning for rapidly rising terrain ahead of the aircraft.

21.5.1.3. Restriction Two. It cannot be used to determine decision height (DH), except for Cat II ILS, because Cat II ILS is the only approach that depicts the height of the aircraft above the terrain at the DH point.

21.5.2. Specific Radar Altimeters. Refer to your flight manual or command directives for specific radar altimeter tolerances, guidance, and procedures.

Chapter 22

SPATIAL DISORIENTATION

22.1. General Information.

22.1.1. Occurrence. Spatial disorientation (SD) has been a significant factor in at least 13 percent of all major aircraft accidents and 14 percent of all associated fatalities. These losses amount to over $100 million per year, not to mention the sorrow and grief suffered by family members. Although the potential for spatial disorientation increased dramatically with the introduction of high performance, single-seat fighters into the Air Force inventory, pilots of multi-place aircraft are not exempt from spatial disorientation.

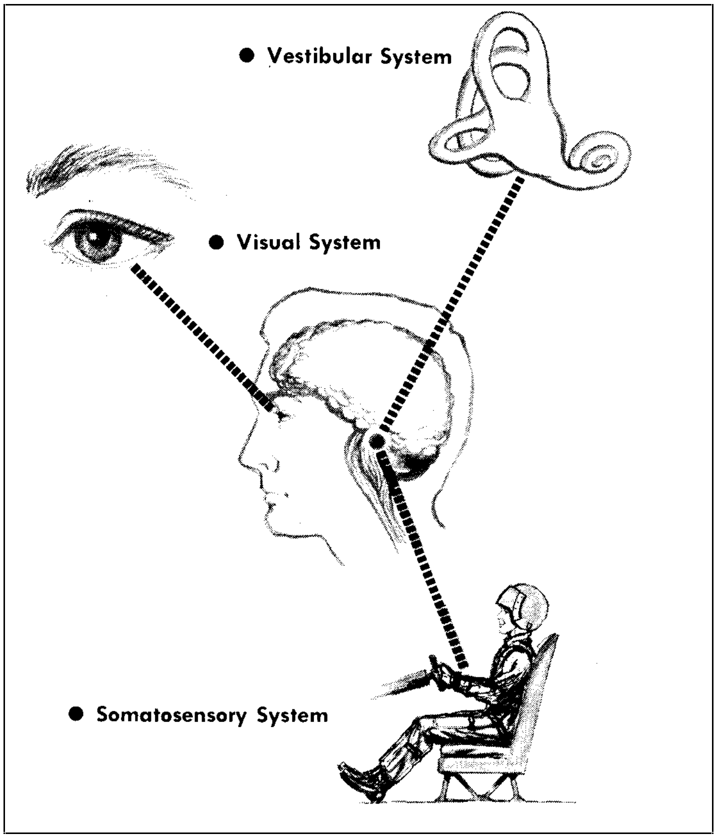
22.1.2. Definition. In general, SD is an incorrect perception of one's linear and angular position and motion relative to the plane of the earth's surface. Specifically in the flight environment, SD is an erroneous percept of any of the parameters displayed by aircraft control and performance flight instruments. The erroneous percept of a navigation parameter is referred to as geographic disorientation. Regardless of a pilot's experience or proficiency, sensory illusions can lead to differences between instrument indications and what the pilot "feels" the aircraft is doing. It should be stressed that disoriented pilots frequently are not aware of their orientation error. Many crashes occur when pilots are busily engaged in some task that takes their attention away from the flight instruments. Even when disoriented pilots perceive conflict between bodily sensations and the flight instruments, crashes can occur when they cannot resolve the conflict. In general, unrecognized spatial disorientation tends to occur during task intensive portions of the mission, while recognized spatial disorientation occurs during attitude changing maneuvers.

22.1.3. Susceptibility. It is important to remember that sensory illusions occur regardless of pilot experience or proficiency. All pilots are susceptible to illusions while flying at night, flying under certain weather conditions, flying demanding maneuvers with extreme linear or angular accelerations, or even in VMC. A basic understanding of the sensory systems, physiological mechanisms of various illusions, and conditions of flight where these illusions may be expected can help the pilot successfully cope with spatial disorientation.

22.2. Orientation and Equilibrium (Figure 22.1). A person's orientation devices are located in both the conscious and subconscious sections of the mind. The subconscious mind uses sensory information from the ambient (or peripheral) visual system, the vestibular system and the somatosensory system to maintain orientation and equilibrium. This information is processed automatically at very high rates and without conscious effort. The conscious mind employs central (focal) vision to determine spatial orientation. In contrast to the speedy processes of the subconscious, information processed in the conscious mind is relatively slow, requiring active thought, and is normally very accurate. For earthbound activities, our subconscious orientation system receives adequate information from the sensory systems. However, when a person is subjected to the flight environment, these sensory systems are no longer totally reliable and may provide the subconscious with false information about its orientation in space. When flying in IMC or without reliable external attitude or motion cues, only the conscious mind with focal vision provides true orientation information.

22.2.1. Vestibular System (Figure 22.2). The primary purpose of the vestibular system is to enhance vision. It provides angular and linear acceleration information to stabilize the eyes when motion of the head and body would otherwise result in blurred vision. The second purpose, in the absence of vision, is to provide perception of position and motion. On the ground, the vestibular system provides reasonably accurate perception of position and motion. In flight, however, the vestibular system may not provide accurate percept of orientation. To understand how this vestibular information can be erroneous, one must look at its two sensors: the semicircular canals and the otolith organs of the inner ear.

Figure 22.1. Organs of Equilibrium (para 22.2).



22.2.1.1. Semicircular Canals. The three semicircular canals on each side of the head are positioned at right angles to each other so that angular accelerations in any spatial plane (pitch, roll, or yaw) can be detected. The fluid within the semicircular canals moves relative to the canal walls when angular accelerations are applied to the head. This fluid movement bends sensory hair filaments in specialized portions of the canals, which sends nerve impulses to the brain resulting in the perception of rotary motion in the plane of the canal stimulated. Again, since the response characteristics of the semicircular canal system evolved for our ground-based environment, peculiar errors may be induced in flight. For example, a very small or short-lived angular acceleration may not be perceived, and the resulting angular velocity can cause large attitude changes to develop over time. Additionally, angular accelerations experienced in flight can be quite different from those experienced on the ground (**Figure 22.1**). Hence, we can erroneously interpret the sensations produced by the fluid movement in the semicircular canal.

22.2.1.2. Otolith Organs. In the presence of linear acceleration or gravity, the sensory hairs that penetrate the otolithic membranes are bent by the relative movements of the otolithic membranes over the underlying structures. This activity is transformed into nerve impulses to the brain, which convey information about head position relative to true vertical (or the direction of the pull of gravity). During flight, inertial forces are combined with the force of gravity and act upon the otolithic membranes. The direction of this combined or resultant force is almost never the direction of the true vertical. During flight, if the brain monitors the position of the otolithic membranes to determine which way is “down”, the brain will be deceived a large portion of the time.

22.2.2. Visual System. Vision is by far the most important sensory system providing spatial orientation during flight. In the absence of vision, orientation would be derived solely from the less accurate vestibular or somatosensory systems, and these systems do not provide reliable motion and position cues in the flight environment.

22.2.2.1. Visual Dominance. Of great importance in minimizing the effects of spatial disorientation is an understanding of the concepts of visual dominance and vestibular suppression. Visual dominance exists when the pilot receives through the eyes all the information used to maintain correct orientation. Vestibular suppression is the ability to suppress unwanted vestibular sensations and reflexes. A pilot’s ability to accomplish vestibular suppression comes as a result of understanding why spatial disorientation occurs and through practicing visual dominance. Experience and proficiency make vestibular suppression easier.

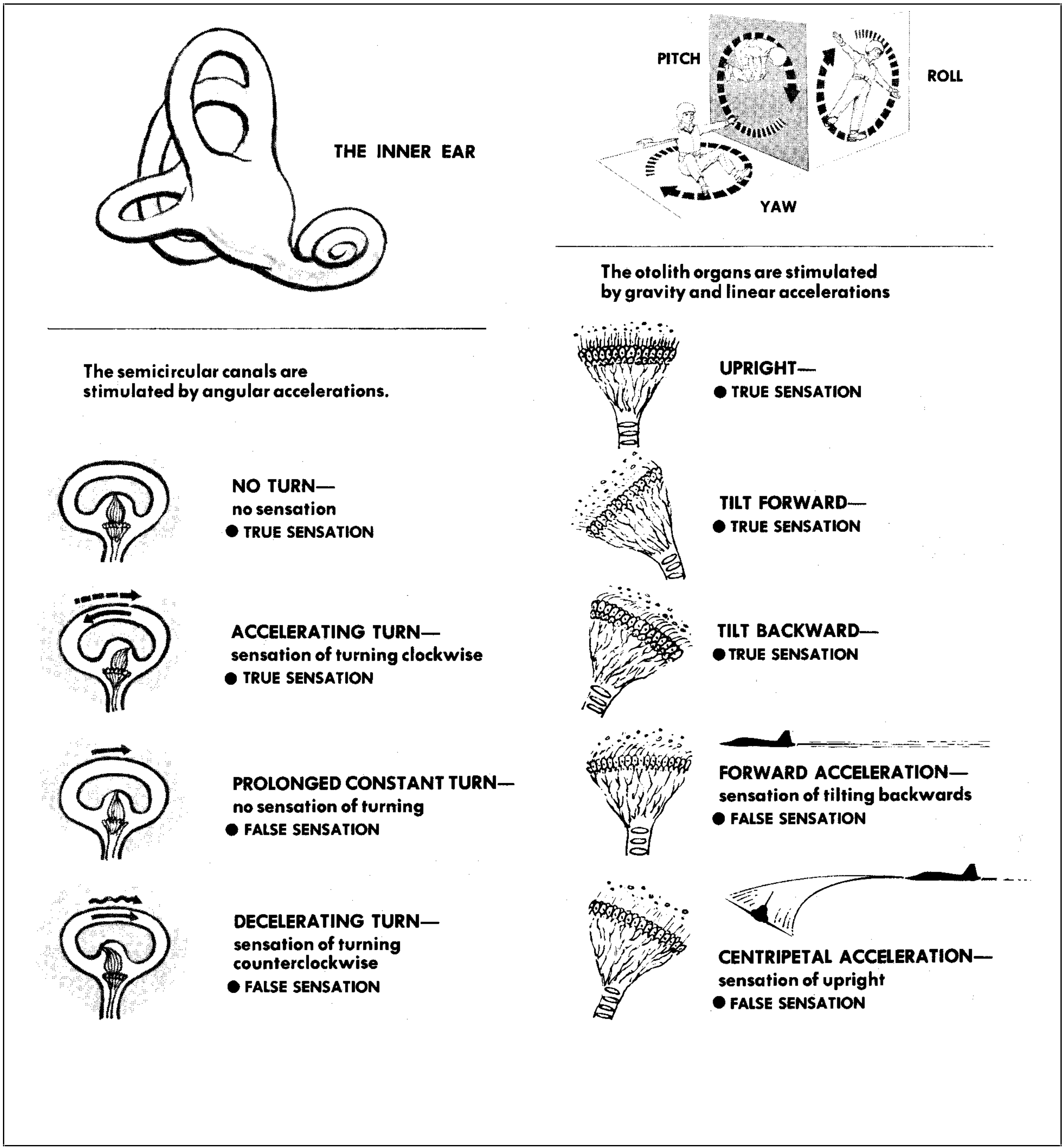
22.2.2.2. Ambient and Focal Vision. The visual system is actually composed of two separate visual systems to provide different visual functions. The ambient (mainly peripheral) visual system is primarily concerned with the question of “where”, thus providing us with spatial orientation. Because ambient vision is monitored at the subconscious level, its information is processed automatically at very high rates and without conscious effort. The focal (or central) visual system is primarily concerned with the question of “what”, providing fine detail for recognition. For spatial orientation, focal vision provides visual cues for judgment about distance and depth, and retrieves information from the flight instruments. While focal vision operates with great precision and accuracy, it is processed in the conscious mind relatively slowly, requiring active thought.

22.2.2.3. Visual Conditions in Flight. During flight, the utility of external visual references varies with the quality of available visual information. Because of the dynamic relationship between visual information available and mission requirements (straight and level flight to aggressive maneuvering), every aviator should be aware that spatial disorientation is possible, under a wide variety of visual conditions.

22.2.2.3.1. Adequate External Vision. On a clear day when adequate external visual references are available, spatial disorientation is unlikely when flying in upright attitudes. However, in the presence of extreme linear and/or angular accelerations and unusual aircraft attitudes demanded in tactical maneuvering, spatial disorientation can occur even on a clear day. Under such circumstances, the availability of a horizon in combination with flight instruments should allow the pilot to maintain visual dominance and naturally suppress false vestibular and somatosensory orientation cues.

22.2.2.3.2. Instrument Conditions. At night, in IMC, or in marginal VMC (i.e., when adequate external visual references are not available), the pilot must maintain spatial orientation and a state of visual dominance solely by reference to aircraft instruments, especially the attitude display. The key to success in instrument flying is to develop an effective instrument crosscheck which provides a continuous source of accurate information related to aircraft attitude, motion, and position. A proficient pilot with an effective crosscheck will have little difficulty in maintaining visual dominance and ignoring other, potentially disorienting, sensory data. The pilot should be aware that what is seen outside the aircraft may be confusing and may lead to visual illusions and sensory conflicts. During times when the aircraft instruments are the sole source of accurate information, pilots can count on becoming disoriented unless they direct their attention to see, correctly interpret, process, and believe the information provided by the instruments.

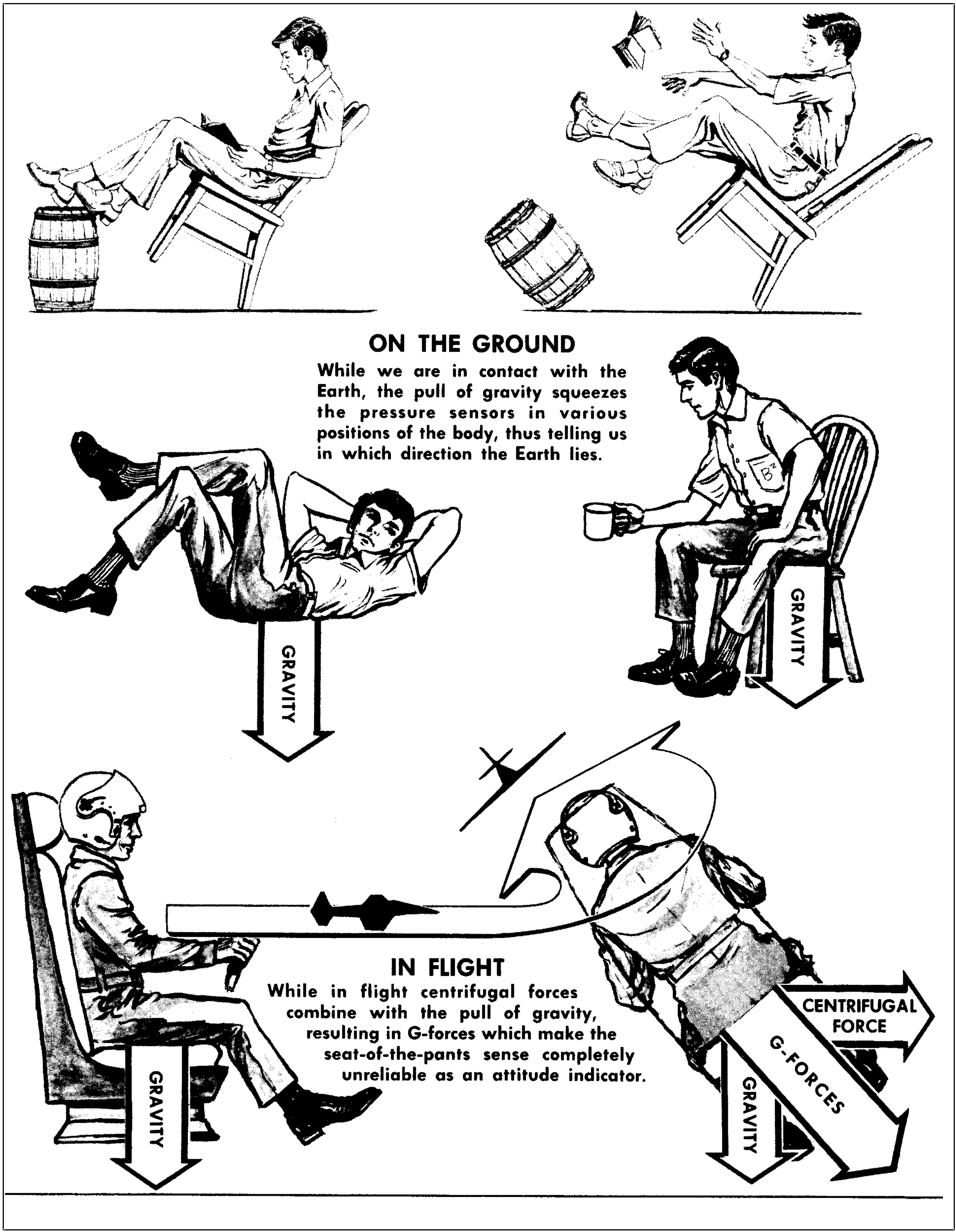
Figure 22.2. Vestibular (Inner Ear) System (para 22.2.1).



22.2.2.3.3. Aided Night Vision. When night vision goggles (NVGs) are employed, the aviator regains external visual references that are not available with natural, unaided vision at night. However, the image provided by NVGs has specific visual limitations; i.e. resolution, field of view, automatic brightness control, and sensitivity to near infrared energy. NVG aviators receive specific training to deal with these factors that combine to produce certain effects, limitations, and illusions not ordinarily encountered in unaided vision. For orientation, a constant aggressive scanning pattern is essential. Utilizing an effective scanning technique compensates for the narrow field of view by enlarging the external field of regard of the aviator. Cockpit instruments are viewed directly by looking beneath the goggles. When employed under appropriate conditions, NVGs enhance orientation by providing an external visual scene where none is available without the goggles. However, it should be noted there are operational limitations (such as weather and minimum ambient illumination requirements) to their effectiveness. AFMAN 11-217, Vol 2 contains a detailed discussion of NVGs.

22.2.3. Somatosensory System (Figure 22.3). Buried in many body structures, including the skin, joints, and muscles, the somatosensory sensors provide important equilibrium information as they respond to pressure and stretch. The sensations they elicit are the pressing feelings that you experience when you sit or the sensations that enable you to know the relative positions of your arms, legs, and body. This system is commonly called the “seat-of-the-pants” sense because some early pilots believed they could determine which way was down by analyzing which portions of their bodies were subject to the greatest amount of pressure. As illustrated in Figure 22.3, the “seat-of-the-pants” sense is completely unreliable as an attitude indicator.

Figure 22.3. Somatosensory System -- The Seat-Of-The-Pants Sense (para 22.2.3).



22.2.4. Auditory System. The auditory response in flight is unique in that it is an acquired skill. Pilots learn early in UPT that when the aircraft is going fast, there is more airframe/canopy wind noise, and when the aircraft is going slow, the noise level decreases. Thus, the pilot is able to grossly discern airspeed by the noise level in the cockpit. For some pilots, the first clue that they are disoriented is a mismatch between the sounds they expect to hear, based upon their perceived attitude, and the actual “wind” noise present.

22.3. Physiological Mechanics of Illusions.

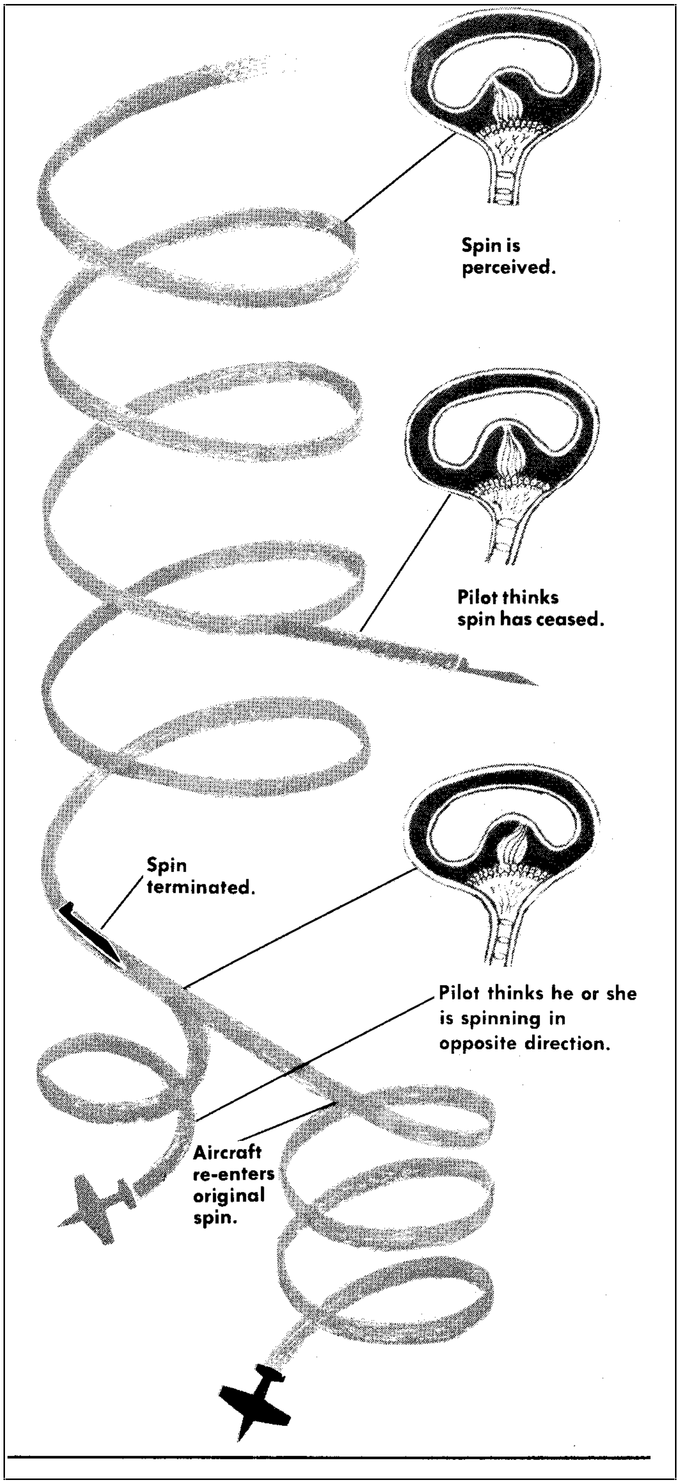
22.3.1. Vestibular Illusions. In the absence of adequate visual orientation cues, the inadequacies of the vestibular and somatosensory systems can, and generally do, result in orientational illusions. It is customary to discuss vestibular illusions in relation to the two components that generate the illusions--the semicircular canals and the otolith organs.

22.3.1.1. Somatogyral Illusion. This set of illusions result from the semicircular canals’ inability to register accurately a prolonged rotation, i.e., sustained angular velocity.

22.3.1.1.1. Graveyard Spin (Figure 22.4). This situation begins with the pilot intentionally or unintentionally entering a spin. The pilot’s first impression is accurate; that is, a spin is perceived. After about 10 to 20 seconds of constant rotation (no angular acceleration), the fluid in the canals comes to rest with respect to the canal walls and the sensory hairs return to the upright, resting position. The sensation is that of no rotational motion despite the fact that the spin continues. If the spin is then terminated, the angular deceleration produced causes a relative motion between the fluid and the canal walls, thus deviating the sensory hairs in the opposite direction. The pilot erroneously perceives spinning in the opposite direction. If the pilot does not recognize the illusion and acts to correct this false impression, he or she will put the aircraft back into the original spin.

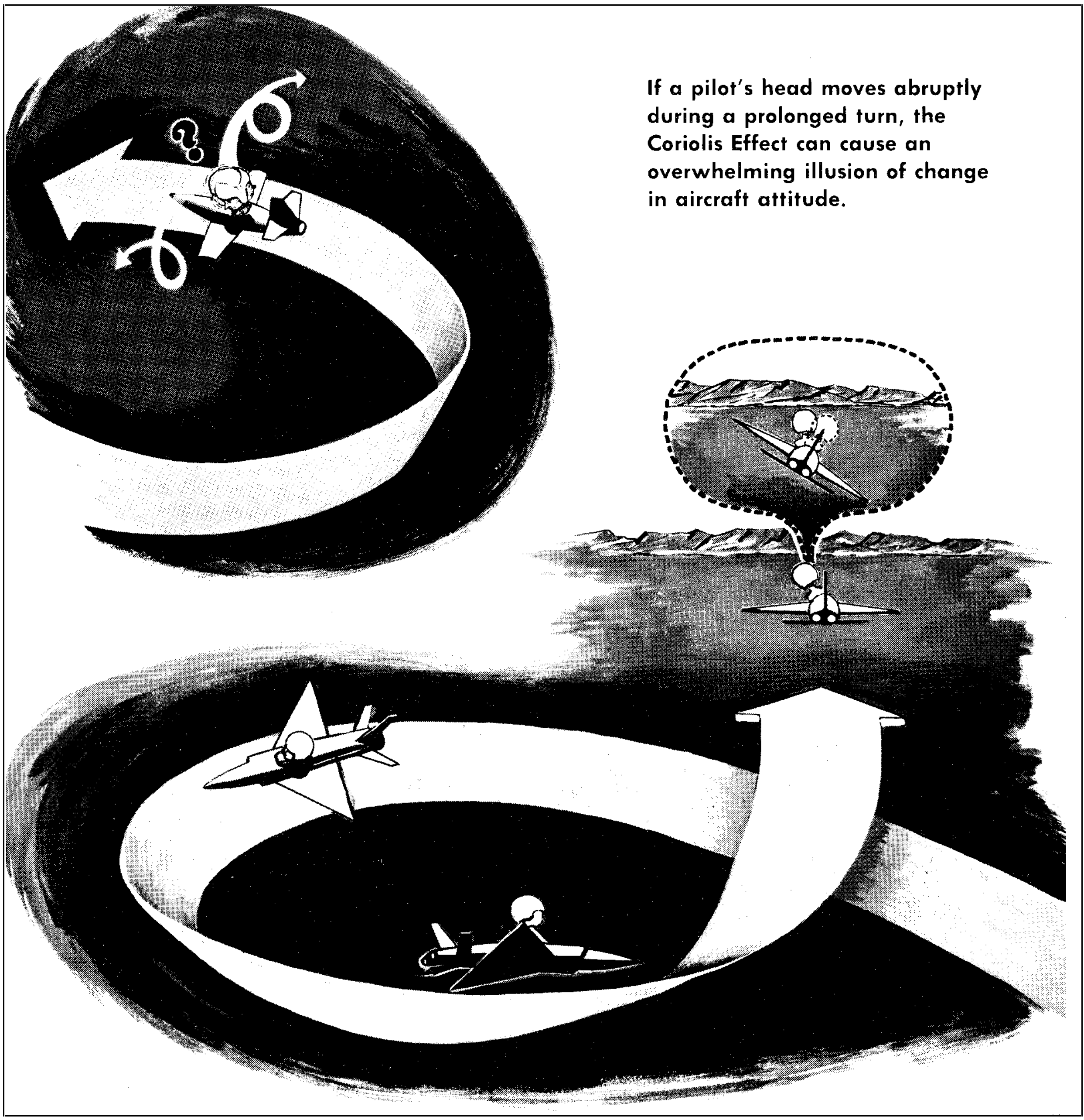
22.3.1.1.2. Graveyard Spiral. In this maneuver the pilot has intentionally or unintentionally put the aircraft into a prolonged turn with a moderate or steep bank. The constant rate of turn causes the pilot to lose the sensation of turning after a period of time. Noting a loss of altitude, the pilot may pull back on the controls or perhaps add power in an attempt to regain the lost altitude. Unless the incorrectly perceived bank attitude is corrected, such actions only serve to tighten a downward spiral. Once the spiral has been established, the pilot will suffer the illusion of turning in the opposite direction after the turning motion of the aircraft has stopped. Under these circumstances, if the pilot fails to suppress all sensory data except the visual, vestibular illusions may cause inappropriate inputs, resulting in re-establishment of the spiral.

Figure 22.4. Graveyard Spin/Spiral (para 22.3.1.1).



22.3.1.2. Coriolis Illusion (Figure 22.5). During high turn rates, abrupt head movements may cause pilots to perceive maneuvers they are not actually doing. When the body is in a prolonged turn in one plane, the fluid in those canals stimulated by the onset of the turn eventually comes up to speed with the canal walls. If the head is then tilted in another plane, the angular momentum of the fluid causes it to move again relative to the canal walls. The resulting sensation is one of rotation in a third plane. If pilots try to correct for the illusion, they may put the aircraft in a dangerous attitude. The coriolis illusion is probably not as important in flight as it was once thought to be, because the relatively low turn rates of instrument flight make coriolis illusion very difficult to generate.

Figure 22.5. The Coriolis Illusion and the Leans (para 22.3.1.2 and 22.3.1.3).

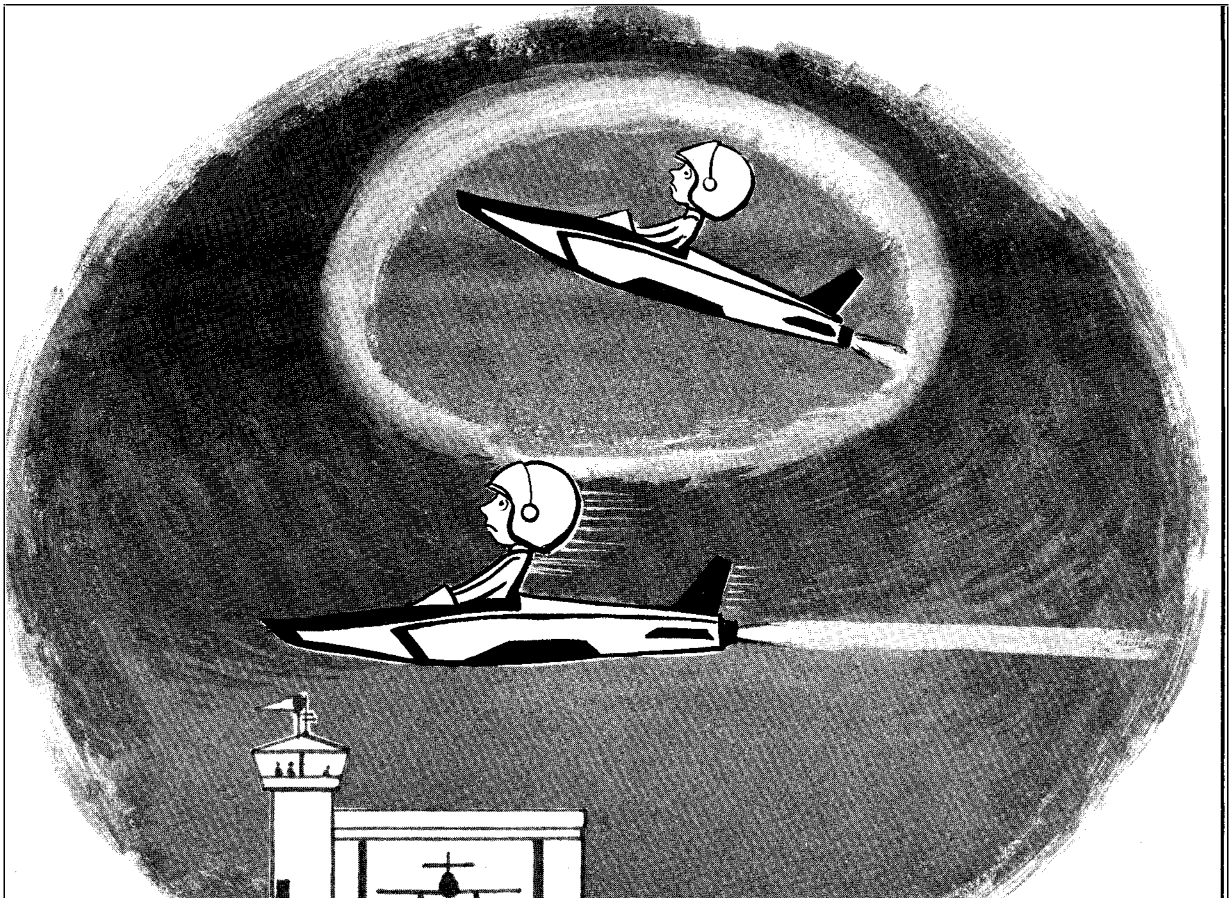


22.3.1.3. The Leans. This is the most common vestibular illusion and is caused by rolling or banking the aircraft after the pilot has a false impression of the true vertical. After a prolonged turn, the pilot may perceive a roll to wings level as a bank and turn in the opposite direction. This can cause pilots to lean in an attempt to assume what they think is a vertical posture. If they establish a very slow roll to the left that does not stimulate the vestibular apparatus and then roll rapidly to the right to level flight, they may generate the false impression of only having rolled to the right, and the leans may result. The leans are most commonly felt when flying formation on the wing in the weather or at night. Since the wingman's attention is on the flight lead and not on the attitude display, it becomes easy for the vestibular or somatosensory system to provide false orientation cues, often reinforced by false ambient visual cues. These false orientation cues can quickly convince the wingman of being in an "unusual" attitude and cause a strong case of the leans. To minimize the effects of the leans while on the wing, it is important for the wingman to occasionally cross-reference the attitude display, without making a head movement if possible. Thus, the pilot must use focal vision to overcome the false cues and to acquire accurate spatial orientation information.

22.3.1.4. Somatogravic Illusion. The otolith organs are responsible for a set of illusions known as somatogravic illusions. This type of illusion is the sensation of change in attitude when the otolith organs are stimulated by linear acceleration. A false nose high sensation can occur when an aircraft accelerates forward in level flight. This somatogravic illusion may be unrecognized during an IMC takeoff or missed approach acceleration if the pilot is not concentrating on flying instruments. Correcting for this illusion during climbout could cause the pilot to dive the aircraft into the ground. A false nose-down sensation can occur as a result of rapid deceleration in the weather. This somatogravic illusion can be particularly disorienting during the "drag" maneuver of an ASLAR approach in IMC because the wingman is required to transition rapidly from wing references to cockpit instrument references at the same time the deceleration occurs. When the pilot is not concentrating on flying instruments, the illusion may not be recognized. By correcting for the illusion of nose-low pitch caused by deceleration on final approach, the pilot may create a low altitude stall.

22.3.1.4.1. Inversion illusion (Figure 22.6). A variant of somatogravic illusion is the inversion illusion, in which G forces act on the otolith organs to give the pilot the feeling of being upside down when the pilot actually is upright but pulling negative Gs. Although the inversion illusion is of greatest magnitude in high-performance aircraft, it can occur in any aircraft. The pilot can overcome the illusion by paying attention to valid external visual references or to aircraft attitude instruments.

Figure 22.6. The Somatogravic Illusion (para 22.3.1.4).



When an aircraft accelerates forward, inertia causes the otolithic membrane in the otolith organs to move. This results in the sensation of climbing, and may cause the pilot to dive in an attempt to compensate for illusory change of attitude.

22.3.1.4.2. G-excess illusion. Although not really a somatogravic illusion, the G-excess illusion does depend on otolith-organ mechanisms. The G-excess illusion is an exaggerated sensation of body tilt caused by a greater that 1-G force on the otolith organs. The additional G force (that amount greater than 1 G) increases the response of the otolith organs, causing the false perception (illusion) of an excessive amount of pitch or bank. When a pilot's head is facing forward in a G-pulling turn, the G-excess effect causes a false percept the aircraft has tilted backwards (pitched up). In the absence of overriding visual cues, the pilot can make dangerous attitude control errors to correct for the G-excess illusion. If the pilot is looking at the "9 o'clock level" position while in a left turn, the G-excess effect would create the illusion the pilot's direction of gaze is above the actual direction; i.e., the aircraft is in less of a bank than is actually the case. The pilot would compensate for the illusion by overbanking. Because of the G-excess illusion, the pilot may be in a bank somewhat greater than the perceived bank angle, and feel comfortable in it. The G-excess effect and the illusion of underbank do not necessarily disappear as a result of the compensatory overbank. The same phenomenon can occur repeatedly as long as the G load is maintained. Thus, even though the initial perceptual error may be small, the accumulation of erroneous compensatory control input can result in a rapidly developing severe overbank and the accompanying earthward velocity vector.

22.3.1.5. Nystagmus. During and immediately after maneuvers resulting from particularly violent angular accelerations, such as spins and rapid aileron rolls, the vestibular system can fail to stabilize vision. The eyes can exhibit an uncontrollable oscillatory movement called nystagmus. This eye movement generally results in an inability to focus on either flight instruments or outside visual references. Rolling maneuvers are especially likely to result in visual blurring because of nystagmus. Normally, nystagmus ceases several seconds after termination of angular acceleration; but under conditions of vestibular dominance and high task loading, nystagmus and blurring of vision can persist much longer, even long enough to prevent recovery.

22.3.2. Visual Illusions (Figure 22.7). A wide variety of visual misperceptions are known to occur during flight, and the most common illusions are described here. When flying with NVGs, pilots should be aware that they are susceptible to the same visual illusions but with additional variations. The image intensification process of the goggles can intensify the illusion as well as the ambient light.

Figure 22.7. Visual Illusions (para 22.3.2).

22.3.2.1. Blending of Earth and Sky. At night with both aided and unaided vision, pilots may confuse ground lights with stars. In doing so, the possibility exists of flying into the ground because the perceived horizon is below the actual horizon. Pilots may also confuse unlighted areas of the earth with an overcast night sky. If pilots erroneously perceive ground features (such as the seashore) as the horizon, they are in danger of flying into the unlighted water or terrain above it. A pilot flying with aided night vision may see a fairly bright light source and mistake it for an aircraft or ground light, when in fact it is a distant star with high near infrared energy that is barely visible with unaided vision.

22.3.2.2. NVG Flight Over Water. Flight over water is particularly dangerous with NVGs since water is virtually invisible to NVGs unless some surface texture is present. A frequent cause of spatial disorientation with NVGs has been the reflection of stars by water surfaces. Therefore, NVG flight over water should be conducted with an increased reliance on instruments as if the aircraft were in IMC. Because of the number of illusions that can occur, extraordinary vigilance must be maintained in the aircrew's crosscheck between outside visual references and instrument references to prevent misinterpretation of the NVG scene.

22.3.2.3. False Vertical and Horizontal Cues. Flying over sloping cloud decks or land that slopes gradually upward into mountainous terrain often compels pilots to fly with their wings parallel to the slope, rather than wings-level, or to climb or descend with the slope. A related phenomenon is the disorientation caused by the aurora borealis in which false vertical and horizontal cues generated by the aurora result in attitude confusion in pilots trying to fly formation or refuel at night in northern regions.

22.3.2.4. No Vertical or Horizontal Cues. This situation is especially hazardous during night formation flights when the only outside reference is the lights of the lead aircraft. Frequent cockpit instrument scans, to include altitude, are essential when taking "spacing." Keeping the leader's lights in the same relative position on the windscreen does not ensure adequate horizontal or vertical spacing, nor does it ensure adequate height above the terrain. Especially during deceleration, when aircraft pitch attitude increases, keeping lead in the same position on the windscreen can cause a substantial loss of altitude. Night intercepts are especially dangerous without frequent instrument crosschecks. An overshoot and subsequent pullback toward lead can be confusing if you think that you are below the lights when in reality you are level (altitude-wise) with the lights but in a 90-degree bank. A maneuver to offset yourself to one side or the other could have disastrous results.

22.3.2.5. Undetected IMC. A particular hazard exists when flying with NVGs in weather conditions conducive to the formation of thin clouds or fog. NVGs are primarily sensitive to near infrared energy, and near infrared energy is poorly reflected by moisture. A pilot using NVGs will be able to detect dense clouds or fog, especially clouds silhouetted against a clear sky. However, thin clouds or fog may actually be invisible with NVGs, because not enough energy is reflected from their surface to create an image. Of more significance is the situation where thin clouds are obscuring slightly thicker clouds, which are themselves obscuring somewhat more dense clouds. There may not be enough contrast between succeeding cloud banks to alert aviators to IMC conditions prior to inadvertent entry. It is possible to enter IMC without ever detecting its presence while utilizing NVGs. To combat this phenomenon, NVG pilots must be aware of slight changes in the quality of the NVG image. As the illumination level decreases with the increasing cloud cover, the automatic brightness control in the goggle adjusts to maintain constant image luminance. After the goggles reach maximum brightness, the image will begin to degrade. The pilot must interpret the degraded image in the NVG image as a warning that environmental conditions may be deteriorating.

22.3.2.6. Vection Illusions. A sensation of self-motion induced by relative movement of viewed objects is called vection. Such sensations are frequently illusory, and can be of linear (translational) or angular (rotational) movement. An example of a linear vection illusion is that of an adjacent automobile creeping forward at a stoplight and creating the sensation that one's own vehicle is creeping backwards. In formation flying, such illusions are common. An example of an angular vection illusion is the feeling of rotation one can experience when the revolving refection of a rotating anti-collision light is viewed in fog or clouds.

22.3.2.7. Visual Autokinesis. A stationary light stared at for 6 to 12 seconds in the dark will appear to move. This phenomenon can cause considerable confusion in pilots flying formation or rejoining on a tanker at night. To minimize or overcome this phenomenon: (a) shift your gaze frequently to avoid prolonged fixation on the light, (b) view the target beside or through, and in reference to, a relatively stationary structure such as a canopy bow, (c) make eye, head, and body movements to try to destroy the illusion, and (d) as always, monitor the flight instruments to prevent or resolve any perceptual conflict. Increasing the brilliance, size, and number of lights, or causing the lights to flash, will diminish the effect of the autokinesis phenomenon.

22.3.2.8. Flicker Vertigo. Rare individuals are susceptible to flickering lights, and can experience unusual sensations caused by the passage of light through propellers or rotor blades or by flashing strobe lights. Light flickering at frequencies from 4 to 20 times per second can produce nausea, dizziness, convulsions, and even unconsciousness in those individuals.

22.3.2.9. Black-Hole Conditions. Black-hole conditions are encountered when flying on a dark night over water or unlighted terrain with an indiscernible horizon. Pilots without peripheral visual cues needed for orientation develop a sense of stability and misperceive their reference (e.g., flight lead or a lighted runway) is moving about or is malpositioned.

22.3.2.10. Induced Motion Illusion. Induced motion illusion is the perceived motion of objects that are not actually moving, when other objects are physically moving instead. Induced motion is most vivid with indiscernible backgrounds such as "black-hole" conditions (e.g., the illusion of rising light can be an undetected descent).

22.3.3. Somatosensory Illusions.

22.3.3.1. The Seat-of-the-Pants Sense. Pilots can be deceived if they interpret the pressure sensations experienced during flight as meaning the same thing they would in an earth bound situation (i.e., pressure on the seat-of-the-pants indicates down). In flight, this pressure sensation is misleading because during coordinated flight, the force resulting from centripetal acceleration and gravity are always toward the floor of the aircraft. Thus, pilots can never tell through the pressure sensors which direction is the true vertical.

22.3.3.2. Giant Hand Illusion. The giant hand phenomenon is a subconscious reflex behavior, generated by vestibular or somatosensory inputs that interfere with the pilot's conscious control of the aircraft. This illusion gives the impression that some external force is pushing on the aircraft or holding it in a certain attitude. When disorientation is primarily about the roll axis, as with the leans or graveyard spiral, the pilot may see deviation from the desired attitude on the attitude indicator, apply the appropriate stick pressure to roll the aircraft to reduce the unwanted bank angle, and discover that efforts to roll the aircraft appear to be resisted. The aircraft either won't let the pilot roll or, once the airplane has been rolled to the proper attitude, it rolls back to the original attitude as if a giant hand were pushing a wing down. When the disorientation is about the pitch axis, as it is when a somatogravic illusion of pitch-up occurs during forward acceleration, the pilot may experience what feels as excessive nose down trim and the aircraft appears to resist efforts by the pilot to pull the nose up, as if a giant hand were pushing the nose down.

22.3.3.2.1. Reflex Actions. The giant-hand phenomenon is thought to occur as a result of pilot reflex actions during disorientation. Remember, our reflexes are geared to a ground-based environment and, therefore, rely on vestibular and somatosensory inputs to determine which way is up. During disorientation, the desired control input is in conflict with the reflex input, giving the illusion of some external force acting on the aircraft.

22.3.3.2.2. Overcoming the Giant Hand. To overcome the giant hand illusion, the pilot should momentarily remove his or her hand from the control stick to interrupt the reflex response. A positive effort must then be made on the controls to move the attitude indicator to the proper attitude. Some pilots have reported that they used their fingertips or knees to move the controls to keep the illusion dispelled. When they gripped the controls in the usual manner, the apparent control anomaly returned. Clearly, the pilot must be sufficiently knowledgeable about the giant hand illusion to suspect it when the possibility of spatial disorientation exists.

22.4. Types of Spatial Disorientation. There are three distinct types of spatial disorientation. Type I is unrecognized spatial disorientation; the pilot is unaware that anything is wrong and controls the aircraft in response to the false sensations of attitude and motion. Type II is recognized disorientation; the pilot is aware that something is wrong, but may not realize that the source of the problem is spatial disorientation. Type III is incapacitating spatial disorientation; the pilot knows something is wrong, but the physiological or emotional responses to the disorientation are so great that the pilot is unable to recover the aircraft. This may result from the pilot's inability to obtain visual information due to blurring of vision (nystagmus). An example of each type of disorientation follows:

22.4.1. Example of Type I SD. The last of four aircraft took off on a daytime sortie in the weather, intending to follow the other three in a radar in-trail departure. Because of a navigational error shortly after takeoff, the pilot was unable to acquire the other aircraft on radar. Frustrated, the pilot elected to intercept the other aircraft knowing they would be on the arc of the Standard Instrument Departure. The pilot proceeded directly to that point, scanning the radar diligently for the blips that should be appearing at any time. Meanwhile, after climbing to 4,000 feet above ground level, the pilot entered a 2,000-3,000 foot per minute descent as the result of an unrecognized, 3-degree nose-low attitude. After receiving requested position information from another member of the flight, the mishap pilot suddenly made a steeply banked turn, either to avoid a perceived threat of collision or to join up with the rest of the flight. Unfortunately, the pilot had already descended far below the other aircraft and was going too fast to avoid the ground. This mishap resulted from unrecognized, or Type I, disorientation. The specific illusion responsible was the somatogravic illusion created by the forward acceleration of the aircraft during takeoff and climbout. Preoccupation with the radar scanning compromised the pilot's instrument crosscheck to the point where the false vestibular cues were able to dominate orientational information processing. Having accepted this inaccurate spatial orientation "feeling", the pilot controlled the aircraft accordingly until it was too late to recover.

22.4.2. Example of Type II SD. On a clear day with unlimited visibility and a distinct horizon, the pilot was flying a two-on-two air combat training mission over water. After a series of roll reversals during the engagement, the pilot thought the aircraft was straight and level when the pilot acquired the bandits slightly low and to the right. In reality, the pilot was in a 90-degree left bank looking up at the other aircraft. To ensure a successful separation, the pilot rolled to the left and pulled to raise the nose slightly. Actually, the pilot had rolled almost inverted and pulled down. What alerted the pilot to being disoriented was that the aircraft sounded as if it was going very fast. When the pilot looked inside and checked, the instruments showed the pilot was in an inverted 60-70 degree dive accelerating through Mach. The recovery was all instinct: roll to the nearest horizon and pull. The pilot pulled 12.5 G during the recovery and bottomed out at 2,000 feet above the water. This incident of recognized, or Type II, spatial disorientation occurred because of channelized attention on the second bandit, a breakdown of crosscheck, and subsequent loss of attitude awareness. Type II SD happens more often than mishap reporting would indicate and is a known hazard associated with employing an aircraft as a weapons platform.

22.4.3. Example of Type III SD. On a clear day three aircraft were engaged in vigorous air combat tactics training. One pilot initiated a hard left turn at 17,000 feet above ground level. For reasons that have not been established with certainty, the pilot's aircraft began to roll to the left at a rate estimated at 150 to 220 degrees/second. The pilot transmitted, "out-of-control autoroll," while descending through 15,000 feet. The pilot made at least one successful attempt to stop the roll as evidenced by the momentary cessation of the roll at 8,000 feet; then the aircraft began to roll again to the left. Forty seconds elapsed between when the rolling began and when the pilot ejected--but too late. Regardless of whether the rolling was caused by a mechanical malfunction or was induced by the pilot, the certain result of this extreme motion was vestibulo-ocular disorganization, which not only prevented the pilot from reading the instruments but also kept the pilot from orienting with the natural horizon. Thus, incapacitating, or Type III, disorientation probably prevented the pilot from taking corrective action to stop the roll and keep it stopped; if not that, it certainly compromised the pilot's ability to assess accurately the level to which the situation had deteriorated.

22.5. Causes of Spatial Disorientation. There are a number of conditions or factors that will increase the potential for spatial disorientation. Some of these situations are physiological in nature (human factors) while others are external factors related to the environment in which the pilot must fly. Awareness on the part of the pilot is required to reduce the risks associated with these situations and factors.

22.5.1. Personal Factors. Mental stress, fatigue, hypoxia, various medicines, G stress, temperature stresses, and emotional problems can reduce the pilot's ability to resist spatial disorientation. A pilot who is proficient at accomplishing and prioritizing mission tasks (with an efficient instrument crosscheck), is mentally alert, and is physically and emotionally qualified to fly will have significantly less difficulty maintaining orientation. On the other hand, a pilot who becomes task-saturated easily; fails to properly prioritize tasks; is mentally stressed; is preoccupied with personal problems; or is fatigued, ill, or taking non-prescribed medication is at increased risk of becoming disoriented.

22.5.2. Workload. A pilot's proficiency on instruments and formation flying is decreased when he or she is busy manipulating cockpit controls, anxious, mentally stressed or fatigued. When the pilot is distracted from cross-checking the instruments during task intensive phases of flight in marginal weather or reduced visibility conditions, the pilot's ability to recognize and resist spatial disorientation is severely diminished.

22.5.3. Inexperience. Inexperienced pilots with little instrument time are particularly susceptible to spatial disorientation. It takes time and experience to "feel" comfortable in a new aircraft system and develop a solid, effective instrument crosscheck. A pilot who still must search for switches, knobs, and controls in the cockpit has less time to concentrate on flight instruments and may be distracted during a critical phase of instrument flight. The cockpit workload associated with complex aircraft is particularly significant for the recent pilot graduate or pilots new to these systems. A second crewmember is not always available to change radio channels, set up navigation aids, and share other cockpit chores. Therefore, it is essential for an effective instrument crosscheck to be developed early and established during all phases of flight. Other cockpit duties, like radio changes, radar operation, etc., must not be allowed to distract the pilot from basic instrument flying.

22.5.4. Proficiency. Total flying time does not protect an experienced pilot from spatial disorientation. More important is current proficiency and the number of flying hours or sorties in the past 30 days. Aircraft mishaps due to spatial disorientation generally involve a pilot who has had limited flying experience in the past 30 days. Flying proficiency begins to deteriorate rapidly after 3 or 4 weeks out of the cockpit. Vulnerability to spatial disorientation is high for the first few flights following a significant break in flying duties.

22.5.5. Instrument Time. Pilots with less instrument time are more susceptible to spatial disorientation than more experienced pilots. Many spatial disorientation incidents have been reported during the penetration turn, final approach, climbout after takeoff, trail departures, and while performing high-performance flight maneuvers. This is when the vestibular illusions are the most devastating. Other very critical times are at night and during weather formation flights, when the wingman loses sight of the lead or when a pilot flying in VMC suddenly enters IMC.

22.5.6. Phases of Flight. Although distraction, channelized attention, and task saturation are not the same as spatial disorientation, they precipitate it by keeping the pilot from maintaining an effective instrument crosscheck. Spatial disorientation incidents have occurred during all phases of flight. During the following critical phases pilots are particularly susceptible to becoming spatially disoriented because of the extra potential for distraction, channelized attention, and task saturation.

22.5.6.1. Takeoff and Landing. The takeoff and landing phase of flight is a dynamic and demanding environment. Aircraft acceleration, speed, trim requirements, rate of climb or descent, and rate of turn are all undergoing frequent changes. The aircraft may pass in and out of VMC and IMC. At night, ground lights may add confusion. Radio channel or IFF/SIF changes may be directed during a critical phase of flight while close to the ground. Unexpected changes in climbout or approach clearance may increase workload and interrupt an efficient instrument crosscheck. An unexpected requirement to make a missed approach or circling approach at night or in IMC is particularly demanding, and at a strange field with poor runway lighting, even more demanding.

22.5.6.2. Air-to-Ground. Another critical phase of flight, with a high potential for spatial disorientation, is the maneuvering associated with air-to-ground ordnance deliveries during night or periods of reduced visibility and air combat maneuvers. Again, under such conditions the only completely reliable information related to aircraft attitude is provided to the pilot by the flight instruments. Because of the nature of the mission, the pilot's attention is directed outside the cockpit. Potential for distraction is great. What the pilot sees outside the cockpit may be misleading or the pilot may fail to scan an important instrument parameter (such as attitude, airspeed, altitude, or vertical velocity) during a critical phase of the weapons delivery. These factors easily can lead to an unrecognized spatial disorientation or "lack of attitude awareness" in which the pilot inadvertently places the aircraft in a position from which recovery is impossible.

22.5.6.3. Formation Flying. A demanding situation with a high potential for creating spatial disorientation is night or weather formation flying. Formation flying presents special problems to the pilot in maintaining spatial orientation. First and most important, pilots flying on the wing cannot maintain appropriate visual dominance. They are deprived of any reliable visual information concerning aircraft attitude related to the earth's surface. They cannot see the true horizon and have little or no time to scan their own instruments. Under these conditions, it becomes difficult to suppress information provided by unreliable sources such as the vestibular system. Illusions of various kinds are almost inevitable. A pilot's concentration on maintaining proper wing position may be compromised by what the pilot "feels" the aircraft attitude to be. Lack of confidence in lead will increase tension and anxiety. An inexperienced, rough, flight lead will most certainly aggravate the situation. Poor in-flight communications and the lack of specific procedures (properly briefed) to recover a disoriented wingman will increase the potential for an aircraft mishap.

22.6. Prevention of Spatial Disorientation Mishaps. The pilot's role in preventing mishaps due to spatial disorientation essentially involves three things: training, good flight planning, and knowledge of procedures. It must be emphasized that the key to success in instrument flying is an efficient instrument crosscheck. The only reliable aircraft orientation information, at night or in IMC, is provided by the flight instruments. Any situation or factor that interferes with this flow of information, directly or indirectly, increases the potential for disorientation.

22.6.1. Training. The training and education of the pilot about the dangers of spatial disorientation begin with the information in this chapter. Additional information is provided by flight surgeons, aerospace physiologists, IRC instructors, and flying safety officers through lectures, slide presentations, films, video tapes, and safety journals. Experienced pilots can pass on valuable information to new crewmembers in flight briefings and squadron meetings.

22.6.1.1. Basic Knowledge. The effects of spatial disorientation can be minimized through an understanding of the physiological mechanisms that cause various illusions, the phases of flight where the illusions can be expected, and a plan of action (procedure) to follow in dealing with sensory conflicts once they occur.

22.6.1.2. Flight Simulators. Aircraft simulators are excellent training devices for learning instrument flight procedures. Some special-purpose devices used in physiological training, such as the Vertifuge, effectively demonstrate some of the illusions that can occur in IMC.

22.6.1.3. Actual Aircraft. Regular and frequent instrument flight in the aircraft either under the hood (if available), at night, or in actual weather conditions is necessary to provide the pilot the experience and confidence needed to fly safely in instrument conditions.

22.6.2. Flight Planning. Thorough preflight planning is important in reducing the potential for spatial disorientation incidents, particularly in fighter-type aircraft. It is difficult for a pilot to fly the airplane and maintain an effective instrument crosscheck while searching for information in the IFR supplement.

22.6.2.1. General information. Before takeoff acquire all of the information needed to safely complete an instrument flight. This is particularly important for cross-country flights to strange fields in night weather conditions. The remarks section of the IFR Supplement Airport/Facility Directory and FLIP AP/l should be checked for known approach illusions. Attention should be directed during flight planning to events that may be unexpected. What are the missed approach procedures? What is the circling minimum descent altitude (MDA)? What type of runway lighting system is installed at the alternate airfield?

22.6.2.2. Specific situation. If available at the base of intended landing, pilots flying single-seat aircraft should plan to make a single frequency, en route descent to a radar monitored, precision approach during night or IMC.

22.6.3. Procedures. It is important that aviators have an established set of recommended procedures to follow in the event they experience spatial disorientation. The general procedures put forth here may differ depending on type of aircraft (such as single-seat, dual-seat, or crew-type aircraft) or type of mission (formation flight or NVG flight). Additionally, commands normally establish specific procedures for aircraft under their control. A few general principles can be stated here.

22.6.3.1. General Principles. Any pilot who does not continually monitor the flight instruments during IMC, night, and other conditions of reduced visibility will become spatially disoriented in a matter of seconds. The pilot may divert attention from the instruments just long enough to study an approach plate, look for a wingman, or assess the effect of a weapons drop, and feel perfectly comfortable while Type I disorientation develops. The pilot may either fly the aircraft into the ground without realizing the error, may look back at the instruments and regain orientation immediately but too late to prevent a mishap, or may develop Type II disorientation and have to struggle with a sensory conflict to maintain control of the aircraft. The general procedure for dealing with spatial disorientation is the same for all aircraft.

22.6.3.1.1. Recognize Problem. If a pilot begins to feel disoriented, the key is to recognize the problem early and take immediate corrective actions before aircraft control is compromised.

22.6.3.1.2. Reestablish Visual Dominance. The pilot must reestablish accurate visual dominance. To do this, keep the head in the cockpit, defer all cockpit chores that are not essential, and concentrate solely on flying basic instruments. Make frequent reference to the attitude display that is the primary reference needed to establish and maintain visual dominance. The pilot must make the instruments "read right." Apply the necessary control inputs to make the attitude indicator display the desired orientation and adjust that display to make the other flight parameters fall into line.

22.6.3.1.3. Beware of Persistent Symptoms. If the symptoms do not improve immediately or if they get worse, the pilot should bring the aircraft to straight-and-level flight using the attitude display. Maintain straight-and-level flight until the symptoms abate. Declare an emergency if necessary, and advise ATC of the problem.

22.6.3.1.4. Resolve Sensory Conflict. If action is not taken early, the pilot may not be able to resolve the sensory conflict. It is possible for spatial disorientation to proceed to a point (a true state of panic) where the pilot is unable to either see, interpret, or process information from the flight instruments. Further, it may not be possible to hear or respond to verbal instructions. Aircraft control in such a situation may be impossible. The pilot must admit that physiological limits have been exceeded and the only alternative may be to abandon the aircraft.

22.6.3.1.5. Transfer Aircraft Control. If the pilot experiences spatial disorientation to a degree that it interferes with maintaining aircraft control, then control of the aircraft should be transferred to the second crewmember, if qualified. If an autopilot is available, consideration should be given to using it to control the aircraft.

22.6.3.2. Single-Seat/Solo Aircraft. A pilot alone in an aircraft is more limited in applying these general principles to deal with spatial disorientation. In this situation, the pilot obviously does not have the option to transfer aircraft control, except possibly to the autopilot.

22.6.3.3. Dual-Seat Aircraft. The same general principles stated above apply to a dual-seat aircraft. However, a second crewmember is generally available to share the cockpit workload.

22.6.3.3.1. Division of Workload. The other crewmember can assist the pilot by copying clearances, changing radio/IFF channels, and acquiring information from flight information publications. The division of workload between the crewmembers should be clearly understood and covered in the preflight briefing.

22.6.3.3.2. Critical Phases. During departures, penetrations/en route descents, or critical phases of flight, the second crewmember should closely monitor and call out altimeter settings, altitudes, airspeeds, and other appropriate information.

22.6.3.4. Crew-Type Aircraft. The same general principles stated above plus the comments for dual-seat aircraft apply to crew-type aircraft. Although additional crewmembers are available to reduce pilot workload, illusions and sensory conflicts are possible and do occur. Illusions experienced here are more likely to be visual in origin than vestibular.

22.6.3.4.1. Causes of Disorientation. Weather- and night-related incidents of spatial disorientation occur in these aircraft. The causes are varied but can be related to distractions, poor runway lighting, fatigue, and circadian rhythm problems.

22.6.3.4.2. Crew Coordination. Specific procedures concerning division of workload and crew coordination should be clearly understood and covered in the preflight briefing.

22.6.3.5. **Flying Formation.** All of the general principles for dealing with spatial disorientation apply to formation flights. Additional procedures are necessary since the potential for spatial disorientation is greatest for formation flights during night or weather conditions.

22.6.3.5.1. Proficiency. Pilots scheduled for formation flights in night/IMC should be current and proficient in instrument, night, and formation flying. Particular attention should be directed to the number of sorties and flying hours in the past 30 days.

22.6.3.5.2. Safe Formation Flight. There are two essential requirements for safe formation flight. First, the flight leader must be experienced, competent, and smooth. Second, the wingman must be proficient in formation flying. The wingman must have total confidence in lead and concentrate primarily on maintaining a proper wing position.

22.6.3.5.3. Night Join-ups. Night join-ups are inherently difficult, particularly when conducted at low altitude over water or dark terrain. Alternative profiles, such as a trail departure and climbout, should be considered.

22.6.3.5.4. Deteriorating Weather. If the weather encountered during a formation flight is either too dense or turbulent to ensure safe flight, the flight leader should separate the aircraft under controlled conditions. This may be better than having a wingman initiate lost wingman procedures at a time that may be dangerous or, worse yet, when the wingman is severely disoriented.

22.6.3.5.5. Disoriented Wingman. In the preflight briefing, the flight leader should cover specific procedures to manage a disoriented wingman.

NOTE: Lost wingman procedures are designed to ensure safe separation between aircraft in a flight when a wingman loses sight of lead. Lost wingman procedures are not designed to recover a wingman with severe spatial disorientation. Precise execution is required to perform lost wingman procedures; a severely disoriented pilot may not be able to accomplish this.

22.6.3.5.6. Communication. The flight lead should encourage a wingman to verbalize a feeling of disorientation. A few words from lead may reassure the wingman and may help form a mental picture of the flight's position in space. For example: "Two, we are level at 20,000 feet in a 30 degree left bank at 300 knots."

22.6.3.5.7. Persistent Problem. If the wingman continues to have problems, the lead should bring the flight to straight-and-level and advise the wingman. If possible, maintain straight-and-level for at least 30 seconds and up to 60 seconds. Generally, the wingman's symptoms will subside in 30 to 60 seconds. Advise ATC if an amended clearance is necessary.

22.6.3.5.8. Lead Transfer. If the above procedures are not effective, then lead should consider transferring the flight lead position to the wingman while straight-and-level.

NOTE: Once assuming lead, maintain straight-and-level flight for 60 seconds before initiating turns, climbs, or descents. The objective is for the disoriented pilot to reestablish visual dominance as quickly as possible. Again, a wingman who is severely disoriented should normally not elect or be directed to execute lost wingman procedures. At this point, consideration should be given to terminating the mission and recovering the flight by the simplest and safest means possible. Under exceptional circumstances, however, when the above procedures are ineffective and the disoriented wingman cannot continue to fly formation safely, the lost wingman procedure and single ship recovery are a viable last resort.

22.6.3.5.9. Lost Wingman. Spatial disorientation may not be experienced until the pilot executes lost wingman procedures. Sudden vestibular and other erroneous sensory inputs may not agree with instrument indications. It is most important at that moment for the pilot to believe and trust the attitude display and to make the attitude display reflect the desired aircraft orientation.

Chapter 23

INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO) PROCEDURES

23.1. Introduction. The ICAO is composed of over 180 member nations, and is a part of the United Nations. Unlike the Federal Aviation Administration (FAA), whose regulations are directive, ICAO is basically an advisory organization that jointly agrees on procedural criteria. These criteria are published in a document called Procedures for Air Navigation Services-Aircraft Operations (PANS-OPS). Individual ICAO member nations may then comply with all, a part of, or none of the criteria published in PANS-OPS. For example, the United States is an ICAO member nation, but uses none of the PANS-OPS procedures. We use the Federal Aviation Regulations for procedural guidance instead. A specific nation's adoption of ICAO criteria makes that criteria directive in that country. When adopted by a participating nation, these procedures are intended to be strictly adhered to by flight crews in order to achieve and maintain an acceptable level of safety in flight operations. The information provided in this chapter is based on the standards of PANS-OPS.

23.1.1. The Continuum of Safety. Even more so than in the United States, international flying requires good judgement on the part of the pilot. The Air Force expects and encourages you to apply it. No book of hard and fast rules could ever hope to cover all the various situations you may encounter everywhere in the world. The global mission of the USAF means that you may well be required to operate in countries without a well-developed aviation system, or into airfields where the ICAO rules have been ignored, replaced or poorly applied. The PIC must necessarily be the final judge of what is safe and prudent for any given mission on any given day.

23.1.2. Applicability. Procedures described in this chapter apply only in airspace not under FAA control. These procedures are ICAO standard procedures and may be modified by each country (as the U.S. has).

23.1.3. Finding Current Information and Procedures. Check the Area Planning FLIP and the FCG to find procedures for specific Theaters, Regions and Countries.

23.1.4. Terminal Instrument Approach Procedures (IAPs). There are many different kinds of approaches published in the DOD FLIP books for regions outside the United States. You may find approaches designed using U.S. TERPs at overseas bases. You may also find approaches designed under the civil PANS-OPS criteria. Or you may find procedures that use host nation criteria that are different from PANS-OPS. Aircraft executing maneuvers other than those intended by the host nation approach design could exceed the boundaries of the protected airspace or may cause overflight of unauthorized areas. ***All ICAO procedures must be flown as they are depicted.***

23.2. Definitions. Here are a few ICAO definitions which differ from those commonly used in the United States.

23.2.1. PANS-OPS. PANS-OPS is a two-part document. The first volume is for pilots, and is similar to the FAA's AIM. The second volume contains the ICAO "TERPs." The document is intended for the use of the international civilian aviation community, not the military. There have been a number of editions of PANS-OPS published since the creation of the ICAO, each with significant changes in the details of instrument approach procedure design. This means that you may find approaches in different parts of the world that have been designed with entirely different rules.

23.2.2. Aircraft Categories. Aircraft approach categories play a much bigger role in the design of ICAO instrument procedures than they do in the U. S. In addition to affecting final approach minimums, PANS-OPS references maximum speeds by category for such operations as holding, departures, and the intermediate segments of instrument approaches. To make matters even more confusing, these additional “category” restrictions specify speeds that are completely different from the familiar approach speeds on final. The appropriate PANS-OPS “category” speeds appear in tables later in this chapter.

23.2.3. Track. The projection on the earth’s surface of the path of an aircraft, the direction of which path at any point is usually expressed in degrees from North. This means you must apply any known winds/drift to maintain the ground path.

23.2.4. Bank Angle. Procedures are based on average achieved bank angle of 25 degrees, or the bank angle giving a rate of turn of 3 degrees per second, whichever is less.

23.2.5. Established on Course. The ICAO defines “established on course” as being within half full scale deflection for an ILS or VOR/TACAN and within ± 5° of the required bearing for the NDB. ***Do not consider yourself “established on course” until you are within these limits.*** ICAO obstacle clearance surfaces assume that the pilot does not normally deviate from the centerline more than one-half scale deflection after being established on track. Despite the fact that there is a range of “acceptable” variation, make every attempt to fly the aircraft on the course centerline and on the glide path. Allowing a more than half-scale deflection (or a more than half-scale fly-up deflection on glideslope) combined with other system tolerances could place the aircraft near the edge or at the bottom of the protected airspace where loss of protection from obstacles can occur.

23.3. Departure Procedures.

23.3.1. Screen Heights. It may be difficult or impossible to accurately determine screen height used for a particular departure procedure. Since most of the world uses the “35 foot” rule used by the FAA, we suggest you do the same unless you can determine that a different screen height applies. Use caution, be conservative, and make use of all available resources when attempting to determine the actual screen height. For a further discussion of the topic, see Chapter 9.

23.3.2. Climb Gradient. ICAO gradients are the same as the FAA’s, but they are expressed as percent gradients instead of ft/NM. ICAO obstacle clearance during departures is based on a 2.5% gradient obstacle clearance (152 feet/NM) and an increasing 0.8% obstacle clearance (48 feet/NM). This equates to a minimum climb gradient of 3.3% (200 feet/NM). Minimum climb gradients exceeding 3.3% will be specified to an altitude/height after which the 3.3% will be used.

23.3.3. Basic Rules for All Departures. PANS-OPS uses the same initial departure concept as the U.S. TERPs. Unless the procedure specifies otherwise, ***you must climb on runway heading at a minimum of 200 feet/NM (3.3%) until reaching 400 feet above the departure end of the runway (DER). Continue to climb at a minimum of 200 feet/NM until reaching a safe enroute altitude.***

23.3.4. Omnidirectional Departures. The PANS-OPS “Omnidirectional Departure” is somewhat similar to the FAA’s “Diverse Departure.” It is a departure procedure without any track guidance provided. There are some very important differences, though, because an Omnidirectional Departure may be published even though obstacles penetrate the 40:1 Obstacle Identification Surface. If this is the case, PANS-OPS gives the departure designer a number of ways to publish departure restrictions. These restrictions may be published singly, or in any combination.

23.3.4.1. Standard case. Where no obstacles penetrate the 40:1 OIS, then no departure restrictions will be published. Upon reaching 400 feet above DER, you may turn in any direction.

23.3.4.2. Specified turn altitude. The procedure may specify a 3.3% climb to an altitude where a safe omnidirectional turn can be made.

23.3.4.3. Specified climb gradient. The procedure may specify a minimum climb gradient of more than 3.3% to an altitude before turns are permitted.

23.3.4.4. Sector departure. The procedure may identify sectors for which either a minimum turn altitude or a minimum climb gradient is specified. (For example, "Climb straight ahead to 2000 feet before commencing a turn to the east/sector 180°-270°).

23.3.5. Departures with Track Guidance (SIDs). PANS-OPS uses the term Standard Instrument Departure (SID) to refer to departures using track guidance. Minimum climb gradients may apply. There are two basic types: straight and turning.

23.3.5.1. Straight departures. Whenever possible, a straight departure will be specified. A departure is considered "straight" if the track is aligned within 15° of the runway centerline.

23.3.5.2. Turning departures. Where a departure route requires a turn of more than 15°, a turning departure may be constructed. Turns may be specified at an altitude/height, at a fix or at a facility. If an obstacle prohibits turning before the departure end of the runway or prior to reaching an altitude/height, an earliest turning point or a minimum turning altitude/height will be specified. When it is necessary, after a turn, to fly a heading to intercept a specified radial/bearing, the procedure will specify the turning point, the track to be made good and the radial/bearing to be intercepted.

–Turning departures are designed with maximum speed limits. These maximum speeds may be published by category or by a note. For example, these procedures may be annotated, "Departure limited to CAT C Aircraft" or "Departure turn limited to 220 KIAS maximum." ***You must comply with the speed limit published on the departure to remain within protected airspace. If you require a higher speed, you must request an alternate departure procedure.***

–If the departure is limited to specific aircraft categories, these are the applicable speeds:

Aircraft Category	Max Airspeed (KIAS)
A	120
B	165
C	265
D	290
E	300

23.4. Low Altitude Approach Procedures.

23.4.1. Procedural Tracks. Procedural Track approaches are the most common way of transitioning from the enroute structure. These approaches are often much more complicated than a comparable U. S. approach, and may include multiple NAVAIDs, fixes and course changes, but they are flown essentially the same as described in Chapter 13.

23.4.2. Reversal Procedures and Racetrack Procedures. If the instrument approach cannot be designed as a procedural track arrival, then a reversal procedure or a racetrack or a holding pattern is required.

23.4.2.1. Reversal Procedures. ICAO "Reversal Procedures" are similar in concept to FAA "Procedure Turns". The ICAO recognizes three distinctly different methods of performing a "reversal procedure", each with its own airspace characteristics:

1. The 45°/180° Procedure Turn (**Figure 23.1**)
2. The 80°/260° Procedure Turn (**Figure 23.2**)
3. The Base Turn (**Figure 23.3**)

Entry is restricted to a specific direction or sector. To remain within the airspace provided requires strict adherence to the directions and timing specified.

NOTE: The protected airspace for "reversal procedures" does not permit a racetrack or holding maneuver to be conducted unless so specified. ***You may not enter an ICAO procedure turn using the "Holding Technique" described in Chapter 13.*** Instead, refer to the entry procedures below.

23.4.2.1.1. The 45°/180° Procedure Turn. This procedure starts at a facility or fix and consists of:

–A straight leg with track guidance; this straight leg may be timed or limited by a radial or DME distance;
–A 45° turn;
–A straight leg without track guidance. This straight leg is timed; it is 1 minute from the start of the turn for categories A and B aircraft and 1 minute 15 seconds from the start of the turn for categories C, D and E aircraft;
–A 180° turn in the opposite direction to intercept the inbound track.

NOTE: ***You must adjust the time or distance on the outbound track to ensure the reversal is initiated at a point specified on the IAP if so depicted, or the maneuver is completed within the specified "remain within" distance.***

23.4.2.1.2. The 80°/260° Procedure Turn. This procedure starts at a facility or fix and consists of:

–A straight leg with track guidance; this straight leg may be timed or limited by a radial or DME distance;
–An 80° turn;
–A 260° turn in the opposite direction to intercept the inbound track.

NOTE: ***You must adjust the time or distance on the outbound track to ensure the reversal is initiated at a point specified on the IAP if so depicted, or the maneuver is completed within the specified "remain within" distance.***

23.4.2.1.3. The Base Turn. This procedure consists of intercepting and maintaining a specified outbound track, timing from the facility or proceeding to a specified fix, followed by a turn to intercept the inbound track.

NOTE: The base turn procedure is not optional. ***You may not fly one of the "procedure turns" described above instead of the depicted base turn.*** More than one track may be depicted depending on aircraft category.

Figure 23.1. 45°/180° Course Reversal.

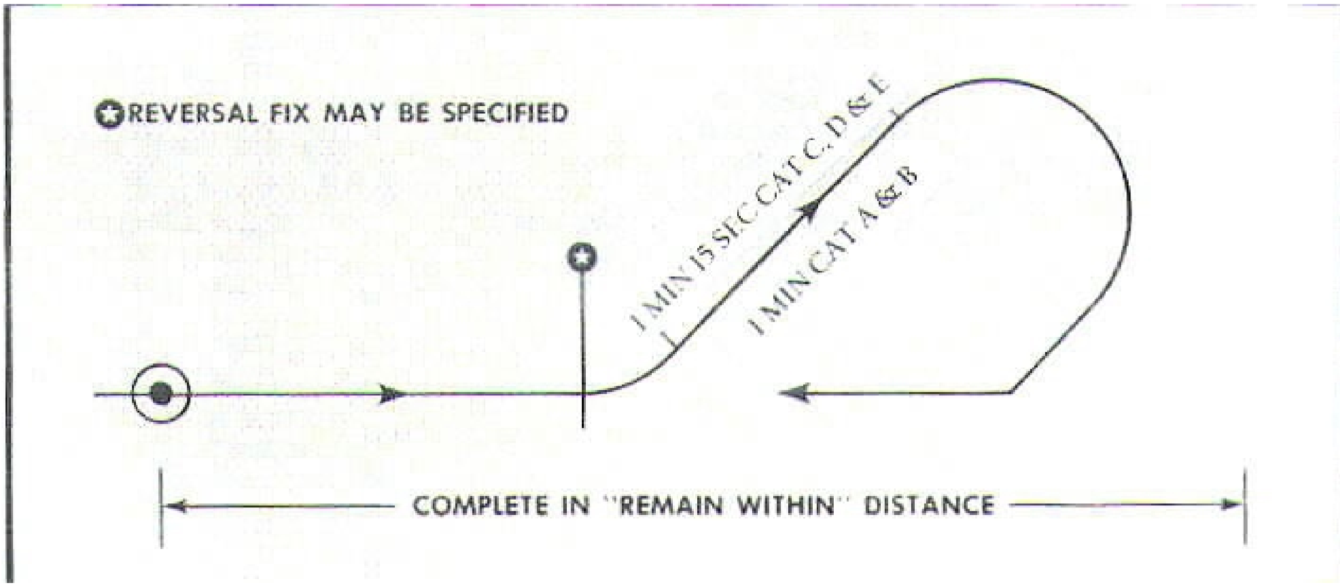


Figure 23.2. 80°/260° Course Reversal.

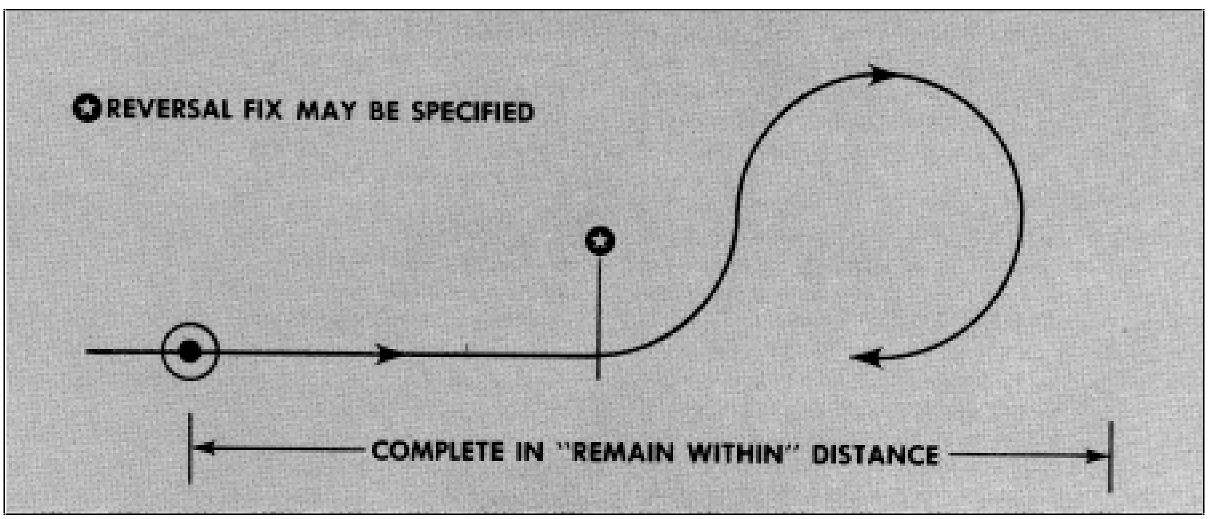
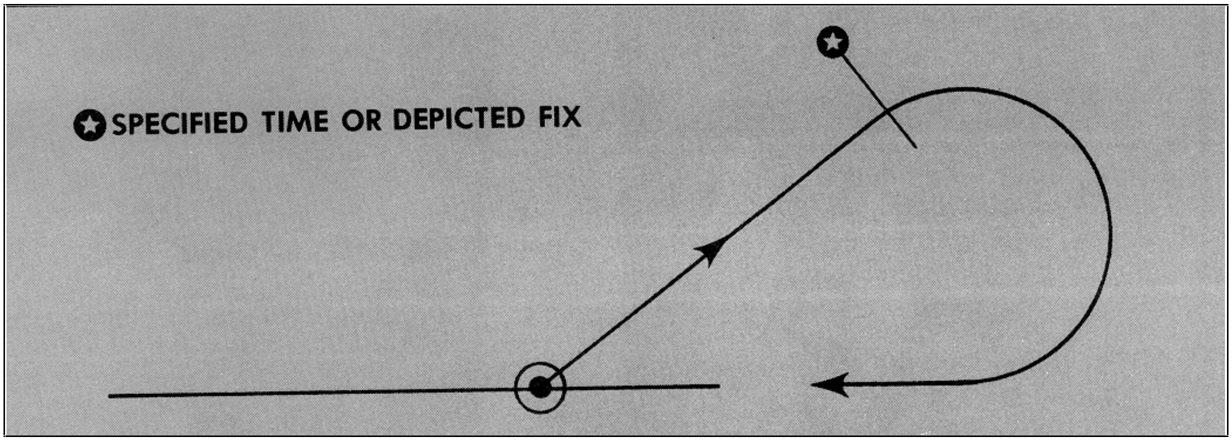


Figure 23.3. Base Turns.



23.4.2.2. Reversal Procedure Entry.

Of all the differences between FAA and ICAO procedures, the entry into the three course reversal maneuvers has historically been the area of greatest confusion for USAF pilots. A short discussion is in order:

23.4.2.2.1. The 30° Entry Sector. The reason PANS-OPS specifies this entry sector is because, unlike in the U. S., the course reversal protected airspace may not include any airspace except that on the outbound side of the procedure turn fix. In the U. S., protected airspace includes a large "entry zone" surrounding the fix.

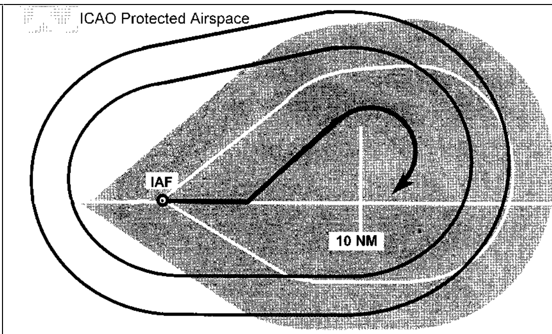
23.4.2.2.2. What if you Arrive From Outside the Entry Sector?

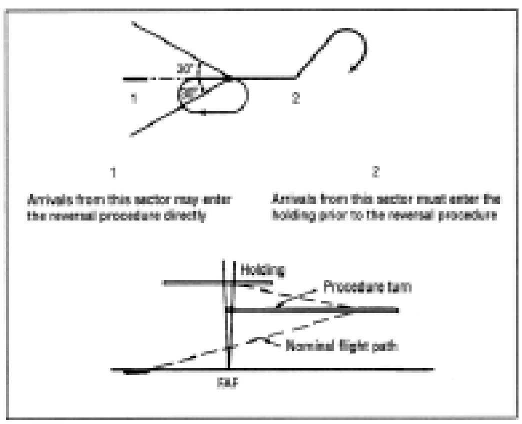
23.4.2.2.2.1. Arrival Routing. There is often some form of published arrival routing into the course reversal IAF, such as a STAR, feeder routing, or arrival airway. This arrival routing may not fall into the 30 degree entry sector. Such arrival routes will be blended into the reversal approach, and protected airspace is provided to allow the pilot to turn onto the outbound reversal track. Pilots need not request "maneuvering airspace" to perform an alignment maneuver. Such requests are often met with confusion by ATC. You should remain within protected airspace on the published arrival routing, whether or not that happens to align you with the 30° entry sector.

23.4.2.2.2.2. Using the Arrival Holding Pattern. On most ICAO course reversals, a holding pattern is published at or near the IAF to accommodate arrivals from outside the 30 degree sector and not on a published arrival routing. PANS-OPS directs pilots arriving from outside the entry sector to enter holding prior to the reversal procedure. In most cases, the holding pattern will align you for the approach.

23.4.2.2.2.3. Off-airway Arrivals. What if there is no suitable Holding Pattern? The danger arises when attempting to perform the course reversal when arriving into the IAF from a direction not anticipated by the approach designer, such as when you request to proceed direct to the fix from a point off the arrival airway. Sometimes there is no holding pattern published for your alignment, or there is a holding pattern that does not turn you into the entry sector. In this case, you will need to maneuver into the entry sector somehow. You must understand how small the protected airspace is, especially when compared to an FAA procedure turn. You may be operating completely outside of protected airspace while proceeding to the IAF, and terrain and obstacle clearance may be totally up to you. Use good judgement, consider the published minimum safe/sector altitudes, and do not rely solely on ATC to keep you safe.

Figure 23.4. Comparison of FAA and ICAO Protected Airspace for a Procedure Turn.

FAA protected airspace for a procedure turn is shown in white, with the ICAO airspace in grey. Note that there is no primary protected airspace to the West of the IAF under PANS-OPS criteria.	

ICAO Course Reversal Entry Sector.	
	1. Arrivals from within the entry sector will be in protected airspace immediately upon passing the IAF. 2. If there is a suitable holding pattern, you can arrive from outside the entry sector and use a turn in holding to align with the entry sector.

23.4.1.2.3. Reversal Entry Procedures.

23.4.1.2.3.1. ***Unless the procedure specifies particular entry restrictions, the 45°/180°, 80°/260°, and base turn reversal procedures must be entered from a track within ± 30° of the outbound reversal track (Figure 23.5).*** There is a special rule for base turns: for base turns where the ± 30° entry sector does not include the reciprocal of the inbound track, the entry sector is expanded to include the reciprocal. (**Figure 23.6**).

–If the aircraft's arrival track is not within the entry sector:

–Comply with the published entry restrictions or arrival routing; or

–If there is a suitable arrival holding pattern published, enter holding prior to the reversal procedure; or

–If there is no published routing or suitable holding pattern, use good judgement while maneuvering the aircraft into the entry sector.

–For racetrack entry, see paragraph 23.5.2.2.

Figure 23.5. Procedure Turn Entry (45°/180° or 80°/260°).

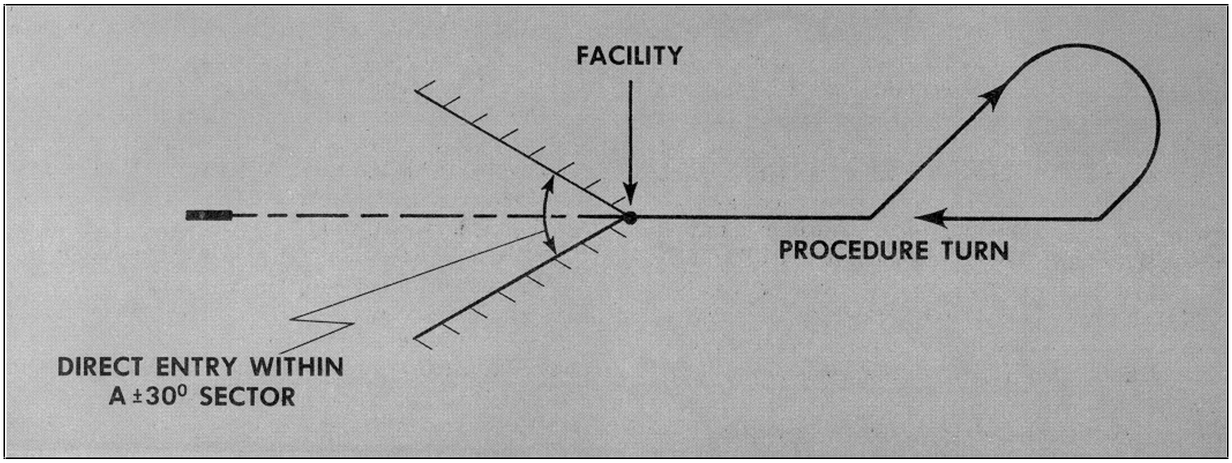
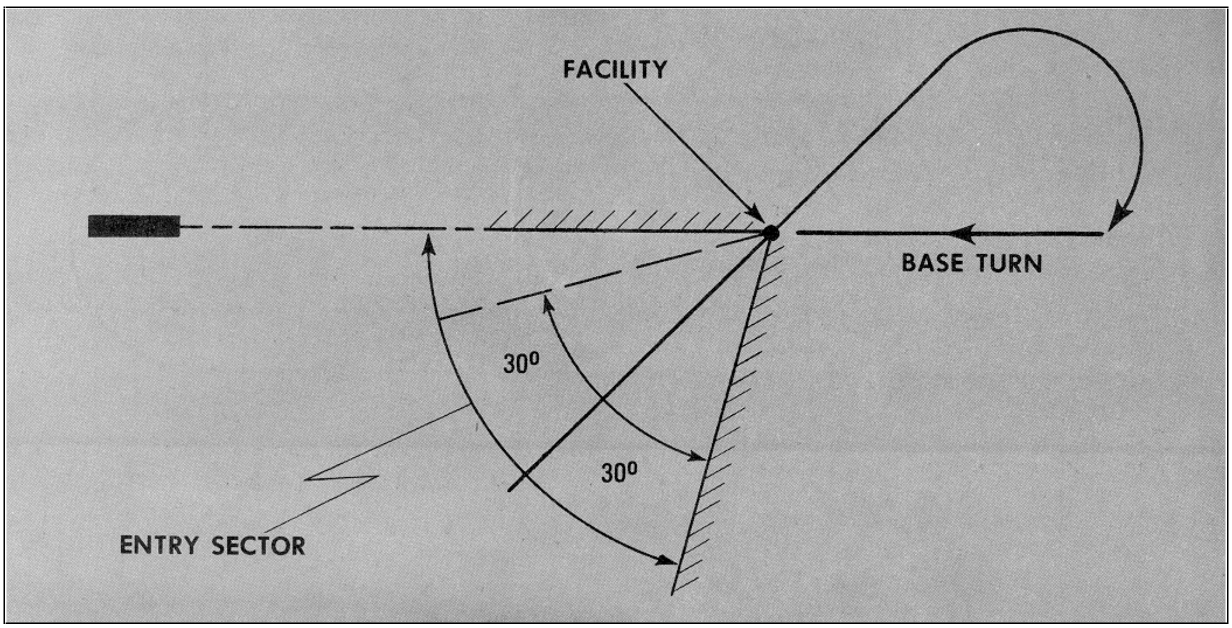


Figure 23.6. Base Turn Entry.



23.4.1.2.4. Timing. ***Begin timing to comply with published times or "remain within" distances when outbound abeam the facility or fix. If the abeam position cannot be determined while in a turn, start timing after completing the turn.***

23.4.1.2.5. Descent. A descent can be depicted at any point along a course reversal. ***When a descent is depicted at the IAF, start descent when abeam or past the IAF and on a parallel or intercept heading to the depicted outbound track. For descents past the IAF, be established on a segment of the IAP before beginning a descent to the altitude associated with that segment.***

NOTE: According to the ICAO's definition, "established on a segment" is considered being within half full scale deflection for an ILS or VOR and within ± 5° of the required bearing for the NDB.

23.4.1.2.6. Remaining Within Protected Airspace. ***The course reversal maneuver must be completed within the prescribed "remain within" distance, if one is specified and at or above the altitude specified for its completion.*** Most ICAO course reversals specify a fix or a time to start the reversal turn, instead of a "remain within" distance. Comply with all guidance on the IAP. Do not automatically assume you can treat an ICAO course reversal maneuver the same way as you would a procedure turn in the United States.

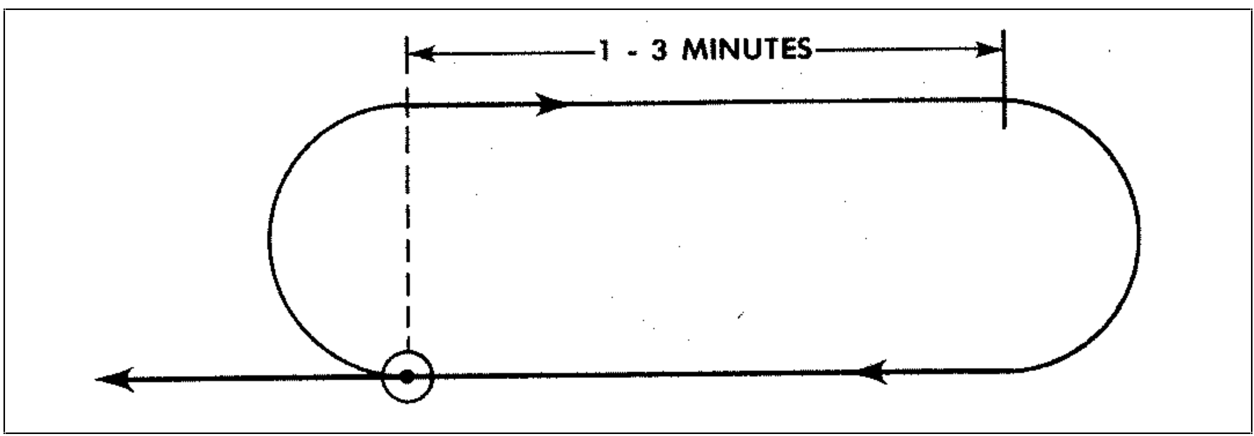
23.4.1.2.7. Airspeed Restrictions. ***Before reaching the IAF, reduce to maneuvering airspeed. Use holding speed if maneuvering speed is not specified for your aircraft.***

23.4.1.2.7.1. If the procedure is limited to specific aircraft categories, these are the applicable speeds:

Category	Max Speed
A	110 KIAS
B	140 KIAS
C	240 KIAS
D	250 KIAS
E	250 KIAS

Additional speed restrictions may be charted on individual IAPs. ***However, the maximum speeds by category, as shown above, will not be exceeded without approval of the appropriate air traffic control (ATC) agency***.

Figure 23.7. Racetrack Procedure.



23.4.2.2. The Racetrack (Figure 23.7). The ICAO "Racetrack Procedure" is similar in concept to an FAA "Holding In Lieu of Procedure Turn". This maneuver consists of a holding pattern with outbound leg lengths of 1 to 3 minutes, specified in 30-second increments. As an alternative to timing, the outbound leg may be limited by a DME distance or an intersecting radial or bearing.

23.4.2.2.1. Racetrack Entry Procedure. Normally a racetrack procedure is used when aircraft arrive overhead the fix from various directions. Entry procedures for a racetrack are the same as entry procedures for holding patterns with several exceptions:

–The teardrop offset will not exceed 30° from the inbound course.

–The teardrop entry from sector 2 is limited to 1 1/2 minutes wings level on the 30 degree teardrop track, after which the pilot is expected to turn to a heading to parallel the outbound track for the remainder of the outbound time. If the outbound time is only 1 minute, the time on the 30 degree teardrop track will be 1 minute also.

–Parallel entries may not return directly to the facility without first intercepting the inbound track.

–All maneuvering will be done as much as practical on the maneuvering side of the inbound track.

NOTE: When necessary due to airspace limitations, entry into the racetrack procedure may be restricted to specified routes. When so restricted, the entry routes will be depicted on the IAP. Racetrack procedures are used where sufficient distance is not available in a straight segment to accommodate the required loss of altitude and when entry into a reversal maneuver is not practical. They may also be specified as alternatives to reversal procedures to increase operational flexibility.

23.4.2.2.2. Shuttle Procedure. A "Shuttle" is a descent or climb conducted in a holding pattern. A shuttle is normally specified where the descent required between the end of the initial approach and the beginning of the final approach exceeds standard ICAO approach design limits.

23.4.2.2.3. Alternate Procedures*:* There may be alternate procedures specified to any of the procedures described above. IAPs will contain the appropriate depiction and the words "alternative procedure." Pilots should be prepared to execute either procedure. ***Prior to accepting clearance for an approach which depicts an alternative procedure, determine which procedure the controlling agency expects***.

23.4.2.2.4. Circling Procedures. ICAO circling protected airspace is essentially the same as in the U.S. One important distinction to make is between the terms "runway environment" and "airport environment***."*** ***While circling using an ICAO-designed procedure, you must maintain visual contact with the runway environment (as defined in para 14.1.1.2.6) throughout the entire circling maneuver.*** In the United States, you are only required to maintain visual contact with the airport environment while circling to land.

23.5. Holding.

23.5.1. Bank Angle. Make all turns at a bank angle of 25 degrees or at a rate of 3 degrees per second, whichever requires the lesser bank. ICAO procedures do not allow correcting for winds by adjusting bank angle. The "triple-drift" technique described in Chapter 10 is a good way to correct for winds without varying your bank angle.

23.5.2. Tracks. All procedures depict tracks. ***Attempt to maintain the track by allowing for known winds and applying corrections to heading and timing during entry and while flying in the holding pattern.***

23.5.3. Limiting Radial. When holding away from a NAVAID, where the distance from the holding fix to the NAVAID is short, a limiting radial may be specified. A limiting radial may also be specified where airspace conservation is essential. If you encounter the limiting radial first, initiate a turn onto the radial until you turn inbound. Do not exceed the limiting DME distance, if published.

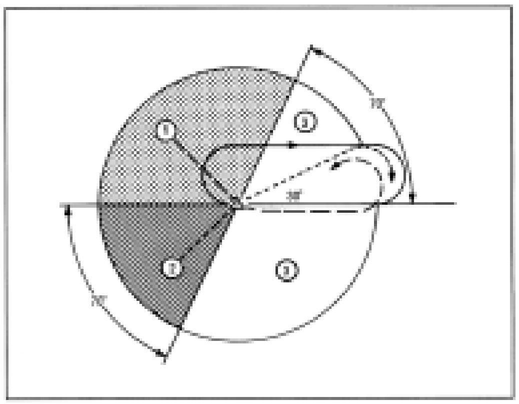
23.5.4. Holding Entry Procedure. ***The ICAO holding entry procedure is a mandatory procedure. All timing, distances, and limiting radials must be complied with. Enter the holding pattern based on your heading (±5°) relative to the three entry sectors depicted in Figure 23.8. Upon reaching the holding fix, follow the appropriate procedure for your entry sector:***

23.5.4.1. Sector 1 (Parallel). Turn onto an outbound heading for the appropriate time or distance, then turn towards the holding side to intercept the inbound track or to return to the fix.

23.5.4.2. Sector 2 (Offset). Turn to a heading to make good a track making an angle of 30° from the reciprocal of the inbound track on the holding side. Fly outbound for the appropriate period of time, until the appropriate limiting DME is attained, or where a limiting radial is also specified, either until the limiting DME is attained or until the limiting radial is encountered, whichever occurs first, then turn right to intercept the inbound holding track.

23.5.4.3. Sector 3 (Direct). Turn and follow the holding pattern.

Figure 23.8. ICAO Holding Pattern Entry Sectors.



1. Sector 1: make a parallel entry.
2. Sector 2: make a teardrop entry. The teardrop is defined as the 30° offset track.
3. Sector 3: make a direct entry.

23.5.5. Airspeeds. There is little standardization of maximum holding airspeeds in PANS-OPS. There are three completely different tables of holding airspeeds that an approach designer could have used, depending on which edition of PANS-OPS was used when the holding pattern was constructed. As if that were not difficult enough, many countries publish their own holding pattern airspeeds. This information is supposed to be published in FLIP, but it may be quite difficult or impossible for to you to actually find it. You must understand, though, that the concept is the same as in the United States: maximum holding airspeeds are defined by PANS-OPS (or the host country) and have no relation to the holding speed specified in the aircraft flight manual. If you cannot, (or do not want to) find the precise maximum holding speed, you may use the table below as a recommendation. The table reproduces the airspeeds from the Second Edition of PANS-OPS, and is the most common table used.

ALTITUDE	AIRSPEED	AIRSPEED
	Normal Conditions	Turbulence*
0-14000 Feet (CAT A and B)	170	170
0-14000 Feet (CAT C and D)	230	280
14001-20000	240	280 or 0.8 Mach, whichever is less
20001-34000	265	280 or 0.8 Mach, whichever is less
34001+	0.83 Mach	0.83 Mach

NOTE: *The speeds published for turbulence conditions shall be used for holding only after prior clearance with ATC, unless the relevant publications indicate that the holding area can accommodate aircraft flying at these high holding speeds.

23.5.6. Holding Pattern Lengths. On the second and subsequent arrivals over the fix, turn and fly an outbound track that will most appropriately position the aircraft for the turn onto the inbound track. Continue outbound until the appropriate limiting distance or time. ICAO outbound legs are the limiting factor for both timed and fixed distance holding patterns. The times are: 1 minute outbound at or below 14000 feet MSL, or 1 1/2 minutes outbound above 14000 feet MSL.

23.5.7. Wind Corrections. Attempt to correct both heading and timing to compensate for the effects of wind to ensure the inbound track is regained before passing the holding fix inbound. Indications available from the NAVAID and estimated or known winds should be used in making these corrections. If a limiting radial is published and encountered prior to the outbound limits, it must be followed until a turn inbound is initiated.

23.6 Noise Abatement Procedures. PANS-OPS publishes two recommended noise abatement procedures, which are reproduced here for reference. Procedure "A" is intended to provide noise relief during the latter part of the climbout, while Procedure "B" is intended to provide noise relief during that part of the procedure close to the airport. Nothing in PANS-OPS noise abatement procedures shall prevent a pilot from exercising his or her authority for the safe operation of the aircraft or from using any noise abatement procedures specified in the individual aircraft flight manual. You may choose which, if any, noise abatement procedures to use.

23.6.1. Noise Abatement Procedure "A".

–From take-off to 1,500 feet above the aerodrome elevation, use:

Take-off power

Take-off flap setting

Climb at V_2 + 10 to 20 knots or as limited by body angle

–At 1,500 feet above the aerodrome elevation,

Reduce thrust to not less than climb power/thrust

–From 1,500 feet to 3,000 feet above the aerodrome elevation,

Climb at V_2 + 10 to 20 knots

–At 3,000 feet and above the aerodrome elevation,

Accelerate smoothly to en route climb speed with flap retraction on schedule

23.6.2. Noise Abatement Procedure "B".

–From take-off to 1,000 feet above the aerodrome elevation, use:

Take-off power

Take-off flap setting

Climb at V_2 + 10 to 20 knots

–At 1,000 feet above the aerodrome elevation,

Maintain a positive rate of climb, accelerate to zero flap minimum safe maneuvering speed (V_{ZF}) and retract flaps on schedule

–Thereafter reduce thrust consistent with the following:

For high by-pass ratio engines, reduce to normal climb power/thrust

For low by-pass ratio engines, reduce power/thrust to below normal climb thrust but not less than that necessary to maintain the final take-off engine-out climb gradient;

For aircraft with slow flap retraction, reduce power/thrust at an intermediate flap setting.

–From 1,000 feet to 3,000 feet above the aerodrome elevation,

Continue climb at not greater than V_{ZF} + 10 knots

–At 3,000 feet above the aerodrome elevation,

Accelerate smoothly to en route climb speed.

NOTES:

1. The bank angle for turns after take-off should be limited to 15 degrees except where adequate provision is made for an acceleration phase permitting attainment of safe speeds for bank angles greater than 15 degrees. Turns coincident with a reduction of power should not be associated with noise abatement procedures.
2. V_2 is takeoff safety speed, which is the airspeed after lift-off that provides the required one-engine-inoperative climb performance. For single engine aircraft use the minimum safe climb speed.
3. Aircraft not using flaps for take-off should reduce thrust before reaching 1,000 feet but not lower than 500 feet.
4. It is assumed that before reaching the noise-sensitive area that the aircraft will climb at a maximum gradient consistent with the maintenance of a speed not less than that obtained from the above procedures.

23.7. ICAO Altimeter Setting Procedures. There are three different methods of reporting the altimeter measurements. The practice used in the U.S. and in U.S. terminally controlled areas, is to report the proper setting in inches of mercury (IN HG). In most other parts of the world, the metric system is used and you will hear the term "millibars (MB)" or "hectopascals (HPa)," but ATC may provide a setting in IN HG upon request. Both MB and HPa equal the same unit of pressure per square centimeter, and thus can be used interchangeably. For aircraft that have only one type of altimeter scale, or for areas where the altimeter setting is not converted for you, FLIP's Flight Information Handbook (FIH) provides two conversion tables in section D.

23.7.1. QNH Settings. A QNH altimeter setting represents the pressure that would, in theory, exist at sea level at that location by measuring the surface pressure and correcting it to sea level pressure for a standard day. ***Set the reported QNH when descending through, or operating below, the published Transition Level***. With the proper QNH set, the altimeter will indicate your height above Mean Sea Level (MSL). All DOD approach criteria are based upon using QNH altimeter settings.

23.7.2. QNE Settings. QNE is used to indicate your height above an imaginary plane called the "standard datum plane," also known as "FL 0". The established altimeter setting at FL 0 is 29.92 inches of Mercury (IN HG), or 1013.2 millibars or hectopascals. ***Set QNE (29.92) when climbing through, or operating above the Transition Altitude.*** Some pilots prefer to set the QNH/QNE altimeter setting when cleared through, or when approaching, the Transition Level/Altitude. This technique is acceptable, but be prepared to reset the altimeter appropriately in the event of an unexpected level-off.

23.7.3. QFE Settings. QFE is the altimeter setting issued to aircraft to indicate the AGL height above the airport. With the proper QFE set, your altimeter should indicate "0" on the ground. QFE is commonly used by the Royal Air Force and the Royal Navy in the United Kingdom, and in many parts of the Pacific and Eastern Europe.

23.7.4. Transition Altitude. The altitude in the vicinity of an airport at or below which the vertical position of an aircraft is determined from an altimeter set to QNH. Transition altitude is normally specified for each airfield by the country in which the airfield exists. Transition altitude will not normally be below 3,000 feet HAA and must be published on the appropriate charts.

23.7.5. Transition Level. The lowest flight level available for use above the transition altitude. Transition level is usually passed to the aircraft during the approach or landing clearances. The transition layer may be published, or it may be supplied by ATC via the ATIS or during arrival. Half flight levels may be used: for example, "FL 45".

23.7.6. Transition Between Flight Levels and Altitudes. The vertical position of an aircraft at or below transition altitude shall be expressed in altitude (QNH). Vertical position at or above the transition level shall be expressed in terms of flight levels (QNE). When passing through the transition layer, vertical position shall be expressed in terms of flight levels (QNE) when climbing and in terms of altitudes (QNH) when descending. After an approach clearance has been issued and the descent to land is commenced, the vertical positioning of an aircraft above the transition level may be by reference to altitude (QNH) provided that level flight above the transition altitude is not indicated or anticipated. This is intended for turbo jet aircraft where an uninterrupted descent from high altitude is desired and for airfields equipped to reference altitudes throughout the descent.

23.7.7. Altimeter Errors. When the altimeter does not indicate the reference elevation or height exactly, but is within specified tolerances, no adjustment of this indication should be made either by the pressure adjustment knob or other adjustments on the altimeter during any phase of flight. Furthermore, any error that is within tolerances noted during preflight check on the ground should be ignored by the pilot in flight.

23.7.8. Altimeter Use in Flight. ***Prior to take-off at least one altimeter will be set to the latest QNH/QFE altimeter setting. Set the altimeter to QNE (29.92) climbing through transition altitude. Prior to commencing the initial approach to an airfield, the number of the transition level should be obtained from the appropriate air traffic services unit. Obtain the latest QNH/QFE before descending below the transition level.***

23.8. Transponder Operating Procedures. ***When an aircraft carries a serviceable transponder, the pilot shall operate the transponder at all times during flight, regardless of whether the aircraft is within or outside airspace where secondary surveillance radar (SSR) is used for air traffic service purposes.***

23.8.1. Operating codes. ***Operate codes as assigned by ATC on the basis of regional air navigation agreements. In the absence of any ATC directions or regional air navigation agreements, operate the transponder on Mode A, Code 2000.***

NOTE: The use of Mode A, Code 7700 in certain areas may result in the elimination of the SSR response of the aircraft from the ATC radar display in cases where the ground equipment is not provided with automatic means for its immediate recognition

NOTE: If you squawk 7600 the controller will try to verify by asking you to IDENT or change the code. If your receiver is functioning the controller will communicate with you using the IDENT or code change.

23.8.2. Hi-jack Codes. If you experience an unlawful interference with your aircraft in flight and select code 7500, ATC will request that you confirm this code. Depending upon your circumstances you can confirm the code or not reply at all. The absence of a reply from the pilot will be taken by ATC as an indication that the use of code 7500 is not due to an inadvertent false code selection.

Chapter 24

CATEGORY II and III ILS

24.1. Category II ILS Approach (Airport, Aircraft, and Aircrew Certification Required). A Category II ILS approach provides the capability of flying to minima as low as a DH of 100 feet and an RVR of 1200. The DH for a Category II approach is identified by a preselected height on the aircraft radar altimeter. This figure is enclosed in parentheses on the IAP and is prefaced by RA, example: (RA 113).

24.1.1. Checks. Check flight directors, barometric and radar altimeters, and any other Category II equipment. Set the DH on the radar altimeter (if required for the approach).

24.1.2. Brief. Brief Category I procedures as a backup approach if appropriate.

24.1.3. Faults. Announce the illumination of any Category II system fault identification light.

NOTE: Depending on the Category II equipment installed, a fault indication below 300 feet AGL may require an immediate go-around command.

24.1.4. Failures Prior to 300 feet AGL. If any required Category II component fails prior to 300 feet AGL, the system is capable of a Category I approach only unless the failure can be corrected prior to 300 feet AGL.

24.1.5. Failures Below 300 feet AGL. Any failure of a required Category II component below 300 feet AGL requires the pilot to execute an immediate missed approach unless visual cues are sufficient to complete the approach and landing.

24.1.6. Advisory Calls. Make appropriate advisory altitude calls on the approach, including a call 100 feet above the DH.

NOTE: Tolerances for continuing the approach from 100 feet above DH are: airspeed ±5 knots of computed final approach speed or the speed directed by the flight manual for Category II approaches, and deviation from glide slope and localizer not to exceed one-half dot.

24.1.7. Visual Cues. From 100 feet above the DH to the Category II DH, the pilot not flying the aircraft will concentrate primarily on outside references to determine if visual cues are sufficient to complete the landing visually.

24.1.8. Continue. ***Continue the approach at DH only if the following conditions are met:***

24.1.8.1. Runway. Runway environment (as defined in para 14.1.1.2.6) is in sight.

24.1.8.2. Airspeed. Airspeed is within ± 5 knots of the computed final approach speed or as directed by the flight manual.

24.1.8.3. Deviations. Localizer or glide slope deviations do not exceed one-half dot.

24.1.8.4. Aircraft position. The aircraft's position is within, and tracking to remain within, the extended lateral confines of the runway.

24.1.8.5. Stabilized. The aircraft is stabilized with reference to attitude and airspeed.

24.1.9. Go Around. Go around at DH if the runway environment is not in sight or if any of the above tolerances are exceeded.

NOTE: These procedures are intended for use by Category II ILS certified aircrews only. Individual MAJCOM directives and aircraft manuals have established minimum equipment requirements and restrictions that must be complied with prior to initiating a Category II ILS approach.

24.2. Category IIIa ILS (Airport, Aircraft, and Aircrew Certification Required).

24.2.1. Definitions.

24.2.1.1. Category IIIa. A precision instrument approach and landing without a decision height (DH), or a DH below 100 feet (30 meters) and controlling runway visual range not less than 700 feet (240 meters).

24.2.1.2. Alert Height (AH). A height defined as 100 feet above the highest elevation in the touchdown zone, above which a Category III approach would be discontinued and a missed approach initiated if a failure occurred in one of the required redundant operational systems in the airplane or in the relevant ground equipment. Below this height, the approach, flare, touchdown, and rollout may be safely accomplished following any individual failure in the associated Category III systems.

24.2.2. Operational Concepts. The weather conditions encountered in Category III operations range from adequate visual references for manual rollout in Category IIIa, to inadequate visual references even for taxi operations in Category IIIc. To maintain a high level of safety during approach and landing operations in very low visibilities, the airborne system and ground support system requirements established for Category III operations should be compatible with the limited visual references that are available. The primary mode of Category III operations is automatic approach to touchdown using automatic landing systems that does not require pilot intervention. However, pilot intervention should be anticipated in the unlikely event that the pilot detects or strongly suspects inadequate aircraft performance as well as when it is determined that an automatic touchdown cannot be safely accomplished within the touchdown zone.

24.2.3. Fail Operational Category III Operations. Aircraft certification is based on the total airborne system being operative down to AH height of 100 feet. The aircraft will accomplish an automatic landing and rollout using the remaining automatic systems following failure of one system below AH. Equipment failures above AH must result in a go-around or reversion to another approach if those requirements can be met. For Category IIIa fail-operational approach and landing without a rollout control system, visual reference with the touchdown zone is required and should be verified prior to the minimum height specified by the operator for the particular aircraft type. These visual cues combined with controlling transmissometer RVR report of visibility at or above minima are necessary to verify that the initial landing rollout can be accomplished visually. Lacking visual reference prior to the specified minimum height or in the event of receiving a report of controlling RVR below minima prior to this height, a go-around should be accomplished. For Category IIIa fail-operational approach and landing with a rollout control system, the availability of visual reference is not a specific requirement for continuation of an approach to touchdown. The design of the cockpit instrumentation, system comparators, and warning systems should be adequate in combination to assure that the pilot can verify that the aircraft will safely touchdown within the touchdown zone and safely rollout if the controlling RVR is reported at or above approved minima. The aircraft may go-around safely from any altitude to touchdown. Use manual go-around after touchdown.

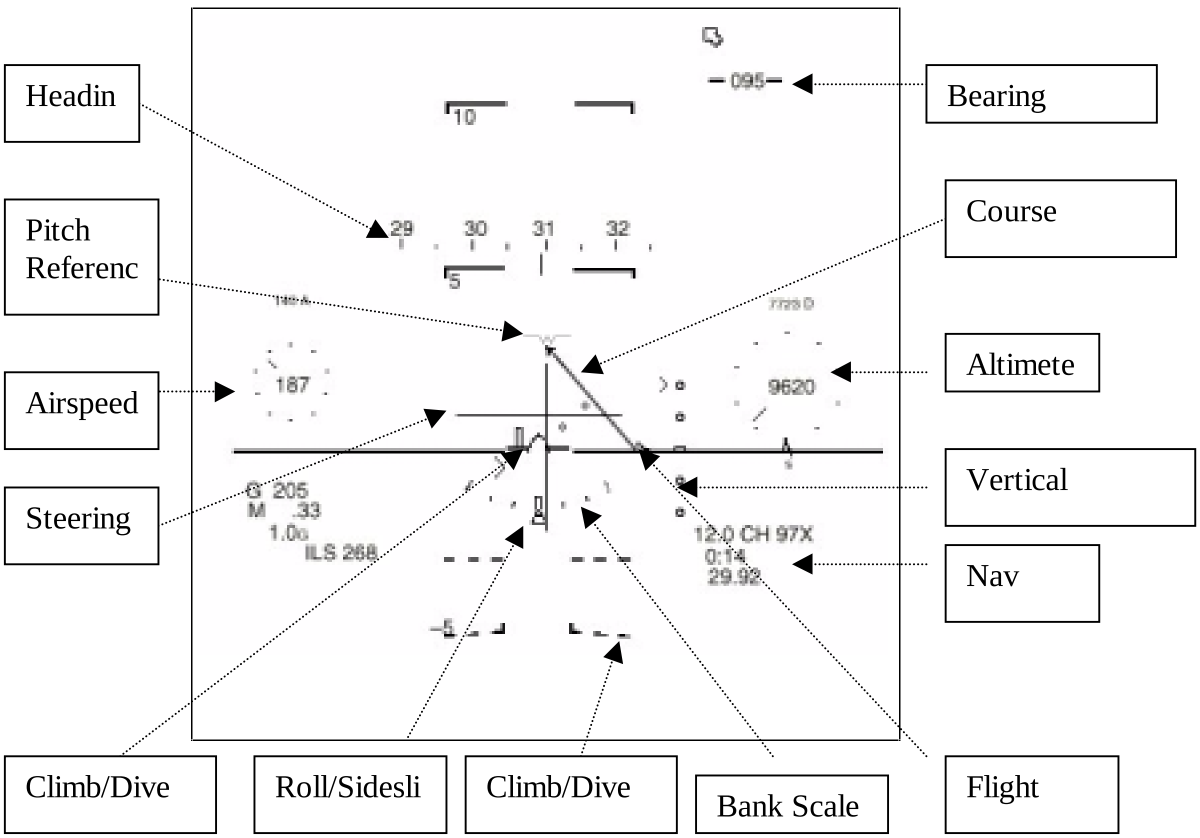
24.2.4. Procedures. See individual MAJCOM directives and aircraft manuals for minimum equipment requirements, restrictions, and procedures used when initiating Category III ILS approaches.

Chapter 25

THE HEAD-UP DISPLAY (HUD)

25.1. General Use of HUDs. HUDs currently in use vary in field-of-view, symbology, and operation. However, most HUDs provide similar displays for instrument flight. **Figure 25.1** shows a typical HUD configuration and some of the terms for its symbology. Refer to your aircraft flight manual for specific information on HUD operation, symbology, and failure indications.

Figure 25.1. Typical HUD Configuration (Instrument Approach Mode) (para 25.1).



25.2. Use of HUDs in Instrument Flight.

25.2.1. Part of Normal Crosscheck. Unless your HUD is specifically endorsed as a Primary Flight Reference (PFR) according to AFI 11-202, Volume 3, it should not be used as a sole-source instrument reference. HUDs not endorsed as a PFR may be integrated into the normal instrument crosscheck, but concerns about insidious failures and its use in maintaining attitude awareness and recovering from unusual attitudes preclude its use as a sole-source instrument reference. Improvements in information integrity and failure indications have increased confidence in the HUD's reliability; however, the combination of symbology and mechanization enabling its use as a sole-source attitude reference has not been incorporated into all HUDs. It is important for pilots to know the HUD's capabilities and limitations so they can take full advantage of its strengths and learn to work with its weaknesses.

25.2.2. Format. The format of the HUD's scales and references may differ greatly from their head-down counterparts but their content and sources of origin are usually similar if not identical.

25.2.2.1. Command Symbol. The flight path marker (FPM), or velocity vector (VV), as it is referred to on some HUDs, in conjunction with the flight path scale, is the HUD feature most used during instrument flight. Simply put, the FPM is a symbol that displays pitch compensated for angle of attack, drift, and yaw. It shows where the aircraft is actually going, assuming a properly functioning inertial navigation system (INS), and may be used to set a precise climb or dive angle relative to the HUD's flight path scale. This ability to show the actual flight path of the aircraft makes the FPM a unique control and performance element. The major advantage of vector (FPM) flying over conventional attitude flying is the ease of setting a precise glide path instead of using the ADI, VVI, and airspeed to approximate a glide path. The FPM can also be used to determine where the aircraft will touchdown. Drawbacks to vector flying include the tendency of the display to float around the combining glass, especially in crosswinds, the bobbing motion of the FPM as it lags behind the movement of the nose of the aircraft, and the degraded usefulness of the FPM when it exceeds the limits of the field-of-view at high angles of attack and in large drift or yaw situations. Some aircraft address these drawbacks with a "drift cutout mode" which maintains the lateral position of the FPM on the HUD centerline. Other aircraft simultaneously display a climb/dive marker (CDM) with the FPM. The CDM displays the current climb/dive angle while remaining horizontally fixed to the centerline of the HUD.

25.2.2.2. Flight Path Scale. Typically, the flight path scale is displayed in a 1:1 angular relationship with the "real world," though some HUDs gradually compress the scale at steeper climb/dive angles to reduce movement of the symbols and create a global display similar to that found on an attitude indicator. The HUD's expanded flight path scale allows the pilot to make smaller, more precise corrections than is possible using conventional head-down displays. Like the FPM, the flight path scale can be of limited use when it approaches the limits of the HUD's field-of-view.

25.2.2.3. Other Scales. HUD scales (except for the flight path scale) are essentially repeaters of the head-down performance instruments. They provide information such as airspeed, altitude, heading, vertical velocity, and angle of attack. These scales are often direct readouts of pitot static or air data computer information and are as reliable as the primary instruments. An important difference between the head-up and head-down scales is the formats they employ. Digital displays of airspeed and altitude are very precise but they do not show trends or rate of change very well. Vertical scales show trend but they are not intuitive (that is, should the altitude scale move downward when the altitude is decreasing or should the higher numbers always be at the top of the scale) and they are not as precise as digital scales. The HUD heading scale is easier to use than the head-down heading indicator for small heading changes, such as on final approach, because of its expanded scaling, but it is cumbersome when used to determine angular relationships with a desired course or other traffic. Vertical velocity, an indispensable element in flying a precision glide path using conventional pitch reference techniques, becomes extraneous data when flying a glide path with a valid FPM. It is apparent then that proficiency in HUD flying requires the development of an integrated crosscheck which encompasses the most useful information available. Always confirm the HUD data before using it and continue to crosscheck it against the head-down data to confirm its accuracy.

25.2.2.4. Navigation Information. Navigation information displayed on the HUD varies from aircraft to aircraft both in symbology and format. Sources (INS, TACAN, ILS) may be selectable, so it is important to remember which source has been selected and whether the display is raw data or steering information. The ILS mode may display either course guidance or course deviation. As in flying command steering bars on an attitude indicator, the pilot must not fixate on HUD steering commands but continue to reference raw data to determine aircraft position and to verify the HUD commands. Chasing the steering commands with the FPM may result in over-controlling, especially if raw data is not provided on the HUD.

25.2.2.5. Information Missing. The lack of power indicators and bearing information prevents most current HUDs from providing complete "control" or "navigation" information and reinforces the need for the pilot to use the HUD as only part of an integrated crosscheck.

25.2.3. Instrument Flight Use. To effectively use the HUD for instrument flight, the pilot must first understand basic attitude flying procedures and techniques and be proficient in flying instruments using various elements of HUD information to complement the instrument crosscheck.

25.2.3.1. Instrument Takeoff and Climb. Prior to takeoff, ensure that information displayed on the HUD agrees with that on the conventional instruments. Rotation is accomplished by establishing the initial pitch attitude using a combination of outside visual cues and the attitude reference. The initial pitch attitude may be set on the HUD if it contains a pitch reference symbol, otherwise, use the head down attitude reference. When the FPM becomes active and a stabilized pitch is established, use the FPM for precise adjustments. Continue to crosscheck the airspeed and VVI to ensure the climb angle is correct, making adjustments using the FPM as necessary.

25.2.3.2. Level Off. Begin the level off at a predetermined lead point. Fly the FPM smoothly to the level flight path line, adjusting the rate of movement so that level flight occurs at the desired altitude. When the FPM is stabilized on the horizon line of the HUD, the altimeter and VVI should be steady. The HUD information should be considered unreliable if indications of a climb or dive persist.

25.2.3.3. Penetration/Descent. Determine the descent gradient (altitude to lose/[distance to travel in NM x 100] = descent gradient) required to meet any altitude restrictions and fly the FPM to the corresponding angle on the flight path scale. Crosscheck the actual altitude with the desired altitude at intermediate points during the descent to ensure the proper dive angle is set.

25.2.3.4. Approach. Set the illumination intensity. At night or in dense weather low illumination levels in the HUD may be washed out by the runway or approach lighting. Ensure the approach angle of attack corresponds to the computed final approach airspeed. If the angle of attack is in the appropriate range but the airspeed is higher than expected, the aircraft may not be properly configured for landing.

25.2.3.4.1. Non-precision. Compute the descent angle from the FAF to the VDP. At the FAF fly the FPM to the desired angle and crosscheck the airspeed, vertical velocity, and angle of attack. If the MDA is reached prior to the VDP, wait until the dive line corresponding to the desired visual glide path is over the desired touchdown zone and then lower the FPM to the touchdown zone.

25.2.3.4.2. Precision. The FPM can be used very effectively for establishing and maintaining precision glide paths. From stabilized, level flight adjust the FPM to the desired glide path angle at the glide slope intercept point. Crosscheck the airspeed, vertical velocity, and angle of attack, to confirm proper performance. Using a combination of FPM and the expanded heading scale in the HUD, make small bank corrections to correct to the final course. Continue to crosscheck the head-down raw data to ensure approach tolerances are not exceeded.

25.2.3.4.3. Transition from Instrument Flight. Because of the HUD's location within the pilot's forward field-of-view, it can facilitate the transition from instrument flight to visual acquisition of the runway. If the FPM is on the touchdown zone at a descent angle less than 2.5°, the aircraft is on a low, flat approach; discontinue the descent until the proper glide path can be acquired. If the FPM is used to maintain precise glide path control, once established on the ILS glide slope, it should closely coincide with the runway point of intercept (RPI) when the instrument to visual transition occurs. Current HUDs are designed to have as many as three different symbols overlay the touchdown zone when the aircraft is on the proper course and glide slope.

CAUTION: These symbols may tend to obscure the external visual scene so fly instruments down to the flare looking through the HUD, not at it.

25.3. HUD Limitations.

25.3.1. Global Orientation. Many HUDs are incapable of providing intuitive global orientation information because of the small sections of space that they represent. Also, since many HUDs provide only a partial picture of the aircraft's attitude, a pilot who tries to use the HUD to confirm an unusual attitude may see only a blur of lines and numbers. In a fast moving environment, the pilot may not be able to differentiate or recognize the difference between the solid climb lines from the identical, but dashed, dive lines in the flight path scale. Any confusion or delay in initiating proper recovery inputs may make recovery impossible.

NOTE: Unless your HUD is endorsed as a PFR, do not use it when spatially disoriented, for recovery from an unusual attitude, or during lost wingman situations; use the head down display anytime an immediate attitude reference is required. Typically, head down displays are inherently easier to use in these situations due to the larger attitude coverage, color asymmetry between the ground and sky, and reduced interference from the outside visual scene (glare, optical illusions, etc.). For this reason, even if your HUD is endorsed as a PFR, current Air Force guidance requires the head down display be available to the pilot with not more than one hands-on switch action.

25.3.2. Flight path information. Most HUD flight path information is based on an INS. Many INSs have the capability to compute and display different types of airspeed (calibrated, true, or ground) and heading (magnetic or ground track). Though the INS and HUD have become increasingly more reliable, they can fail insidiously and with little or no warning. If such a failure occurs the pilot must realize that the types of airspeed and heading selected may change as the displays revert to a different mode of operation, and the FPM may disappear, leaving the pilot with a fixed pitch reference at a surprisingly different climb or dive angle. Be prepared for any such failure by constantly cross-checking the head-down attitude reference and other performance instruments.

25.3.3. Interpretation. Remember that the HUD picture is only a small piece of the "big picture," so what the pilot sees on the HUD must be accurately interpreted. That is to say, you may be on-speed with the FPM at the correct flight path angle but aiming well short of the runway, or you may be on-speed with the FPM on the desired aim point, but at too high a descent angle, resulting in an unacceptably high sink rate, or at too low a descent angle resulting in a dragged-in final and short touchdown.

25.3.4. Fixation. Fixation on HUD information can cause a breakdown in a proper instrument crosscheck and contribute to poor situational awareness. Information displayed on the HUD can be very compelling to the pilot. The tendency for the pilot to fixate on the HUD is increased by the display of excessive and unnecessary information or when the HUD brightness level is not adjusted properly for the background contrast. Minimize the tendency to fixate on the HUD by maintaining an efficient composite crosscheck and ensuring the HUD brightness level is properly adjusted.

25.3.5. HUD Field of View. HUD symbology may also obscure objects within the HUD field of view. When non-essential HUD information is displayed or when the HUD brightness level is excessive, the probability of obscuration is dramatically increased. Proper HUD settings (including elimination of non-task-essential information and adjusting the brightness to the proper level) are imperative to prevent potential hazards to safe flight.

25.3.6. Conventional Crosscheck. Finally, pilots should remain proficient in the conventional instrument crosscheck for their specific aircraft. Regardless of the type HUD you have (endorsed as a PFR or not), it is important to occasionally fly an instrument approach or accomplish a level-off without using the HUD so you retain your proficiency in the event of a HUD malfunction. The results may indicate a need to practice your conventional instrument crosscheck. Using HUD information incorrectly or at the wrong time can actually increase pilot workload, but timely, proper use of it can help you fly more precise instruments on a routine basis.

ROBERT H. FOGLESONG, Lt General, USAF
DCS/Air and Space Operations

Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

ACT	Approach Clearance Time
ADF	Automatic Direction Finding
ADI	Attitude Director Indicator
AGL	Above Ground Level
AIMS	ATC Radar Beacon System/Identification Friend or Foe/Mark XII System
AMI	Airspeed Mach Indicator
ARTS	Automated Radar Terminal Systems
ASLAR	Aircraft Surge Launch and Recovery
ASR	Aircraft Surveillance Radar
ATIS	Automatic Terminal Information Service
ATC	Air Traffic Control
AVVI	Altitude Vertical Velocity Indicator
BDHI	Bearing Distance Heading Indicator
C/A	Course Acquisition
CADC	Central Air Data Computer
CAS	Calibrated Airspeed
CDI	Course Deviation Indicator
CDU	Control Display Unit
CI	Course Indicator
CVFP	Charted Visual Flight Procedure
DG	Directional Gyro
DH	Decision Height
DME	Distance Measuring Equipment
DME/P	Precision Distance Measuring Equipment
DR	Dead Reckoning
EAS	Equivalent Airspeed
EFC	Expect Further Clearance
ETA	Estimated Time of Arrival
ETE	Estimated Time En Route
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FAS	Final Approach Speed
FDS	Flight Director System
FL	Flight Level
FLIP	Flight Information Publication
FOV	Field of View
fpm	Feet Per Minute
FPM	Flight Path Marker
FSS	Flight Service Station
GCA	Ground Controlled Approach
GCCS	Global Command and Control System
GPI	Glide Path Intercept Point
GPS	Global Positioning System

GS	Groundspeed
GSI	Glide Slope Indicator
HG	Holding Fix
Hg	Mercury
HIRL	High Intensity Runway Lighting
HSI	Horizontal Situation Indicator
HUD	Head-Up-Display
Hz	Hertz (cycles per second)
IAF	Initial Approach Fix
IAP	Instrument Approach Procedure
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organization
IFF	Identification, Friend or Foe
IFIS	Integrated Flight Instrument System
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IM	Inner Marker
IMC	Instrument Meteorological Conditions
IMN	Indicated Mach Number
INS	Inertial Navigation System
IRC	Instrument Refresher Course
ITO	Instrument Takeoff
kHz	Kilohertz
KIAS	Knots Indicated Airspeed
KTAS	Knots True Airspeed
LCVASI	Low Cost Visual Approach Slope Indicator
LDA	Localizer Type Directional Aid
LOC	Localizer
LORAN	Long-Range Aid to Navigation
MAP	Missed Approach Point
MCA	Minimum Crossing Altitude
MCS	Master Control Station
MDA	Minimum Descent Altitude
MEA	Minimum En Route Altitude
mHz	MilliHertz
MHz	Megahertz
MIRL	Medium Intensity Runway Lighting
MLS	Microwave Landing System
MM	Middle Marker
MOCA	Minimum Obstruction Clearance Altitude
MRA	Minimum Reception Altitude
MSL	Mean Sea Level
MVA	Minimum Vectoring Altitude
NAVAID	Navigational Aid
NDB	Nondirectional Beacon
NM	Nautical Miles
NoPT	No Procedure Turn Required

NOTAM	Notices to Airmen
OM	Outer Marker
PAPI	Precision Approach Path Indicator
PAR	Precision Approach Radar
PAV	Pressure Altitude Variation
PLASI	Pulse Light Approach Slope Indicator
PT	Procedure Turn
Radar	Radio Detecting and Ranging
RDF	Radio Direction Finding
REIL	Runway End Identifier Lights
RMI	Radio Magnetic Indicator
RNAV	Area Navigation
ROC	Required Obstacle Clearance
RPI	Runway Point of Intercept
rpm	Revolutions per minute
RVR	Runway Visual Range
SDF	Simplified Directional Facility
SDP	Standard Datum Plane
SID	Standard Instrument Departure
SIF	Selective Identification Feature
STAR	Standard Terminal Arrival
TACAN	Tactical Air Navigation
TAS	True Airspeed
TCH	Threshold Crossing Height
TCN	Terminal Change Notice
TERPs	Terminal Instrument Procedures
TMN	True Mach Number
UE	User Equipment
UHF	Ultra High Frequency
VASI	Visual Approach Slope Indicator
VDP	Visual Descent Point
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional Range
VORTAC	VHF Omnidirectional Range/Tactical Air Navigation
VV	Velocity Vector
VVI	Vertical Velocity Indicator