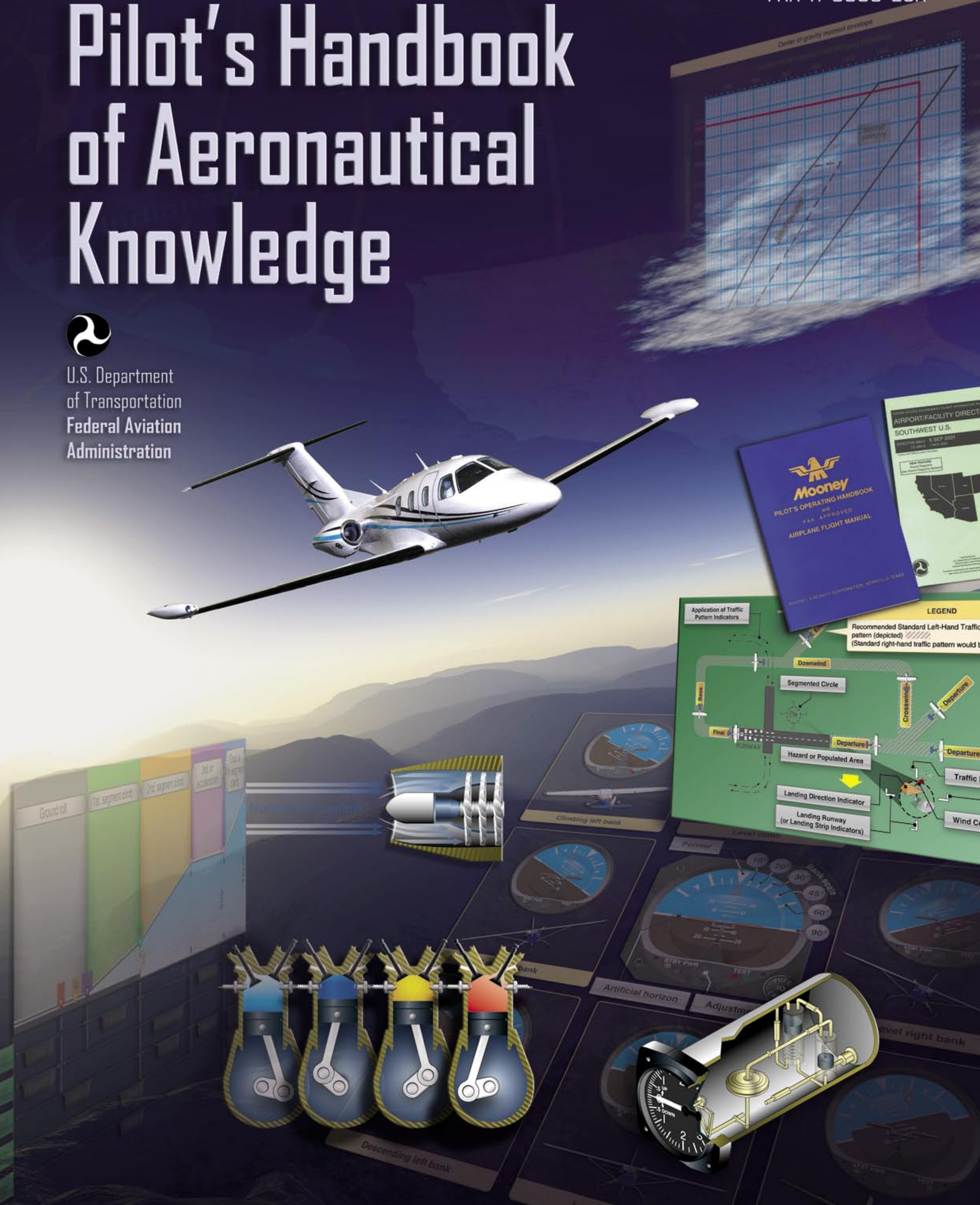
FAA-H-8083-25A

Pilot's Handbook of Aeronautical Knowledge



U.S. Department
of Transportation
Federal Aviation Administration

Pilot's Handbook of Aeronautical Knowledge

2008

U.S. Department of Transportation
FEDERAL AVIATION ADMINISTRATION
Flight Standards Service

Preface

The Pilot's Handbook of Aeronautical Knowledge provides basic knowledge that is essential for pilots. This handbook introduces pilots to the broad spectrum of knowledge that will be needed as they progress in their pilot training. Except for the Code of Federal Regulations pertinent to civil aviation, most of the knowledge areas applicable to pilot certification are presented. This handbook is useful to beginning pilots, as well as those pursuing more advanced pilot certificates.

Occasionally the word "must" or similar language is used where the desired action is deemed critical. The use of such language is not intended to add to, interpret, or relieve a duty imposed by Title 14 of the Code of Federal Regulations (14 CFR).

It is essential for persons using this handbook to become familiar with and apply the pertinent parts of 14 CFR and the Aeronautical Information Manual (AIM). The AIM is available online at www.faa.gov. The current Flight Standards Service airman training and testing material and learning statements for all airman certificates and ratings can be obtained from www.faa.gov.

This handbook supersedes FAA-H-8083-25, Pilot's Handbook of Aeronautical Knowledge, dated 2003.

This handbook is available for download, in PDF format, from www.faa.gov.

This handbook is published by the United States Department of Transportation, Federal Aviation Administration, Airman Testing Standards Branch, AFS-630, P.O. Box 25082, Oklahoma City, OK 73125.

Comments regarding this publication should be sent, in email form, to the following address:

AFS630comments@faa.gov

- Red line (V_{NE})—never exceed speed. Operating above this speed is prohibited since it may result in damage or structural failure.

Other Airspeed Limitations

Some important airspeed limitations are not marked on the face of the ASI, but are found on placards and in the AFM/POH. These airspeeds include:

- Design maneuvering speed (V_A)—the maximum speed at which the structural design's limit load can be imposed (either by gusts or full deflection of the control surfaces) without causing structural damage. It is important to consider weight when referencing this speed. For example, VA may be 100 knots when an airplane is heavily loaded, but only 90 knots when the load is light.
- Landing gear operating speed (V_{LO})—the maximum speed for extending or retracting the landing gear if flying an aircraft with retractable landing gear.
- Landing gear extended speed (V_{LE})—the maximum speed at which an aircraft can be safely flown with the landing gear extended.
- Best angle-of-climb speed (V_X)—the airspeed at which an aircraft gains the greatest amount of altitude in a given distance. It is used during a short-field takeoff to clear an obstacle.
- Best rate-of-climb speed (V_Y)—the airspeed that provides the most altitude gain in a given period of time.
- Single-engine best rate-of-climb (V_{YSE})—the best rate-of-climb or minimum rate-of-sink in a light twin-engine aircraft with one engine inoperative. It is marked on the ASI with a blue line. V_{YSE} is commonly referred to as "Blue Line."
- Minimum control speed (V_{MC})—the minimum flight speed at which a light, twin-engine aircraft can be satisfactorily controlled when an engine suddenly becomes inoperative and the remaining engine is at takeoff power.

Instrument Check

Prior to takeoff, the ASI should read zero. However, if there is a strong wind blowing directly into the pitot tube, the ASI may read higher than zero. When beginning the takeoff, make sure the airspeed is increasing at an appropriate rate.

Blockage of the Pitot-Static System

Errors almost always indicate blockage of the pitot tube, the static port(s), or both. Blockage may be caused by moisture (including ice), dirt, or even insects. During preflight, make sure the pitot tube cover is removed. Then, check the pitot and static port openings. A blocked pitot tube affects the accuracy of the ASI, but, a blockage of the static port not only affects the ASI, but also causes errors in the altimeter and VSI.

Blocked Pitot System

The pitot system can become blocked completely or only partially if the pitot tube drain hole remains open. If the pitot tube becomes blocked and its associated drain hole remains clear, ram air no longer is able to enter the pitot system. Air already in the system vents through the drain hole, and the remaining pressure drops to ambient (outside) air pressure. Under these circumstances, the ASI reading decreases to zero, because the ASI senses no difference between ram and static air pressure. The ASI no longer operates since dynamic pressure can not enter the pitot tube opening. Static pressure is able to equalize on both sides since the pitot drain hole is still open. The apparent loss of airspeed is not usually instantaneous but happens very quickly. *[Figure 7-9]*

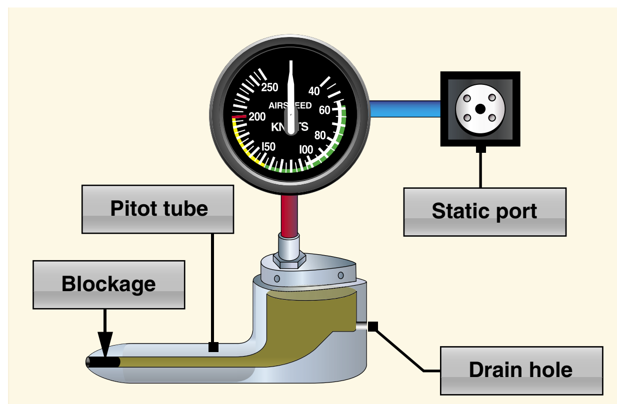


Figure 7-9. *A blocked pitot tube, but clear drain hole.*

If both the pitot tube opening and the drain hole should become clogged simultaneously, then the pressure in the pitot tube is trapped. No change is noted on the airspeed indication should the airspeed increase or decrease. If the static port is unblocked and the aircraft should change altitude, then a change is noted on the ASI. The change is not related to a change in airspeed but a change in static pressure. The total pressure in the pitot tube does not change due to the blockage; however, the static pressure will change.

Because airspeed indications rely upon both static and dynamic pressure together, the blockage of either of these systems affects the ASI reading. Remember that the ASI has a diaphragm in which dynamic air pressure is entered. Behind this diaphragm is a reference pressure called static pressure that comes from the static ports. The diaphragm pressurizes against this static pressure and as a result changes the airspeed indication via levers and indicators. *[Figure 7-10]*

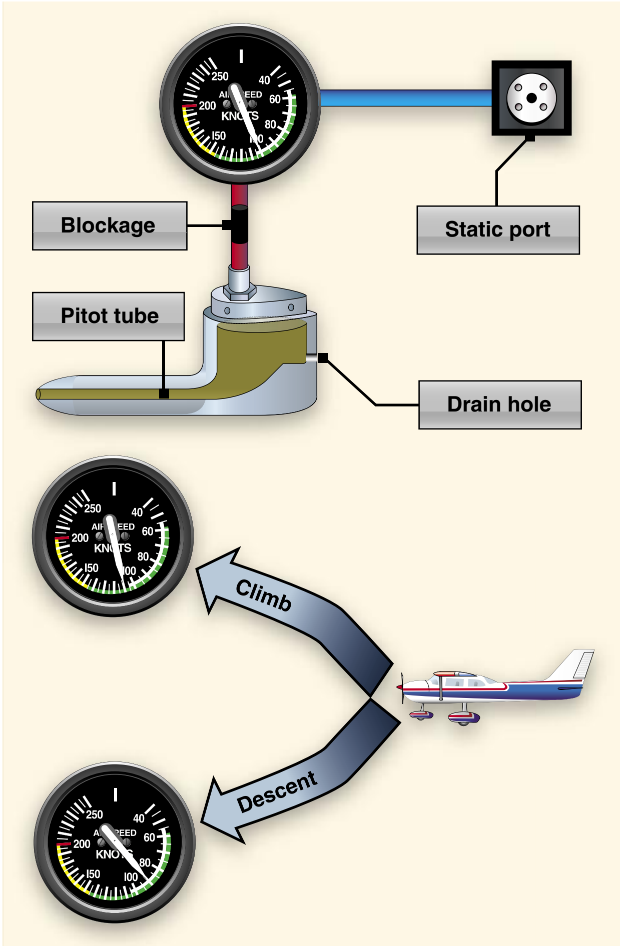


Figure 7-10. *Blocked pitot system with clear static system.*

For example, take an aircraft and slow it down to zero knots at given altitude. If the static port (providing static pressure) and the pitot tube (providing dynamic pressure) are both unobstructed, the following claims can be made:

1. The ASI would be zero.
2. There must be a relationship between both dynamic and static pressure. At zero speed, dynamic pressure and static pressure are the same: static air pressure.
3. Because both dynamic and static air pressure are equal at zero speed with increased speed, dynamic pressure must include two components: static pressure and dynamic pressure.

It can be inferred that airspeed indication must be based upon a relationship between these two pressures, and indeed it is. An ASI uses the static pressure as a reference pressure and as a result, the ASI's case is kept at this pressure behind the diaphragm. On the other hand, the dynamic pressure through the pitot tube is connected to a highly sensitive diaphragm within the ASI case. Because an aircraft in zero motion (regardless of altitude) results in a zero airspeed, the pitot tube always provides static pressure in addition to dynamic pressure.

Therefore, the airspeed indication is the result of two pressures: the pitot tube static and dynamic pressure within the diaphragm as measured against the static pressure in case. What does this mean if the pitot tube is obstructed?

If the aircraft were to descend, the pressure in the pitot system including the diaphragm would remain constant. It is clogged and the diaphragm is at a single pressure. But as the descent is made, the static pressure would increase against the diaphragm causing it to compress thereby resulting in an indication of decreased airspeed. Conversely, if the aircraft were to climb, the static pressure would decrease allowing the diaphragm to expand, thereby showing an indication of greater airspeed. *[Figure 7-10]*

The pitot tube may become blocked during flight due to visible moisture. Some aircraft may be equipped with pitot heat for flight in visible moisture. Consult the AFM/POH for specific procedures regarding the use of pitot heat.

Blocked Static System

If the static system becomes blocked but the pitot tube remains clear, the ASI continues to operate; however, it is inaccurate. The airspeed indicates lower than the actual airspeed when the aircraft is operated above the altitude where the static ports became blocked, because the trapped static pressure is higher than normal for that altitude. When operating at a lower altitude, a faster than actual airspeed is displayed due to the relatively low static pressure trapped in the system.

Revisiting the ratios that were used to explain a blocked pitot tube, the same principle applies for a blocked static port. If the aircraft descends, the static pressure increases on the pitot side showing an increase on the ASI. This assumes that the aircraft does not actually increase its speed. The increase in static pressure on the pitot side is equivalent to an increase in dynamic pressure since the pressure can not change on the static side.

If an aircraft begins to climb after a static port becomes blocked, the airspeed begins to show a decrease as the aircraft continues to climb. This is due to the decrease in static pressure on the pitot side, while the pressure on the static side is held constant.

A blockage of the static system also affects the altimeter and VSI. Trapped static pressure causes the altimeter to freeze at the altitude where the blockage occurred. In the case of the VSI, a blocked static system produces a continuous zero indication. *[Figure 7-11]*

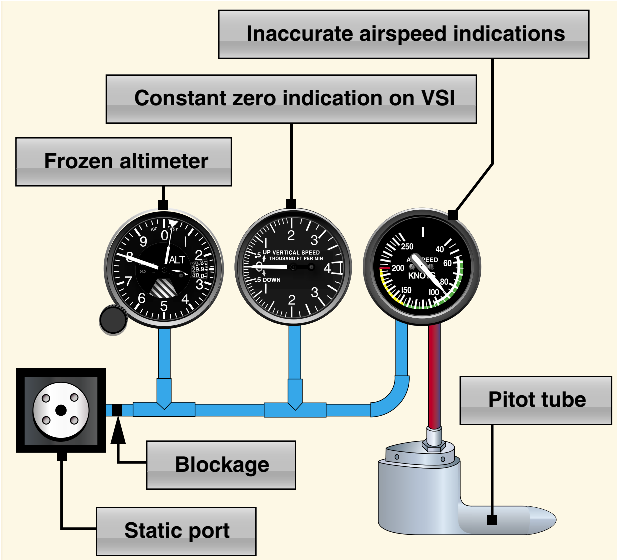


Figure 7-11. *Blocked static system.*

Some aircraft are equipped with an alternate static source in the flight deck. In the case of a blocked static source, opening the alternate static source introduces static pressure from the flight deck back into the system. Flight deck static pressure is lower than outside static pressure. Check the aircraft AOM/POH for airspeed corrections when utilizing alternate static pressure.

Electronic Flight Display (EFD)

Advances in digital displays and solid state electronic components have been introduced into the flight decks of general aviation (GA) aircraft. In addition to the improvement in system reliability, which increases overall safety, electronic flight displays (EFD) have decreased the overall cost of equipping aircraft with state-of-the-art instrumentation. Primary electronic instrumentation packages are less prone to failure than their analogue counterparts. No longer is it necessary for aircraft designers to create cluttered panel layouts in order to accommodate all necessary flight instruments. Instead, multi-panel digital flight displays combine all flight instruments onto a single screen which is called a primary flight display (PFD). The traditional "six pack" of instruments is now displayed on one liquid crystal display (LCD) screen.

Airspeed Tape

Configured similarly to traditional panel layouts, the ASI is located on the left side of the screen and is displayed as a vertical speed tape. As the aircraft increases in speed, the larger numbers descend from the top of the tape. The TAS is displayed at the bottom of the tape through the input to the air data computer (ADC) from the outside air temperature probe. Airspeed markings for V_X, V_Y, and rotation speed (V_R) are displayed for pilot reference. An additional pilot-controlled airspeed bug is available to set at any desired reference speed. As on traditional analogue ASIs, the electronic airspeed tape displays the color-coded ranges for the flap operating range, normal range, and caution range. *[Figure 7-12]* The number value changes color to red when the airspeed exceeds V_{NE} to warn the pilot of exceeding the maximum speed limitation.

Attitude Indicator

One improvement over analogue instrumentation is the larger attitude indicator on EFD. The artificial horizon spans the entire width of the PFD. *[Figure 7-12]* This expanded instrumentation offers better reference through all phases of flight and all flight maneuvers. The attitude indicator receives its information from the Attitude Heading and Reference System (AHRS).

Altimeter

The altimeter is located on the right side of the PFD. *[Figure 7-12]* As the altitude increases, the larger numbers descend from the top of the display tape, with the current altitude being displayed in the black box in the center of the display tape. The altitude is displayed in increments of 20 feet.

Vertical Speed Indicator (VSI)

The VSI is displayed to the right of the altimeter tape and can take the form of an arced indicator or a vertical speed tape. *[Figure 7-12]* Both are equipped with a vertical speed bug.

Heading Indicator

The heading indicator is located below the artificial horizon and is normally modeled after a Horizontal Situation Indicator (HSI). *[Figure 7-12]* As in the case of the attitude indicator, the heading indicator receives its information from the magnetometer which feeds information to the AHRS unit and then out to the PFD.

Turn Indicator

The turn indicator takes a slightly different form than the traditional instrumentation. A sliding bar moves left and right below the triangle to indicate deflection from coordinated flight. *[Figure 7-12]* Reference for coordinated flight comes from accelerometers contained in the AHRS unit.

Tachometer

The sixth instrument normally associated with the "six pack" package is the tachometer. This is the only instrument that is not located on the PFD. The tachometer is normally located on the multi-function display (MFD). In the event of a display screen failure, it is displayed on the remaining screen with the PFD flight instrumentation. *[Figure 7-13]*