

# FLIGHT INSTRUMENTS

## 1. Introduction

**The flight instruments are the instruments in the cockpit of an aircraft that provide the pilot with flight parameters.**

The flight instruments are used in conditions of poor visibility when pilot loses visual reference outside the aircraft.

When you are sitting in the airplane, you will probably notice six flight instruments in front of you. The typical arrangement of these instruments is shown below:

1. Airspeed indicator
2. Attitude indicator
3. Altimeter
4. Turn coordinator
5. Heading indicator
6. Vertical speed indicator



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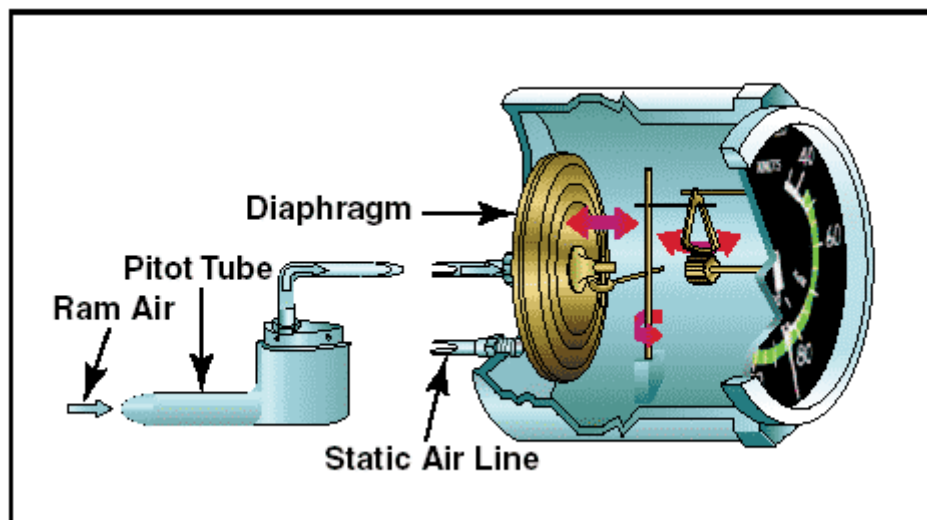
## 2. Airspeed indicator

The airspeed indicator (ASI) displays the speed at which the airplane is moving through the air.



The direct instrument reading obtained from the airspeed indicator, uncorrected for variations in atmospheric density, installation error, or instrument error. Manufacturers use this airspeed as the basis for determining airplane performance.

The airspeed indicator is a sensitive differential pressure gauge which measures and shows the difference between impact pressure from Pitot tube, and static pressure from static line (the undisturbed atmospheric pressure at current flight level).



These two pressures will be equal when the airplane is parked on the ground in calm air. When the airplane moves through the air, the pressure on the pitot line becomes greater than the pressure in the static lines. This difference in pressure is registered by the airspeed pointer on the face of the instrument, which is calibrated in miles per hour, knots, or both.

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The altimeter can display also other speed information:



- White arc: This arc is commonly referred to as the flap operating range since its lower limit represents the full flap stall speed and its upper limit provides the maximum flap speed (Approaches and landings are usually flown at speeds within the white arc).
- Lower limit of white arc (VS0): The stalling speed or the minimum steady flight speed in the landing configuration. In small airplanes, this is the power-off stall speed at the maximum landing weight in the landing configuration (gear and flaps down).
- Upper limit of the white arc (VFE): The maximum speed with the flaps extended.
- Green arc: This is the normal operating range of the airplane. Most flying occurs within this range.
- Lower limit of green arc (VS1): The stalling speed or the minimum steady flight speed obtained in a specified configuration. For most airplanes, this is the power-off stall speed at the maximum takeoff weight in the clean configuration (gear up, if retractable, and flaps up).
- Upper limit of green arc (VNO): The maximum structural cruising speed. Do not exceed this speed except in smooth air.
- Yellow arc: Caution range. Fly within this range only in smooth air, and then, only with caution.
- Red line (VNE): Never exceed speed. Operating above this speed is prohibited since it may result in damage or structural failure.

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### 3. Attitude indicator

The attitude indicator displays a picture of the attitude of the aircraft.



There is also a miniature aircraft (orange line) and horizon bar representation. The horizon is displayed using a white line which separates the instrument in two part : the blue one which represents the sky and the brown one which represents the earth.

The relationship of the miniature aircraft to the horizon bar is the same as the relationship of the real aircraft to the actual horizon. The instrument gives an instantaneous indication of even the smallest changes in attitude.

The gyro in the attitude indicator is mounted in a horizontal plane and depends upon rigidity in space for its operation. The horizon bar represents the true horizon. This bar is fixed to the gyro and remains in a horizontal plane as the aircraft is pitched or banked about its lateral or longitudinal axis, indicating the attitude of the aircraft relative to the true horizon.

This instrument is used to know without any visual reference about the attitude of the aircraft. With it, the pilot can know if the aircraft is:



climbing



descending



turning left



turning right

Note that the little orange triangle on the top shows the bank angle with the white graduation.

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## 4. Altimeter

The altimeter displays the altitude of the airplane above mean sea level (MSL) when properly adjusted to the current pressure setting. The value is expressed in feet (ft); it can be meter (m) in some aircrafts.



In aircraft, an aneroid barometer measures the atmospheric pressure from a static port outside the aircraft. Air pressure decreases with an increase of altitude—approximately 100 hectopascals per 800 meters or one inch of mercury per 1000 feet near sea level.

The analog altimeter has 2 needles:

- The longest one for the hundreds of feet
- The shortest one for the thousands of feet



altitude = 3000ft



altitude = 5300ft

The direct value of altimeter can be displayed directly in some instruments with only the long needle for hundreds of feet:



Altitude = 10500ft

**Note that the altimeter shall be calibrated with the pressure value in hPa or inHg using rotating knob on the bottom left or bottom right of the instrument.**

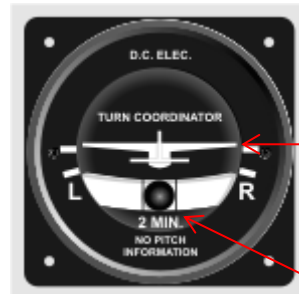
**The pressure chosen can be local airfield pressure QNH or standard QNH 1013 hPa / 29,92 inHg depending of your altitude and country regulation.**

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## 5. Turn coordinator

The turn coordinator (turn and balance indicator) are essentially two aircraft flight instruments in one device. They each act as a rate of turn indicator that displays the rate the aircraft heading is changing and a balance indicator or slip indicator that displays the slip or skid of the turn.



Turn indicator / inclinometer

Balance indicator / ball

The **turn indicator display** contains hash marks where the needle may align during a turn. When the needle is lined up with these hash marks, the aircraft is performing a standard rate turn. The standard rate (or named rate “one”) for most airplanes is three degrees per second or two minutes per 360 degrees of turn (a complete circle). This is marked as "2 min" on the display.

The **balance indicator information** of the aircraft is often obtained by an inclinometer, which is recognized as the ball in a tube



Standard left turn



No turn in progress



Standard right turn

Note that in a standard turn, the ball in balance indicator is always centered.



Aircraft skidding to inside of turn



Coordinated Turn



Aircraft slipping to outside of turn

The turn coordinator should be used as a performance instrument when the attitude indicator has failed.

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## 6. Heading indicator

**The heading indicator is used to inform the pilot of the aircraft's heading.**

It is sometimes referred to by its older names, the directional gyro and also direction indicator.



The heading indicator is fundamentally a mechanical instrument designed to facilitate the use of the magnetic compass. Errors in the magnetic compass are numerous, making straight flight and precision turns to headings difficult to accomplish, particularly in turbulent air.

To remedy errors in the magnetic compass reading, the pilot will typically manoeuvre the airplane with reference to the heading indicator, as the gyroscopic heading indicator is unaffected by dip and acceleration errors.

The primary means of establishing the heading in most small aircraft is the magnetic compass, which, however, suffers from several types of errors, including that created by the "dip" or downward slope of the Earth's magnetic field. Dip whenever the aircraft is in a bank, or during acceleration, making it difficult to use in any flight condition other than perfectly straight and level.

The pilot will periodically reset the heading indicator to the heading shown on the magnetic compass



Heading indicator shows 130°

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## 7. Vertical speed indicator

The vertical speed indicator (VSI), called also variometer or a vertical velocity indicator, indicates whether the airplane is climbing, descending, or in level flight. The rate of climb or descent is indicated in feet per minute. If properly calibrated, the VSI indicates zero in level flight.



Aircraft maintain its altitude in level flight

The VSI don't display immediately an accurate indication of a climbing or descending rate. There exists a lag or a time between the initial changes in the rate of climb/descent and the display of this new rate.

Note that turbulence can extend the lag period and cause erratic and unstable rate indications. It exists in some aircraft a vertical speed indicator (IVSI), which incorporates accelerometers to compensate for the lag in the typical VSI.



Aircraft descending -500ft/min



Aircraft climbing +800ft/min

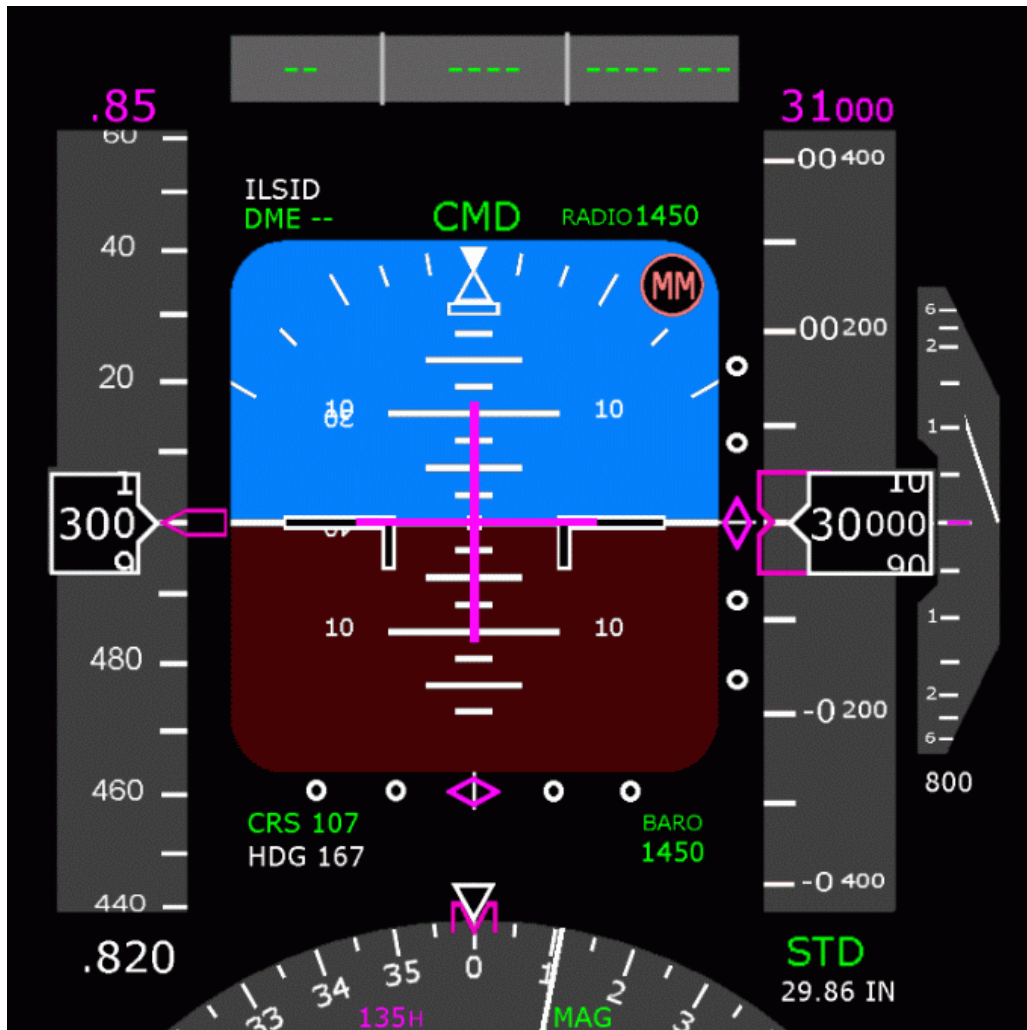
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## 8. Combined instrument

In some complex aircrafts, the cockpit has not the six separate instruments but one primary flight instrument named PFD which includes:

1. Airspeed indicator on the grey left bar (300)
2. Attitude indicator at the middle (blue and brown colored)
3. Altimeter on the grey right bar (30000)
4. Turn coordinator (showed by the white triangle and and white rectangle below “CMD” green text)
5. Heading indicator at the bottom center (0°/360°)
6. Vertical speed indicator (grey trapezoid form on the right)



Of course, in function of aircraft, the primary flight display can differ, but you will find the same information near the same zone of instrument (airspeed indicator on the left, attitude indicator in the centre, altitude and vertical speed indicators on the right heading on the bottom...).

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