Introduction

Flight in cloud can be dangerous because when we are deprived of visual references, the body's other senses may provide conflicting information to the brain. Without the benefit of visual references to resolve these conflicts, loss of aeroplane control can occur very quickly, usually within a minute.

However, instrument flying has a practical application to visual flying when the normal cues are missing or misleading; for example, low flying, mountain flying, night flying, or flying over water with a poor horizon.

Instrument flight is challenging because of the need to interpret and anticipate the instrument readings while recognising or ignoring the conflicting messages sent to the brain by our earthbound orientated senses.

Inadvertent flight into cloud can be avoided by maintaining a high level of situational awareness. However, a five-hour course of instrument flying is included in the requirements for PPL issue, to give the pilot and passengers some chance of survival should the event occur.

Objectives

To experience the sensory illusions which occur when deprived of visual references.

To maintain straight and level flight by sole reference to the aeroplane's instruments.

To climb, descend and turn by sole reference to the aeroplane's instruments.

Considerations

Describe the method of simulation that you will use, for example, hood or glasses.

Discuss the direct and indirect information that each of the flight and engine instruments give, as well as their power source.

The formula Power + Attitude = Performance remains unchanged for instrument flight. There are two types of instruments; control instruments and performance instruments.

Control Instruments

Attitude Indicator or Artificial Horizon

The Attitude Indicator (AI) or Artificial Horizon (AH) is the master instrument, because it presents pitch and bank attitude information directly (in miniature) against an artificial horizon.

Miniaturisation of the outside world means that small movements indicated on the attitude indicator represent quite noticeable changes in pitch and bank. Therefore, it is common to speak of pitch attitude changes in relation to the width of the wing bars representing the aeroplane within the AI. For example, the straight and level attitude is half a wing bar width above the horizon.

Indirectly, the attitude indicator is a guide to airspeed (nose low – high or increasing airspeed, nose high – low or decreasing airspeed).

The attitude indicator is most commonly driven by an engine-driven vacuum pump.

Tachometer

The tachometer directly indicates the engine rpm and indirectly the engine power output. In addition, rpm may indirectly indicate pitch attitude (rpm increasing – nose low, rpm decreasing – nose high).

The tachometer is commonly driven from the engine by a mechanical cable.

Performance Instruments

Airspeed Indicator

This gives the aeroplane's speed directly and, indirectly, pitch attitude (airspeed increasing – nose low, airspeed decreasing – nose high). Its source of information is the pitot-static system.

Altimeter

The altimeter directly indicates the height of the aeroplane above a datum, usually sea level. Indirectly, it indicates pitch attitude (altitude decreasing – nose low, altitude increasing – nose high). Its source of information is the static system.

Heading Indicator

The heading indicator is known as the Directional Indicator (DI), Directional Gyro (DG), or Horizontal Situation Indicator (HSI). The DI directly indicates the aeroplane's heading when aligned with the magnetic compass. Indirectly, it can indicate bank. Heading indicators are commonly driven by the engine-driven vacuum pump.

Turn Coordinator

The Turn Coordinator (TC), or Turn Indicator, directly indicates the rate of change of direction. Indirectly, it can indicate limited angles of bank (provided balance is maintained), commonly up to about 35 degrees. Any further increase in bank angle will not be indicated by the turn coordinator. Turn coordinators are normally electrically driven.

Balance Indicator

This Balance Indicator is commonly incorporated within the turn coordinator and directly indicates balance. Indirectly, it indicates yaw if the wings are level, or bank. Its power source is gravity, or the resultant of in-flight accelerations (CPF, CFF).

Vertical Speed Indicator

The Vertical Speed Indicator (VSI) directly indicates the rate of change of altitude. Indirectly, it indicates pitch attitude, and it is most useful when used as a trend indicator, as it will indicate a tendency to change altitude long before the altimeter registers any change. Its information source is the static system.

Instrument Layout

The four instruments, Attitude Indicator, Airspeed Indicator, Altimeter, and Heading Indicator, are arranged on the instrument panel in a Basic T-shape.

The addition of the Turn Coordinator/Balance Indicator, and the Vertical Speed Indicator make up the full instrument flying panel.

While not part of the six instruments referred to the rpm gauge is incorporated into scan techniques as appropriate.

Instrument Lag

All instruments suffer from lag, some to a greater extent than others. All instruments, other than the VSI, can be considered to be responsive enough for light aeroplane use. The VSI, however, suffers from significant lag, and must be cross-referenced with other instruments to check its indications.

Airmanship

The importance of checking instruments while taxiing, and in-flight **SADIE** checks are revised.

During visual flight training the requirement to counteract inertia (change – check – hold – adjust – trim) will have become automatic as a result of cues detected by peripheral vision. These cues will no longer be available and the necessity to consciously counteract inertia through this process when changing attitude will need to be emphasised during early instrument lessons.

The student should be prompting the lookout, by calling "clear left?" if a left turn is to be conducted and should receive a "clear left" response from the instructor.

Aeroplane Management

The aeroplane's vacuum and pitot-static systems should be described.

The method of setting the attitude indicator's aeroplane symbol before flight, and the desirability of not altering it in flight, are explained.

Human Factors

Humans use three sensing systems to gather and transmit information to the brain in order to remain orientated. These are the balance organs within the vestibular system of the inner ear, the muscular pressure sensors of the nervous system, and vision – the most powerful system of the three.

The balance organs of the vestibular system sense angular acceleration or change of direction in three different planes by the detection of fluid movement in the semicircular canals. In addition, the otolith organ senses linear acceleration as well as head or body tilt, through the movement of a jelly-like mass over sensitive hairs.

This system is limited by the inability to detect change when the direction or the angular acceleration is constant or very slow. It can also misrepresent acceleration as a nose pitch up, because of the effect of inertia.

The muscular pressure sensors of the nervous system are affected by gravity and allow us to detect, for example, whether we are standing or sitting when our eyes are closed.

Crucially, this system cannot differentiate between the various causes of increased G, for example, as the result of pulling out of a dive or of entering a steep turn.

The visual system is the most powerful of the orientation systems and normally resolves any ambiguous or conflicting information received by the brain, for example, this is a steep turn not a pull-out of a dive.

In instrument flight conditions the visual references used to resolve ambiguous or conflicting orientation information are not available. Until considerable practise has been carried out to replace the normal visual cues with instrument readings, orientation conflicts may occur, causing various illusions, for example, the leans.

Because the limitations of the human orientation system are considerable, and instrument failure is rare, **trust the instruments**.

Air Exercise

The air exercise starts with a demonstration of the limitations of the vestibular and muscular systems.

Selective Radial Scan

Selective radial scanning recognises that the attitude indicator is the master instrument and therefore employs an instrument scanning pattern that radiates out from, and always returns to, the attitude indicator.

The relative importance of the performance instruments varies – and therefore the scan rate varies – with the manoeuvre being executed. Describe this in relation to maintaining straight and level as well as achieving straight and level from the climb and descent.

Airborne Sequence

The Exercise

It is important to demonstrate the limitations of the body's physiological orientation systems carefully. The instructions below should be followed exactly so that the student experiences the false sensations of turning and pitching. An unconvincing demonstration may lead the student to believe they are immune to false indications. There are many demonstrations that show the susceptibility of the human senses to disorientation; it should only be necessary to show a few of them.

The False Sensation of Turning

In straight and level flight, ask the student to close their eyes and lower their head, remind them to resist any temptation to look out, if they do they will not feel what is normally sensed during instrument flight.

Lower the right wing very gently and then positively roll the wings level while raising the nose attitude without changing power. At this stage ask the student what attitude the aeroplane is in. Their balance and postural sensations will normally lead them to conclude that the aeroplane has entered a turn to the left.

The False Sensation of Climbing

In straight and level flight, ask the student to close their eyes and lower their head. Enter a medium turn to the left using a positive entry, then very gently change to a turn to the right while applying consistent backpressure to the control column. Ask the student to tell you what attitude they think the aeroplane is in. The sensation they have felt will be that the aeroplane is in a climbing left turn.

Once the student has seen that the sensation received from the senses of balance and posture can be misleading, they will have a better appreciation of the need to be able to fly by instrument reference before attempting to enter cloud or any other condition where outside visual references are minimal or completely absent.

It is not necessary to handle the aeroplane violently or adopt extremes of attitude to achieve the effects of disorientation.

During transitions from the climb or descent to straight and level it will be necessary to slow the students actions down to consciously follow the change – check – hold – adjust – trim sequence.

Student Practise

The student should have observed the instruments on previous VFR flights to verify that small movements on the AI result in noticeable changes in pitch and bank.

Now have the student put on the hood or glasses, get comfortable and ensure they cannot see out. Then they should practise the selective radial scan, first in straight and level, and then moving on to climbs, descents and turns, emphasising the change – check – hold – adjust – trim sequence.

On the Ground

The handout for this lesson should include the limitations of the human balance system, as well as a range of articles on incidents and accidents resulting from attempting continued VFR flight into deteriorating weather.