1 INTRODUCTION

This series of tutorials for the CIX VFR Club are based on real world flight training. Each document focuses on a small part only of the necessary skills required to fly a light aircraft, and by echoing real world training, you will be a better Flight Simulator pilot and get more enjoyment out of the hobby as a result.

These tutorials are written specifically for the Flight Simulator Default Cessna 172. Some details will be different for other aircraft.

You should read Exercise 8 before continuing with this tutorial.

2 OBJECT

The aim of this exercise is to change the aircraft's direction. Four situations are discussed: -

a) A turn at "medium" rate without significant change of altitude.

b) A "rate one" turn without significant loss of altitude.

c) A turn whilst climbing.

d) A turn while descending.

Turns at high angles of bank are covered in Exercise 15.

A "medium rate" turn is conducted at 30^{o} of bank.

A "rate one" turn is a turn made at 180^{o} in one minute. An empirical formula can be used which although not mathematically provable, works accurately for most aircraft. The angle of bank required to achieve a rate one turn is

(Airspeed / 10) +7

e.g. for a Cessna 172 at 100 knots airspeed, the angle of bank for a rate one turn is (100 / 10) + 7 = 17 degrees. This is a real world formula which also works in Flight Simulator.

3 DESCRIPTION

Ensure that you know where you are and the heading you are flying and the heading you wish to achieve. Also, in a VATSIM environment, lookout for other aircraft and listen to the radio which may give clues as to other aircraft's whereabouts and orientation. Club flights are always conducted with "Gyro Drift" enabled in FS, so if necessary, synchronise the Direction Indicator (D.I.) and Compass by pressing the "D" key on the keyboard, so that the D.I. is telling the truth.

In a high wing aircraft such as the Cessna 172, you should lift the "inside" wing momentarily before turning to ensure that the area you are turning towards is clear of other aircraft. This is important in a VATSIM environment when flying near others.

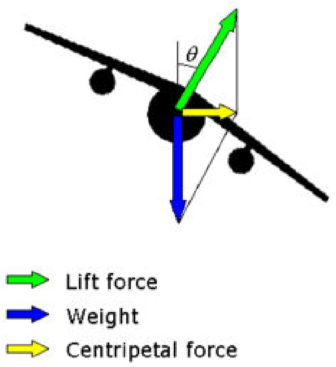
3.1 Aerodynamics

To initiate a left turn, say, the outer, outer wing aileron is deflected down and the inner wing aileron is deflected up, as the pilot moves the joystick left, or turns the control wheel left. This creates additional lift on the outer wing but less lift on the inner wing. So the aircraft rolls to the left. The diagram below shows that once the aircraft is rolled to the left, part of the lift force is converted to a horizontal force, the centripetal force, which makes the aircraft start to turn.

A number of adverse effects occur when an aircraft is turning, which need to be appreciated and corrected by the pilot. These effects can be easily seen if you stop flying your simulated aircraft and let it "do its own thing". Without pilot correction, even if cruise power is maintained, the aircraft will develop a spiral dive and crash.

3.1.1 Loss of Lift

In a turn, the aircraft loses lift, because the maximum lift (green arrow in the image below) is no longer equal and opposite in direction to the weight (blue arrow) of the aircraft (see Exercise 3 section 4 for full details).



To compensate for this loss of lift, aircraft must either add power to increase airspeed, and therefore lift, or increase lift by increasing the angle of attack of the airflow over the wings by raising the nose. The latter is the technique usually adopted for practical reasons. So in turns, a little back pressure on the yoke or joystick is required.

The secondary effect of raising the nose to increase the angle of attack is a loss of airspeed. Turns should therefore never be made at or near stall speed.

3.1.2 Increasing Bank Angle

In a turn, even when the ailerons are centralised, because the outer wing travels further than the inner wing the air flow over it is greater and it therefore generates more lift. The effect of this is to increase the angle of bank, unless corrected, as the turn progresses.

3.1.3 Slipping and Skidding

As you have seen, the outer wing aileron is down and the inner wing aileron is up in the turn to create more lift on the outer wing than the inner wing. More lift = more induced drag, and so there is also now more drag on the outer wing than the inner wing. This causes the nose to swing towards the outside of the turn. This is called adverse yaw. Modern aircraft don't have much adverse yaw as it is “designed out” but they do have some, so the following paragraphs remain important. When adverse yaw is present, he direction of the airflow over the aircraft is somewhat from the inside of the turn rather than straight on the nose, and the aircraft is said to be “slipping”.

In addition, the centripetal force is now out of balance with the horizontal component of the lift force, and so the ball in the turn co-ordinator will move towards the outside of the turn. Rudder input is needed towards the inside of the turn to balance the aeroplane so that it's longitudinal axis is tangential to the arc of the turn. The ball in the turn co-ordinator will be centralised when the forces in the turn are in balance. That is why it is called the Balance Ball!

Skidding is caused when too much rudder is applied; the nose of the aircraft swings towards the inside of the turn; the balance ball moves to the inside of the turn and the relative air flow is slightly from the outside of the turn, not directly on the nose.

3.1.4 The Co-ordinated Turn

In a “co-ordinated” turn, the aircraft is neither slipping nor skidding; the balance ball is centred and the relative airflow is smack on the nose. That is how turns should always be made.

3.2 The Medium Rate Turn.

As you enter the turn, lookout all round and above as best you can in FS. Occasionally a quick flip to outside view before starting the turn can help. From Straight and level flight at 100 knots, roll on bank up to 30° using aileron and rudder in desired direction. Use aileron to maintain the angle of bank and keep the balance ball centred with rudder.

The rule for balancing the ball is “kick the ball”. If the ball moves left, add more left rudder input, if the ball moves right, add more right rudder.

Introduce back pressure on the yoke or joystick to maintain height. You will need quite a significant amount of back pressure (more than real world) but do try to introduce both bank and back pressure smoothly in order to maintain a steady rate of turn without porpoising. Note that you do not trim the aircraft when turning.

A Medium Rate Turn

In an aircraft, once the turn is established, the ailerons are centred to maintain the angle of bank, unlike a car in which the turn of the wheel has to be maintained throughout. Holding the yoke in the turn will result in the angle of bank continuously increasing under the influence of the continued aileron deflections.

Maintain the turn at 30° of bank with small aileron inputs as necessary – check the 30° mark is against the index on the Attitude Indicator. Because the angle of bank has a tendency to increase in turns, even with the ailerons centred, a little corrective (opposite) aileron input is sometimes needed to maintain the required angle of bank. In flight simulator, this tendency to increase the angle of bank in turns isn't always as marked as in the real world and some aircraft will hold a steady angle of bank, and thus a steady turn, without any pilot input for some time.

Keep the balance ball centred and maintain altitude with elevator (check the altimeter). Observe the position at which the horizon intersects the cockpit coaming. This position is always very much the same in a medium turn at

100 knots, so you can use this as a reference in conjunction with the altimeter and Attitude Indicator.

To roll out of the turn level the wings by applying aileron and rudder in the opposite direction to that held when turning. Start to level the wings when the Direction Indicator is 10° before the required heading so that when the wings are level, you are flying accurately on the new heading. Always operate the controls smoothly, particularly when relaxing the back pressure when exiting a turn.

3.3 The Rate One or Standard Turn

The Rate One or Standard turn is the optimum rate of turn. The loss of lift is relatively small for the angle of bank introduced. Greater angles of bank cause a greater loss of lift, lesser angles of bank mean that the rate of turn is too slow – takes too long – for practical manoeuvring. The tendency of the angle of bank to increase is almost absent in a Rate One turn, but nevertheless, the pilot must regularly check that the correct angle of bank is being maintained. Introduce back pressure on the yoke or joystick to maintain height, although you will only need a small amount of back pressure to maintain altitude.

A Rate One turn is a turn carried out at a rate of 3° per second or 180° per minute. An empirical formula can be used which although not mathematically provable, works accurately for most aircraft. The angle of bank required to achieve a rate one turn is

(Airspeed / 10) +7

e.g. for a Cessna 172 at 100 knots airspeed, the angle of bank for a rate one turn is (100 / 10) + 7 = 17 knots. This is a real world formula which also works in Flight Simulator.

In a Rate One turn, the Turn Co-ordinator model aeroplane lower wing is aligned with one of the marks on the outer ring of the instrument (depending on the direction of turn, irrespective of the airspeed in the turn.

3.4 The Climbing Turn

The Climbing Turn starts as a straight climb at 70 knots (see Exercise 7). Firstly, power is added to maximum approved rpm for the aircraft type. When a climb has commenced, the ailerons are used to introduce an angle of bank and the rudder is used to maintain balance – keep the slip ball centred. The turn is carried out at Rate One – about 15° of bank in the C172 – in order to maximise the rate of climb. However, the rate of climb will be less in the turn than when climbing straight ahead, because of the loss of lift caused by banking, as described above. You also need to control airspeed accurately and correct any tendency to overbank especially to the left. Nose attitude will need to be slightly lower than in a straight climb. Try increasing the angle of bank to 30º (no more) and observe that the rate of climb is reduced.

3.5 The Descending Turn in a Cruise Configuration

The descending turn starts from a straight descent in the Cruise Descent configuration. This means the airframe is "clean" (no flaps), and in the Cessna 172, power is about 2100rpm. This tends to result in the nose naturally lowering and the aircraft establishing a stable descent at 500 feet per minute descent, with the airspeed not significantly below cruise speed of 105 knots.

Before commencing the turn, make sure you are not descending into the path of another aircraft – have a good lookout. Bank angle may be up to 30°. Note that the turn increases the rate of descent and lower nose attitude is required to maintain the correct airspeed. Power must be added if the rate of descent exceeds about 500 feet per minute in the Flight Simulator X Cessna 172, as it is real world.

3.6 Descending Turns With Flaps

More commonly, descending turns are made in the approach configuration when turning from base leg to final. Such turns can be quite critical as the tendency to lose concentration is high with several other cockpit tasks in hand preparing for landing. The aircraft is inevitability "low and slow", the most dangerous phase of flight.

After establishing the approach configuration in the Flight Simulator X Cessna 172, with 2 stages of flaps, trimmed at 70 knots, with power at 2000rpm, a gentle descent will already have started from circuit height. The turn is made at Rate One, as steeper angles of bank can result in excessive height loss at the reduced airspeed.

4 FLIGHT PRACTICE

4.1 Outside Checks

a) Altitude - sufficient to begin a safe turn

b) Location: not over another aeroplane, nor likely to head towards terrain or obstacles.

c) Not in an aerodrome ATZ (controlled airspace) without permission

4.2 Cockpit checks

a) Trim for straight and level flight.

b) Engine set at cruising r.p.m.

c) Carburettor heat control to warm.

4.3 Medium Rate Turn

a) Use ailerons to bank the aircraft to 30° of bank.

b) Use rudder to keep the slip ball centred

c) Add back pressure to prevent loss of altitude

d) Accept the secondary effect of reduced airspeed, but monitor approaching stall speed.

4.4 Rate One Turn

a) Use ailerons to bank the aircraft to 15° –17° of bank at 100 knots (Make mental calculated adjustment for different airspeeds).

b) Use rudder to keep the slip ball centred

c) Add back pressure to prevent loss of altitude

d) Accept the secondary effect of reduced airspeed, but monitor approaching stall speed.

4.5 The Climbing Turn

a) Increase power to maximum rpm but below “red line” rpm.

b) Use ailerons to bank the aircraft to 15° –17° of bank at 100 knots (Make mental calculated adjustment for different airspeeds).

c) Use rudder to keep the slip ball centred

d) Monitor pitch attitude to maintain 70 knots airspeed.

4.6 The Cruise Descending Turn

a) Reduce power to around 2100 rpm (FSX Cessna 172

b) Maintain approximately 100 knots by pitch adjustment and trim.

c) Use ailerons to bank the aircraft up to 30° bank

d) Use rudder to keep the slip ball centred

e) Adjust power to maintain 500 feet per minute descent.

4.7 The Powered Descent with Flaps

The descending turn from base leg to final during an approach to land is covered in much more detail in Exercise 13.