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 3 before continuing with this tutorial.

2 UPSETTING THE BALANCE

In exercise 3 it was explained how an aircraft is able to change from flight in a straight line at a constant height when all the four forces acting on it are in balance. It was also explained how an aircraft must rotate around one of the three perpendicular axes if any change from straight and level flight is to be made.

The primary aircraft controls are used to change the aircraft's movement about the three axes of movement.

2.1 Pitch

To change the pitch of an aircraft, the elevator is used to increase or decrease the lift generated by the tail plane. If the control column is pulled back, the elevator is raised creating an increase in the downward force on the tail plane. The tail then moves down and the nose moves up, as the aircraft rotates about the lateral axis through its centre of gravity.

2.2 Roll

To make the Aircraft roll around its longitudinal axis, the lift on each wing is made to be different. This is achieved by the ailerons. When the control column is rotated left, the aileron on the left wing is inclined upwards, which decreases the lift generated by that wing, and the aileron on the right wing is inclined downwards, which increases the lift generated by that wing. These unbalanced forces then force the aircraft to roll.

2.3 Yaw

It is generally aerodynamically undesirable for an aircraft to be deliberately yawed, as it will necessarily increase the area exposed to the airstream, thus increasing drag. There are situations, e.g. turning, which will be covered in lesson 4b, where yaw is required to restore an out of balance flight situation, and as explained in a later lesson, there are some occasions where deliberate yawing has an advantage.

Yaw may be created by turning the rudder with the foot pedals or rudder bar. To yaw the aircraft left, apply pressure with the left foot and vice versa. The rudder movement generated is similar to that of the other control surfaces. An out of balance force is created by the airflow over the rudder, creating a sideways force at the tail which acts to turn the aircraft about the normal axis.

3 MAKING CHANGES

In order to change the balance of the forces we have to change **lift**, because **mass** cannot be changed greatly (the burning of fuel will reduce the mass over time), or **thrust**, because we have little control over **drag** (except in certain special circumstances which will be explained in a future lesson).

3.1 Lift

You change lift primarily by changing the angle of attack (see Exercise 3, paragraph 2.1). Changing speed also affects lift, but in practice, we generally establish a speed we wish to fly at, and change the angle of attack to establish a climb, level flight or descent. Changing the angle of attack is done by raising or lowering the nose using the elevators. Raise the nose – increase the angle of attack – increase the lift, and vice versa.

For example, when flying slowly, an aircraft of a certain mass will require a greater angle of attack than when flying quickly, because the speed of the airflow over the wings is reduced. The lower speed results in less lift, which is compensated by increasing the angle of attack.

Again, for example, if there are two 4 seat aircraft of the same type, flying at the same speed, but one is heavier than the other, perhaps having 3 passengers, whilst the other only has the pilot aboard, the heavier aircraft will be flown with a higher nose attitude (and thus higher angle of attack) to maintain level flight.

3.2 Power

Adding power in almost all moving bodies increases speed. In light aircraft this is also true, but due largely to the relatively low excess power and low inertia they have, compared to large jet aircraft, the **effect** of power changes is observed to change not the speed, but the rate of climb or descent. This is in part due to the fact that the slipstream from the propeller will affect lift as it flows over inner sections of the wings.

If a light aircraft in level flight increases power, and no other control is moved, it will climb. If power is reduced, it will descend. The change of speed on a power change is small, and overridden by the climb or descent which themselves have a greater effect on speed than a power change alone.

Control Airspeed with attitude

Control rate of climb or descent with power.

This is always essential for flying light aircraft of modest power.

4 EFFECTIVENESS OF CONTROLS

Since the effectiveness of the controls is a function of the speed of the airflow over them, then it follows that the controls are more effective at higher airspeeds than low. At slow speeds, the control movement required to obtain the desired effect is greater, and the controls are described as being "sloppy".

Because the elevators and rudder are situated in the slipstream in most single engined aircraft, the airflow over them is increased at high power settings, so they are more effective with power on than, say, in a glide with the engine at idle power. This is demonstrated most clearly during the landing, where the stick is held back more and more and the elevators are deflected more and more, as the slowing aircraft is held in level flight just above the runway immediately prior to touchdown.

5 TRY IT IN THE AIR

Although most readers of these notes will have flown their Flight Simulator before reading them and some no doubt for some time previously, it is recommended that a flight is made where each of the controls is used in isolation to firmly establish in the pilot's mind what is happening. However, the flight is probably best conducted after reading Exercise 4b as well, because the simple theory of applying one force for one effect is not how an aeroplane actually behaves.

However, here is one exercise you can try to demonstrate the truth of:

Control Airspeed with attitude

Control rate of climb or descent with power.

Establish straight and level flight at 2300 r.p.m. and 105 knots, then raise the nose a couple of degrees by easing back on the stick and holding it (or trimming if your skill level has reached this point.) The aircraft will initially climb, but will quickly stop climbing and establish itself at an airspeed lower than the initial 105 knots.

Unfortunately, Flight Simulator has poor pitch attitude damping, so what happens next is a prolonged climb-descent oscillation in pitch, each cycle getting smaller in amplitude (the "phugoid response") until eventually (after about 20 cycles it settles down. In real life, most aircraft are designed to settle down after 3 cycles.

Re-establish straight and level flight at 2300 r.p.m. and 105 knots, then reduce power by 50 r.p.m. The aircraft will descend and continue to descnd. Increase power to 2350 r.p.m. and it will climb and continue to climb.

This vital rule is most obviously demonstrated on the approach to landing, where the attitude is set and trimmed out at approach speed (70 knots in the Cessna 172) and ALL the control of descent is made using the throttle. Small speed changes resulting from power changes are adjusted back to 70 knots using small elevator movements, but the principal control during the approach to land is the throttle lever. If you are too high on approach, reduce power. If too low, add power. There is much more on this subject in a later lesson.