Effects of controls

This lesson is arguably the most important lesson a student will take. A thorough understanding of the primary and secondary effects of control inputs is the basis of all future flying. It is important that the student understands and has the opportunity to practice these effects.

As this is commonly the first formal preflight briefing, a short explanation of the sub-headings should be included, as well as the normal introduction. The *Airmanship* section covers good aviation practice.

This lesson does not aim to teach the student to fly, that will come over the next few lessons. This lesson focuses primarily on each control, how it works, and how it is related to other controls. As a consequence this lesson may seem less coordinated than normal.

Primary flight controls are the elevator, ailerons and rudder. When these are deflected in flight the aeroplane moves about one or more of its three axes. The student needs to know what effect these controls have on the aeroplane's flight path in order to accurately manoeuvre the aeroplane. They also need to see the effect of moving each of these primary flight controls individually, so that any unwanted secondary effect can be countered through coordinated use of the primary flight controls.

Ancillary controls are the throttle, flap and trim. The student needs to know how to operate each of these correctly and what effect their operation will have on the flight of the aeroplane. A clear understanding of the effect of using these controls is important, and then with practice, any adverse effect can be countered.

Objectives

- To operate the primary control surfaces and to experience the feel and observe the first aerodynamic effect on the aeroplane in flight.
- To operate the primary control surfaces and observe the further (or secondary) aerodynamic effects on the aeroplane in flight.
- To operate the ancillary controls and to experience the feel and observe the effect on the aeroplane in flight.

Principles of Flight

Primary Controls

Describe how the aeroplane is controlled on the ground (see *Taxiing* lesson). Speed is controlled by the hand operated throttle and the main wheel-brakes, while direction is controlled by the use of the pedals linked to the steerable nosewheel.

Figure 1

Describe how to hold the aeroplane's controls and explain the concept of dual controls. Identify on your aeroplane which controls are dual, and which are not.

Introduce the terms lift and aerofoil. Describe how lift is produced, with reference to Bernoulli, in the simplest possible terms. For example, if the speed of the airflow is increased the pressure will be reduced and the effectiveness increased, and vice-versa.

Describe the three axes of the aeroplane – lateral, longitudinal and normal (sometimes termed vertical) – and the movement about those axes (use teaching aids).

Figure 2

Drawings, PowerPoints or overheads should be gradually built up and colour coordinated. For example, the lateral axis, the elevator and the word pitch could all be coloured purple.

Describe how deflection of the controls changes the shape and/or angle of attack, affecting lift and producing the first aerodynamic effect. Start with the elevator, as this is the easiest to describe. Then cover the ailerons and the rudder. If the student has difficulty understanding Bernoulli, angle of attack or pressure, state that movement of the controls deflects the airflow and the tail is pushed up or down as applicable (Newton's third law).

The effect of moving the elevator is to pitch the aeroplane. This changes the position of the aeroplane's nose in relation to the horizon – the aeroplane's attitude – and will consequently affect the aeroplane's speed.

The effect of moving the ailerons is to roll the aeroplane. This banks the aeroplane left or right.

The effect of moving the rudder is to yaw the aeroplane. This moves the aeroplane's nose left or right.

Slipstream should be described as the spiral column of air being forced back by the propeller and the primary controls it affects should be pointed out. It should be noted that slipstream is present whenever the propeller is rotating, regardless of the aeroplane's speed. The comparison of standing behind the aeroplane, compared with standing at the wingtip, may help the student visualise the effect of this airflow. This highlights that ailerons are unaffected by slipstream.

Figure 3

Describe the rotational nature of the slipstream and its resultant impact on the tail fin. As the aeroplane spends most of its time in cruise, the manufacturer offsets the tail fin, or the thrust line, to negate the resultant yawing tendency. Therefore, at any power setting other than normal cruise, and at any time the power changes, the aeroplane will want to yaw, and compensating rudder inputs are required.

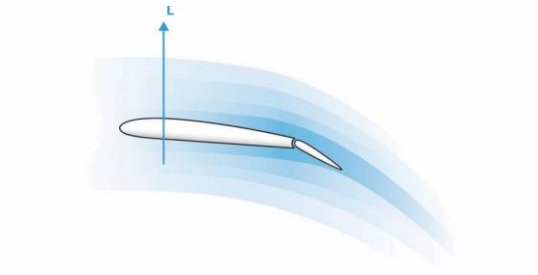
Ancillary Controls

Briefly describe the throttle and its direct connection to the propeller and its effect on the aeroplane's speed. Explain that power is increased by moving the lever (or plunger) forward and decreased by moving the lever rearwards.

Discuss the purpose of trim and how it works. State that most training aeroplanes are fitted with trim tabs to provide sufficient force to hold the primary control surface in the desired position. Emphasise that they are not used to alter the primary control surface's position, they are a pilot aid only. You could also note that trim tabs may be provided on all three primary controls.

Describe where the flaps are located on the aeroplane, how they are operated, how they work (electrically or manually), and the various positions to which they can be selected. It should be noted that flap 'up' means flush with the wings, i.e., they do not extend above the wing.

Figure 4



Describe how the flap changes the shape of the wing and the effect that has on lift, drag, L/D ratio, and pitch. Commonly, in high-wing aeroplanes, the nose pitches up with application of flap, and on low-wing aeroplanes the nose pitches down. The reverse occurs in each case when flap is raised, but importantly all aeroplanes will sink when flap is raised. Describe the actual pitch changes the student will observe as a result of using the flap, and the consequent trim changes that will be required.

The structural airspeed limit for flap extension, and the normal operating range, white arc, should be explained.

Inertia

Because an aeroplane has mass (weight) it is subject to inertia. Explain in very basic terms that inertia is the tendency of a body to remain in its current state. If it has stopped on the ground it will take more power to get it moving than to keep it moving. If you want to decrease the speed in flight, the aeroplane will not slow down instantly, but gradually decelerate. This must be taken into account when changing the speed or the direction of the aeroplane.

Airmanship

Knowing who is physically flying the aeroplane is critical. Get the student into the habit of stating "I have control/you have control." The meaning of "follow me through" should be explained, for example, "I want you to place your hands and feet lightly on the controls and feel what I'm doing, but I retain control."

Explain how to use the clock code to report the relative position, height and distance of other aircraft. Aircraft that appear above the horizon are higher, aircraft on the horizon are at the same level, and aircraft below the horizon are lower. Distance is judged from the known size of the object and is prone to perception errors. For example, a Boeing 747 at 10 miles can look like a Cherokee 140 at 2 miles.

The aeroplane is manoeuvred in the air by visual reference to the horizon and ground features. Visual flight rules mean that cloud must be avoided and the ground or water kept in sight at all times. When you get into the air, point out some major features in your local area, as well as the approximate directions of north, south, east and west, and where your aerodrome is located. Over subsequent briefings the various aspects of VFR flight will be discussed. It is vital that you demonstrate compliance with the various VFR requirements.

I'M SAFE

The '**I'M SAFE**' checklist should be introduced for the student to complete before leaving home for their next lesson.

I Illness

Do not fly when feeling unwell as this will not only degrade the learning experience but affect all phases of flight.

M Medication

How will the effects of medication be altered by the flight environment, for example, altitude? In addition, why is medication being taken, am I unwell? Do I need to consult an AME?

S Stress
This takes up valuable space in the short-term memory. Getting into an aeroplane straight after an argument or with other personal worries affects your information processing capabilities.

A Alcohol
Even in small amounts, alcohol adversely affects brain functioning. Mixed with altitude and the dynamic three-dimensional environment of aviation, it is deadly. Safe periods of abstinence before flight vary with the individual and the amount consumed.

F Fatigue
This affects not only motor skills but also mental skills. Adequate rest is essential for quality information processing and decision making.

E Eating
A balanced diet and drinking water at regular intervals to prevent dehydration is important. Poor eating habits and/or dehydration can have a detrimental effect on the decision-making process.

In addition, the '**I'M SAFE**' checklist should be prominently displayed in the briefing room for quick reference before flight.

Aeroplane Management

A large-scale photograph of the aeroplane instrument panel and/or cabin layout is a valuable aid.

Give a brief explanation of the purpose of the engine controls. Discuss the sense of movement of these controls.

Throttle
The use of smooth throttle operations should be emphasised. As a guide it should take three seconds to move the throttle from fully CLOSED to fully OPEN, and vice versa. Demonstrate an appropriate grip on the throttle.

Mixture
IN or OUT, UP or DOWN. Explain the type of control and that when the mixture control is pulled fully out the fuel supply is cut off from the engine. This is called Idle Cut Off (ICO) and is normally used to stop the engine (not the ignition key – except where there is a solid state ignition system). This will be demonstrated when you shutdown at the end of the lesson. Discuss how the mixture control is used to alter the fuel/air ratio and then state that for initial training flights the mixture control is set at the full rich position. Leaning the mixture will be covered in later lessons.

Carburettor heat
UP or DOWN, IN or OUT. The purpose of the carburettor heat control should be covered.

Briefly outline the reasons and conditions for carburettor ice forming, the symptoms of its formation, and the cure. In addition, the reason for applying carburettor heat before closing the throttle, and the conditions under which carburettor ice is most likely to form, should be described. Introducing warm air into the carburettor alters the mixture, so is not normally used at high power settings.

Discuss when you would use carburettor heat on the ground, and the precautions you need to take while doing so.

Temperature and pressure gauges
Such as oil, cylinder and fuel, have a normal operating range depicted by a green arc. Red lines indicate operating limits, yellow arcs the cautionary ranges, and often white lines or arcs for other purposes (refer Flight Manual). The importance of monitoring temperatures and pressures for normal readings should be explained. It may sometimes be normal to taxi with oil temperature below the green range (see Flight Manual). On the other hand, it would not be normal to see the oil temperature near the top of the green range after a prolonged descent, even though it's in the green.

Human Factors

Describe the VFR see-and-be-seen principle and the importance of a good lookout.

Discuss the limitations of vision, especially on lookout effectiveness. Stress the need to move the head to see around the cabin structures, so that a thorough lookout can be achieved.

Discuss the limitation of the visual system when attempting to detect small stationary objects and alternatively the ability of peripheral vision to detect movement.

Discuss the effects of information overload in relation to human information processing capabilities and the effect on performance. The short-term memory can hold only 7 items ± 2.

Discuss the effects of stress in relation to human information processing capabilities and the effect on performance. As this is the student's first flight it is a busy and new experience. Future lessons build on those before them and the stress reduces.

The benefits of regular practice and the use of a checklist should be encouraged to help with both of these.

Air Exercise

Describe the method of taxiing the aeroplane under its own power, stopping and turning.

Basic flight training is based on the concept of attitude flying by visual reference. It is important to introduce the student to the concept of attitude, being the relationship between the nose (or instrument panel) and wings, and the horizon. Discuss in simple terms how the primary controls are used.

Primary Effects

Discuss the effect of movement of each of the primary controls in flight, with emphasis on the sense of movement of the control column and rudder pedals – not the sense of movement of the control surfaces themselves. It is what the student sees as a result of control movement that is important, for example, easing back on the control column pitches the nose up.

Emphasise the association between control movement and the natural sense, for example, rotating the control column to the right will cause the aeroplane to roll to the right.

In flight these movements are related to the horizon and confirmed with reference to the instruments. These movements rotate the aeroplane about its axes in a natural sense and always have the same effect relative to the pilot, for example, even when banked rudder will still yaw the nose to the pilot's left or right, but up or down in relation to the horizon.

Further Effects

The emphasis here is on aerodynamic effects, sometimes known as aerodynamic cross coupling. When a control movement is made on its own, movement initially occurs around one axis, followed by an undesired movement about another axis. The main point is that these effects only occur when the control is used on its own.

There is no further or secondary effect of elevator.

When aileron is used on its own, the aeroplane will roll, slip and then yaw towards the lower wing.

When rudder is used on its own, the aeroplane will yaw, skid and then roll in the direction of yaw.

In both cases, if the controls are left alone, the aeroplane will enter a spiraling descent. The initial slip or skid can be demonstrated with a model as it may be difficult to detect in the air, but the secondary effect will be clearly seen. The balance ball will indicate these effects, but you may not wish to draw the student's attention to this instrument yet.

It should be emphasised that these further or undesirable effects of ailerons and rudder can be eliminated through coordination of these controls, and will be dealt with in later lessons. In this lesson, your purpose is to demonstrate these secondary effects, and as a consequence aspects of this lesson are uncoordinated.

Airspeed

Discuss the effect of airspeed on the feel of the controls, the aeroplane response rate, and the amount of movement needed to change the flight path. Commonly, the analogy of holding your hand

out the car window and moving it from horizontal to vertical at various speeds is used to describe this effect.

At low airspeeds, typically with a high nose attitude, the controls are easy to move, are less effective and require large movements to bring about a change of flight path. They feel sloppy.

At high airspeeds, typically with a low nose attitude, the controls are harder to move, very effective and require only small movements to bring about a change of flight path. They feel firm.

Slipstream

Figure 5

Describe the effect of slipstream over the elevators and rudder, in relation to high power and idle power settings, at a constant airspeed. At high power the slipstream is increased, and the elevator and rudder are more effective; conversely, at idle power they are less effective. Because the ailerons are situated outside the slipstream their effectiveness does not change with increasing or decreasing slipstream. On some aeroplanes the elevator may be out of the slipstream because of its height, for example the Piper Tomahawk.

Power

With an increase in power the aeroplane will pitch up (for reasons that will be explained in a later lesson) and the nose will yaw to the left. Reducing power will result in a pitch down and yaw to the right. Therefore, whenever the power is changed, the pitch and yaw must be compensated for in order to maintain the attitude.

Trim

Describe the method of trimming, if you are holding the elevator back – trim back, if you are holding the elevator forward – trim forward. Similarly, if the aeroplane is fitted with rudder trim, holding right rudder pressure – move or rotate rudder trim to the right.

Figure 6

Flap

When flap is lowered, lift and drag are increased, which causes the nose to pitch _____.
The opposite effect will occur when flap is raised. The change in lift can be felt and the changes in drag can be seen as an airspeed change. Discuss the L/D ratio in context of the initial application of flap on lift compared with the further application and its effect on drag. Any change in pitch will require a change in the trim.

Airborne Sequence

Before Flight

The importance of inspecting the aeroplane before flight should be emphasised and a demonstration of the full aeroplane preflight inspection given.

During the preflight inspection, point out the major features of the aeroplane, the primary controls and movements, both fixed and adjustable trim tabs, and the effect flap has on the shape of the wing. Point out that while full control movement is acceptable on the ground, only small movements are required in normal flight because the primary controls are situated at the extremities (thus providing a large moment arm).

Make sure the student is seated correctly, seat secure, seat belts done up, and point out the limitations imposed on the lookout as a result of the cabin structure.

During the taxi encourage the student to operate the rudder pedals while you hold the control column and operate the throttle. Gradually hand over control of throttle, brakes and control column to the student. Most students will attempt to steer the aeroplane on the ground by rotating the control column – as in a car. They will soon discover that this has no effect on the aeroplane. With a gentle reminder, they will learn to keep the control column neutral and use their feet on the rudder pedals.

Remind the student that a much greater lateral clearance is required than that required for a car.

Point out major ground features and approximate directions of north, south, east and west.

The Exercise

Primary Effects

Before any demonstration, ensure the student is looking in the right place, i.e., outside over the nose. If the student is looking at the rudder pedals they are unlikely to see the first effect, much less any further effects.

Figure 7

First explain 'nose attitude' and what you mean by it. The line the horizon makes in relation to the aeroplane's nose will be the primary means the student uses to fly the aeroplane. They must have a sound understanding of aeroplane attitude and how to use it, if they are going to become a pilot.

The primary flight controls and their effects are demonstrated one at a time, with emphasis on the natural sense, to experience the affect themselves. After each demonstration, the student should operate each control one at a time. Ensure that during the rudder movement demonstration and student practice that the wings are held laterally level with aileron. Otherwise the student will see the more obvious roll rather than a pure yaw.

Further Effects

Aileron

The aeroplane should be trimmed to fly so that only the lightest of finger and thumb grips is needed on the control column and the feet are only resting on the rudder pedals. Resist the natural tendency to increase backpressure as aileron is applied, otherwise the yaw will not occur. Secondary effects only occur when the primary controls are used on their own.

Drawing the student's attention to the outside reference point, roll the aeroplane with pure aileron using only the finger and thumb. The slip may be difficult to see, however, the yaw and resultant spiral descent should be apparent.

You should ensure three things – firstly that only moderate angles of bank are used, secondly that the student sees how easy it is to stop the spiral descent by using coordinated control inputs, and thirdly that you demonstrate the further effects in both directions.

The student should get the opportunity to move the controls and experience these further effects, but does not need to master it.

Rudder

Once the aeroplane has been returned to straight and level flight, the further effect of rudder should be demonstrated. Gentle application of rudder is all that is required. Once again the skid is difficult to see but the roll and resultant spiral descent is obvious.

Airspeed

Demonstrate the use of elevator by selecting an attitude and watching its resultant effect on airspeed, then give the student the opportunity to experience it.

To effectively demonstrate the effect of airspeed, maintain a constant power setting and vary the airspeed with attitude.

Nose-high attitude equals low or lower airspeed, nose-low attitude equals high or higher airspeed. At this stage there is no requirement to refer to any specific attitude, for example, level or climbing attitude. During this demonstration the throttle should not be moved but left at a medium power setting, so as to make it quite clear that it is the attitude that directly affects the airspeed. During the high airspeed demonstration, however, the throttle will need to be slightly closed unless the aeroplane has a variable speed propeller and a constant speed unit fitted.

In each case (low and high airspeed) the student should note the feel and response of each primary control. Although any slipstream will affect the feel and response of elevator and rudder in most single engine aeroplanes, the average student on their first lesson will not detect it. It is highly unlikely that the student under these conditions will notice any difference at all regardless of the power setting. Therefore, the student will need to be convinced verbally of what they feel. This is achieved by modulating your voice as each control is moved. For example, low airspeed, elevators light, less effective, BIG movements required; high airspeed, elevators **firm**, VERY effective, small movements required. The benefit of a constant power setting to give a clear demonstration of attitude to control airspeed far outweighs the considerations of control feel and response.

You can demonstrate at the end of this sequence that all three controls work in relation to the pilot and not the horizon by rolling in some bank, pitching the nose up or down and yawing left or right at the same time. The student should then be encouraged to operate all three controls for themselves.

Use the phrase "pitch the nose up", instead of "pull back on the control column."

Slipstream

Although the effect of slipstream is present at all airspeeds with the propeller rotating, it is easiest to demonstrate at a high power setting and low airspeed. Set up the aeroplane for a constant low airspeed with full power on (e.g., a climb). Trim. The student should operate all of the controls, noting the feel of effectiveness for each.

The next step is to reduce power to idle to remove the effects of slipstream and set up the same airspeed as before (i.e., a glide). Trim. Now the student again operates all controls, noting the changed feel of those within the slipstream – the elevator and rudder, or just the rudder in the case of the Piper Tomahawk.

To effectively demonstrate the effect of slipstream, maintain a constant airspeed and vary the power setting.

Power

To demonstrate the effects of a power increase or decrease, the aeroplane should be trimmed straight and level at an intermediate power setting. Point out that for this demonstration the feet are off the rudder and the hand is resting lightly on the control column before any power change.

It may be better to demonstrate the effects of reducing power first and then trimming for a descent at a low power setting, for example 1500 rpm, which will provide for a greater pitch change when demonstrating the effects of increasing power. Using full power for this gives a very good demonstration, especially as the aeroplane is trimmed for a descent.

The student should experience compensating for the power changes with appropriate pitch and balance application – "keeping the picture the same."

The instructor should trim the aeroplane as required.

Trim

The use of elevator trim to relieve control loads and maintain a constant attitude is demonstrated next. Be aware that the aeroplane is trimmed for an attitude, not an altitude or airspeed. The student should be asked to hold a constant attitude – any attitude will do – you then apply trim to load the control (caution: do not use excessive amounts of trim in case the student suddenly lets go of the control column). When the student can feel that they are pushing or pulling in an effort to maintain the attitude they should move the trim in the appropriate direction to remove the load.

To trim the aeroplane the student should be encouraged to gradually relax their grip on the control column as they neutralise the control forces and, looking outside at the attitude, observe any change. If a change is observed, the desired attitude should be re-selected with the primary flight controls, then pause while equilibrium is re-established, and then re-trim and start the checking process again. As already pointed out, the student at this stage, cannot feel subtle control pressures. However, the changing attitude should be relatively easy to detect. The aim is to be able to fly the aeroplane at a constant attitude, using only a finger and thumb grip, and this will not be achieved in one lesson.

Flap

Point out the white arc on the airspeed indicator.

To demonstrate the effect of flap, an attitude should be selected for a suitable speed within the white arc. Trimmed for straight and level, flap is selected, the pitch change for the aeroplane type noted and the aeroplane re-trimmed. This will not necessarily require the application of full flap to occur. The student can operate the flap, but be aware that observing the pitch change is the more important aspect. From trimmed level flight demonstrate the effect of raising the flap, and the re-trimming required. Also note the changes in lift and drag, and the sink encountered with changes in airspeed.

After Flight

After landing, allow the student to revise taxiing and to move the mixture control to ICO on shut down.

The operation of the aeroplane's heater/demister and fresh-air vents can be demonstrated.

After the debrief (see below) tell the student the next lesson will be *Straight and Level*, and that you will be using the controls you learnt about today to fly straight and level. They may want to do some further reading on this.

Debrief

Comments are given here as a guide to the novice instructor on how to complete the debrief while gaining the experience needed to expand their teaching.

The debrief is an opportunity to revise the exercise, and for both you and the student to reflect on whether the objectives have been met.

Did the student operate the aeroplane's primary controls and experience the first aerodynamic effects? Did they observe the further effects on the aeroplane in flight? Did they operate and experience the ancillary controls and their effects?

If you require verbal confirmation from the student that the objective has been achieved, questions should be phrased to test understanding. Do not ask if the student observed the secondary effects of the primary controls. Preferably, ask the student to describe the further effect of one, or each, of the primary controls.

It is important at this early level to allay any fears or false expectations by reinforcing the fact that there is much to learn. Competence at this stage is not as important as understanding – every lesson will build on the last and give the student every opportunity to improve.