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DOCUMENT TITLE
AIRCRAFT GENERAL KNOWLEDGE

CHAPTER 1 – AIRCRAFT DESIGN AND CONSTRUCTION

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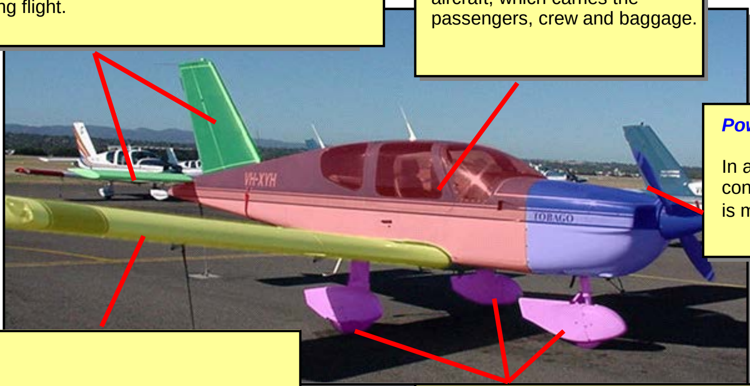
AIRCRAFT DESIGN AND CONSTRUCTION

1.1 The Structure of a Light Aircraft

1.1.1 Overview

The major components of the airframe of an aeroplane are:

- The fuselage
- The wings
- The tail section (empennage)
- The flight controls
- The landing gear (or undercarriage
- The engine and propeller.



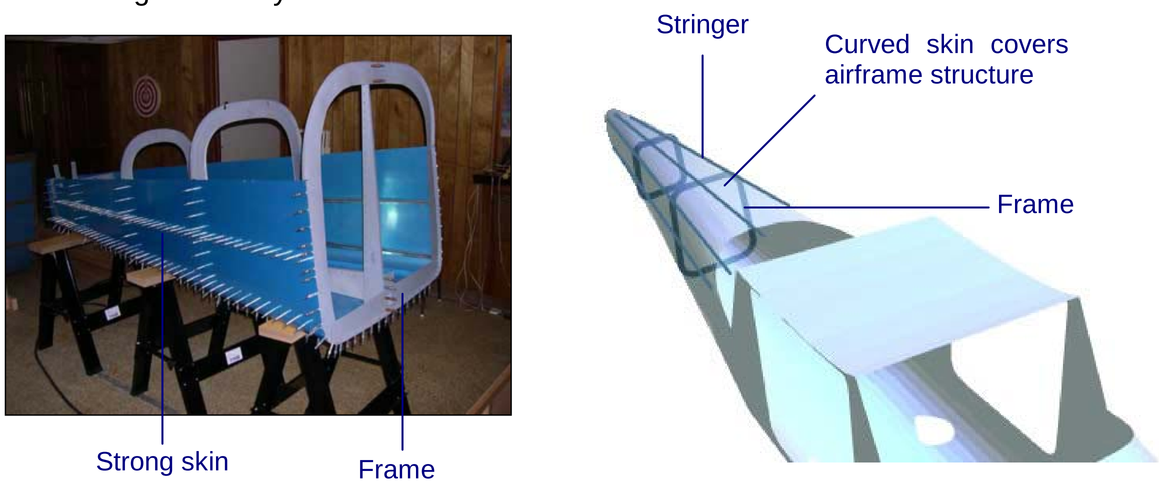
1.1.2 The Fuselage

The fuselage forms the body of the aeroplane to which the wings, tail section, engine and landing gear are attached. It contains a cabin with seats for the pilot and passengers and the flight controls and instruments, and may also contain baggage compartments.

The fuselage must be able to absorb forces generated by the wings and undercarriage in flight and on landing. It must also absorb the bending and twisting moments of the engine and empennage and carry these loads with a minimum weight penalty.

1.1.3 Semi-Monocoque

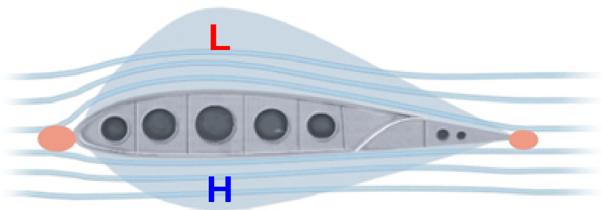
Light aircraft fuselage construction may be of fabric covered steel tube framework, wooden framework and skin, aluminium alloy framework and skin, or composite materials such as glass fibre. The fuselage of many modern training aeroplanes is of **Semi-Monocoque** construction, a light framework covered by a skin (usually aluminium) that carries much of the stress. It is a combination of the best features of a strut-type structure, in which the internal framework carries almost all of the stress, and a monocoque structure which, like an eggshell, has no internal structure, the stress being carried by the skin.



Example of a Semi-Monocoque Construction

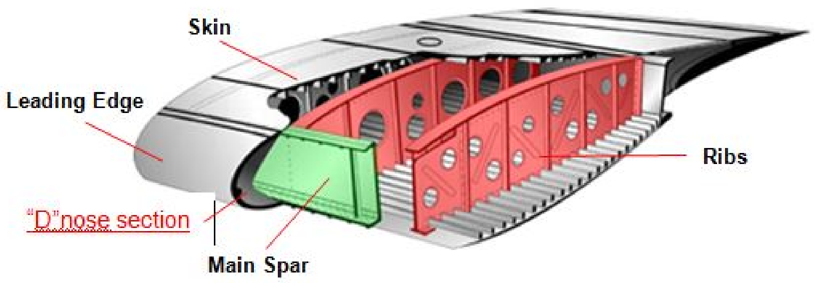
1.1.4 The Wings

The wings are designed so that the airflow over the upper surfaces is accelerated, reducing the static pressure above the wing and causing lift. In level flight, the lift will equal the weight and counteract it. In manoeuvres such as steep turns or pulling out of a dive, the wings must produce lift well in excess of the weight, so they have to be very strong.



1.1.5 Spars

Wings generally have one or more internal spars attached to the fuselage and extending to the wingtips. The spars carry the major loads, which are upward bending where the lift is generated and downward bending where the wings support the fuselage and the wing fuel tanks. Twisting and some of the bending loads are absorbed by the **"D"** nose section of the wing formed by the semi-monocoque construction of the Leading Edge skin, the ribs and the spar.

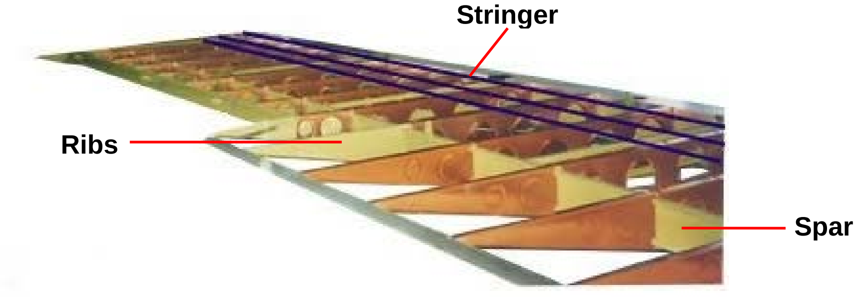


The condition of the wing's leading edge during daily inspection is particularly important. Dents or damage to this section may seriously affect wing strength. Also any roughness from dirt, insects, ice or frost on the leading edge will affect the wing's aerodynamic efficiency.

Some wing spars also have external struts connecting them to the fuselage to provide extra strength by transmitting some of the wing loads to the fuselage.

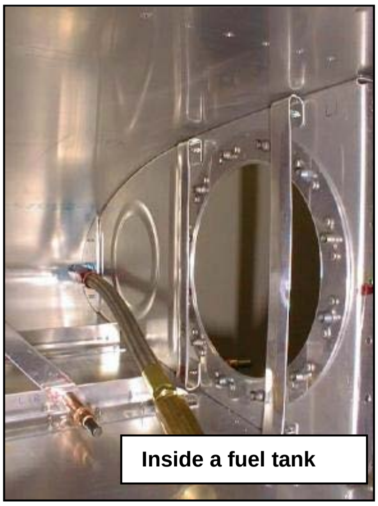
1.1.6 Ribs

Ribs, perpendicular to the wing spars, assisted by stringers running parallel to the spars, provide the aerofoil shape and stiffen the skin, which is attached to them. The ribs transmit loads between the skin and the spars.



The Ailerons are control surfaces which are installed at the outer trailing edge of each wing, and move simultaneously in opposite directions; e.g. left Aileron up, right Aileron down, to allow the pilot to control roll.

Wing flaps are installed on the inner trailing edges and are lowered symmetrically to increase the lifting ability of the wing.


Inside a fuel tank

The wings of many aeroplanes also contain fuel tanks installed between the curved upper and lower surfaces. This is an efficient use of the space available, and the weight of the fuel in the tanks also provides a downward force on the wing structure that reduces the upward bending effect of the lift forces.

Monoplanes are designed with a single set of wings placed so that the aeroplane is known as a high-wing, low-wing, or mid-wing monoplane.

Biplanes, such as the Pitts Special, are designed with a double set of wings. The Cessna 172 is a high-wing monoplane; the Socata/Aerospatiale Tobago is a low-wing monoplane.

1.1.7 The Landing Gear

The landing gear or undercarriage supports the weight of the aeroplane when it is on the ground, and may be either the Tricycle type with a nosewheel, e.g. TB10, or the conventional type with a tailwheel, e.g. Citabria.

Most aeroplanes are equipped with either nosewheel (Tricycle Gear) or tailwheel steering (Conventional Gear) through the rudder pedals, and almost all aircraft have independent main wheel brakes.

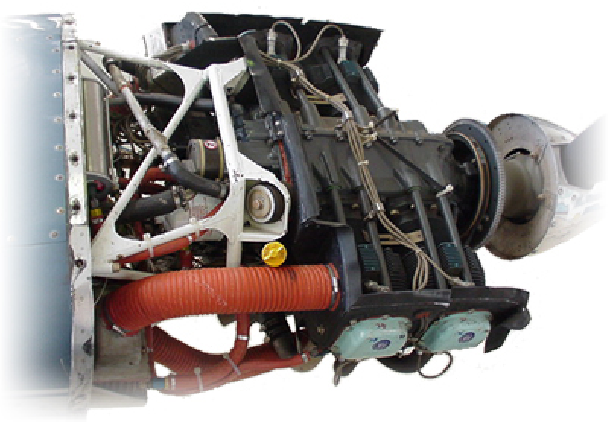
More advanced aeroplanes have retractable landing gear to improve inflight performance by reducing drag, giving better climb capability, higher cruise speeds, improved fuel efficiency, and more range when compared to aircraft with non retractable gear. Most training aeroplanes have fixed landing gear that cannot be retracted.

1.1.8 The Engine and Propeller

In a single engine aircraft the engine is usually located at the front of the fuselage. On simple training aircraft the engine drives a fixed pitch propeller; more advanced aircraft will have a constant speed variable blade angle propeller.

1.1.9 Firewall

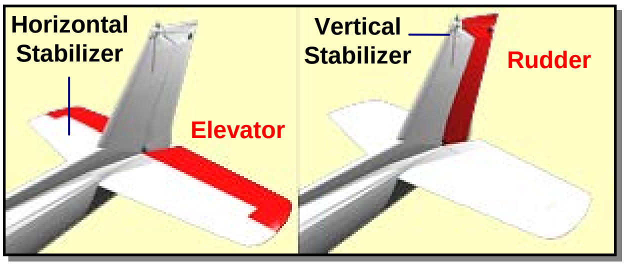
The engine is mounted in a support frame fixed to a fire resistant bulkhead known as a **Firewall**, which isolates the cockpit from the engine. This Firewall is usually manufactured from stainless steel or titanium.



Lycoming 4 cylinder 160 HP

1.2 Stabilising Surfaces

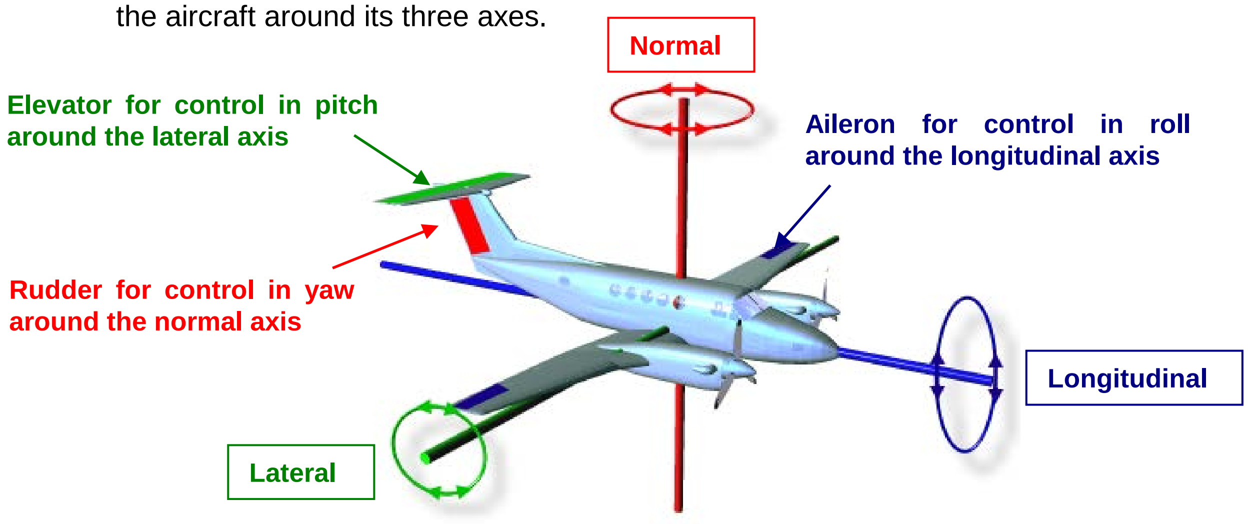
The vertical and horizontal stabilising surfaces of an aircraft ensure that the aircraft remains on its intended path without being affected by any disturbance, such as a gust of wind. They provide longitudinal (Horizontal Stabiliser) as well as directional stability (Vertical Stabiliser or Fin)



The tail section (or Empennage as it is also known) of the aircraft are airfoil shapes, usually of similar construction to the wings. They consist of a fixed Vertical Stabiliser or Fin to which is attached a movable Rudder; and a fixed Horizontal Stabiliser, with a movable Elevator hinged to its trailing edge either side of the Vertical Stabiliser.

1.2.1 The Aircraft Axes

In normal aircraft design, there are three separate control systems for manoeuvring the aircraft around its three axes.



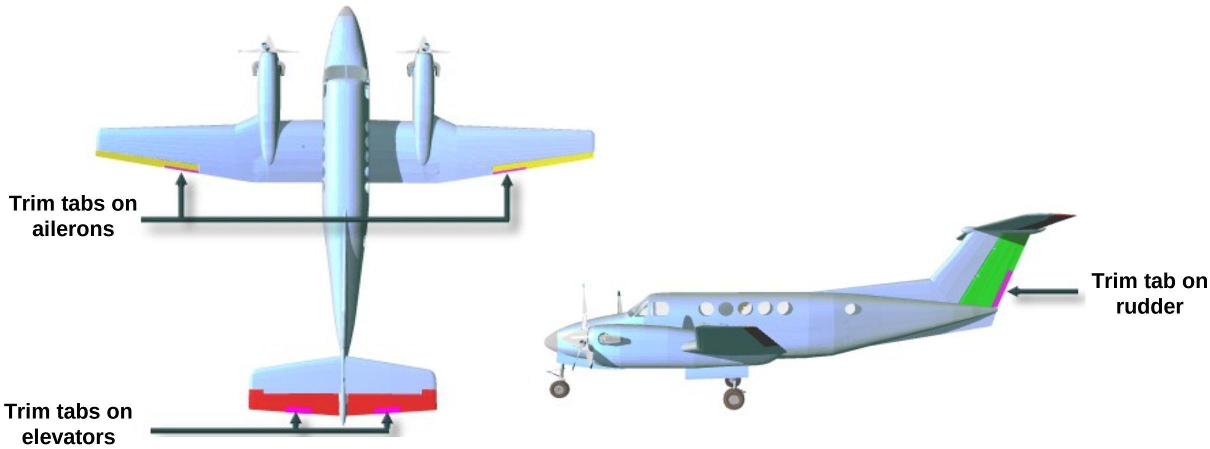
The Vertical Stabiliser or FIN provides the aircraft with directional stability about the vertical axis, while the Horizontal Stabiliser provides longitudinal stability about the lateral axis.

There are variations in design, some aeroplanes having a Stabilator, which is an all-moving tailplane, others having, combined rudders and elevators, known as Ruddervators, in the form of a Butterfly Tail, and yet others having a high T-tail, with the Horizontal Stabiliser mounted on top of the Vertical Stabiliser.

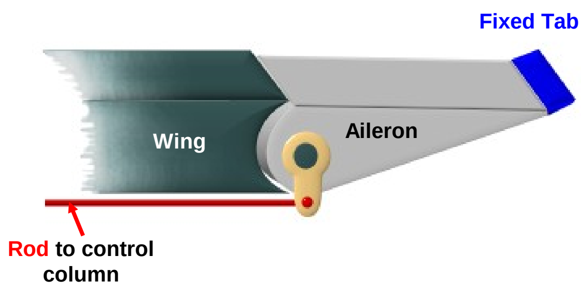
1.2.2 Trim Tabs

To maintain a certain attitude in flight, the pilot needs to exert a force on the control column to keep the aircraft pointing in the desired direction, whether it be a climb, descent or straight and level flight. On long flights, this can quickly tire the pilot. Trim tabs are therefore used to zero this force on the control column by means of a rotating wheel or switch in the cockpit to enable the pilot to fly the aircraft "hands-off".

Trim tabs are small-hinged surfaces and are normally situated at the trailing edges of the primary control surfaces.



Trim tabs can be fixed or adjustable in flight. The cross section and characteristics of a trim tab are similar to that of a wing, but trim tabs are physically much smaller.



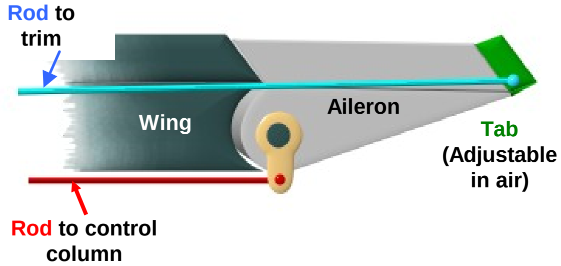
1.2.3 Fixed Trim Tabs

A fixed trim tab can only be adjusted on the ground and the correct position can be determined by executing one or two test flights.

When there is no control column force, the trailing edge of the particular flight control surface will be established by the tab.

1.2.4 Adjustable Trim Tabs

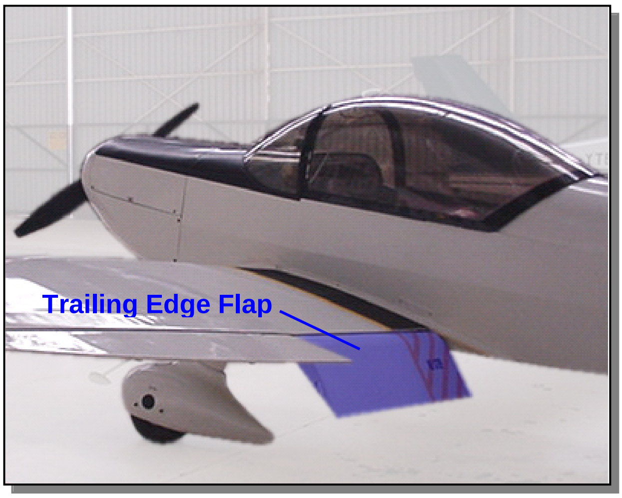
Adjustable trim tabs are used to get rid of unwanted forces on the controls, such as those occurring with a power change or a change in the CG position.



The pilot can adjust these trim tabs electrically or by means of a trim wheel from the cockpit. A **rod** or a system of cables and pulleys control the actual movement of the trim tabs.

The elevator trim tab is usually a small movable aerodynamic surface that forms part of the trailing edge of the elevator. It is controlled from the cockpit using the pitch trim wheel or trim handle to remove prolonged steady control pressures, so that the aeroplane can almost fly itself hands-off, if trimmed correctly, making the pilot's task a little easier.

1.2.5 Trailing Edge Flaps



Flaps are used to increase the camber of the wing, therefore increasing its lift.

This can have the effect of reducing landing speeds and allowing steeper approaches which affords better visibility. Landing distances are significantly reduced.

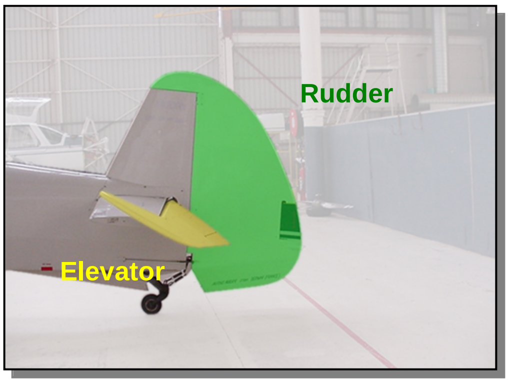
The most common type of flap fitted to most light aircraft is the trailing edge flap.

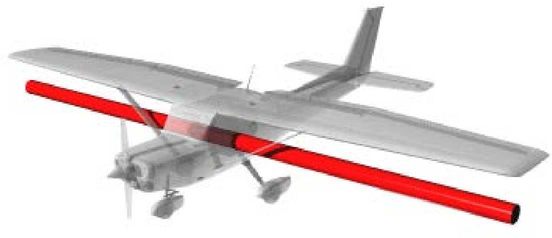
Lowering flap will cause both an increase in lift and drag; but overall a significant lift increase is applied. Applied in stages, the first stage of flaps will only cause a slight drag penalty, but as flap settings are increased the drag becomes significant. Sufficient power must be applied to overcome this increase in drag.

Depending on the aircraft design, lowering/raising flap will cause a nose up or nose down pitching moment. The proficient pilot will compensate by applying either forward or rearward control stick pressure as flaps are lowered.

1.3 The Flight Controls

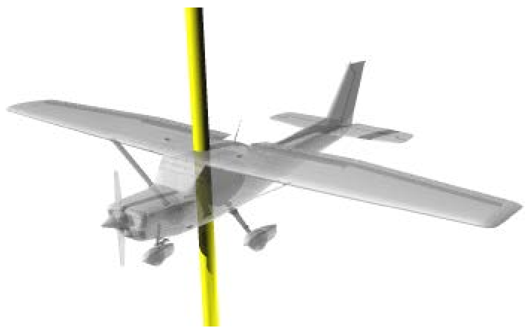
The primary flight control surfaces are the Ailerons, Elevator, and Rudder; they control the aircraft in Roll, Pitch and Yaw.





The aircraft Pitches around the Lateral Axis. Pitch is determined by the Elevator control.

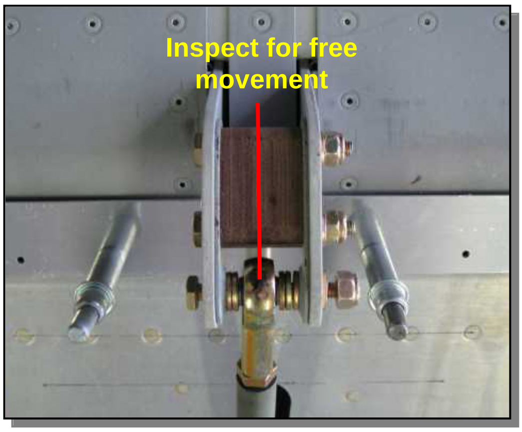
The aircraft Yaws about the Normal Axis. Yaw is determined by the Rudder control.



The aircraft Rolls about the Longitudinal Axis. Roll is determined by the Aileron controls.

The controls are operated from the cockpit by moving the control column or rudder pedals. In a typical aircraft, movement of the control column or rudder pedals operates an internal system of cables and pulleys or rigid Push/Pull rods that then move the relevant control surface.

Turnbuckles may be inserted in the cables to allow adjustment of their tension; this is only done by qualified personnel. Some aircraft use tubular push-pull rods alone, or together with cables to transfer control inputs to the control surfaces.



These use bronze bush or ball bearing connectors, which when exposed to the elements may occasionally become stiff, affecting control input loads. Daily inspections and pre-flight checks should check most of these control links.

1.3.1 Flight Control Stops

To limit the control surfaces from excessive movement in flight and on the ground, there are stops fitted to the airframe and the control surfaces. Primary stops are fitted to flight controls. Secondary stops are usually on the control column to prevent the pilot from overstressing the Flight Control System.