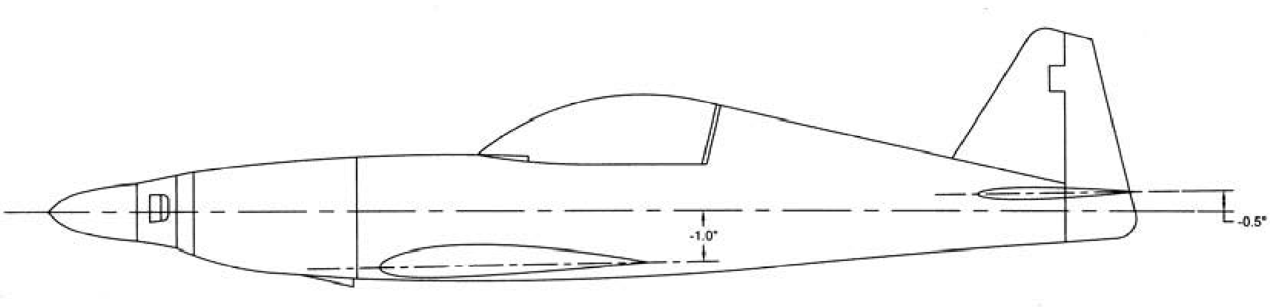
AIRPLANE RIGGING



V_{EX} AVIATION ™

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Chapter 1
Airplane Geometry and Definitions

This chapter discusses the geometric relationships of the various parts of an airplane. Their effect on flight characteristics is discussed in Chapter 2 and in following chapters. An overview of basic control systems and concepts is provided to familiarize the reader with the terminology.

Flight Control Systems

Flight controls are classified as either primary or secondary. Primary flight controls are those that are used to direct the airplane in pitch, roll, and yaw. Secondary flight controls are trim, high-lift devices (flaps), speed brakes, etc..

This manual concentrates on small airplanes with *reversible* flight controls. Reversible flight controls mean that the control stick/yoke/pedals are connected directly to the surface that they actuate through cables, pushrods, bellcranks, pulleys, etc.. Moving the surface will cause movement of the control to which it is attached, hence the term reversible. *Irreversible* flight controls are generally found on large airplanes that have hydraulically actuated controls (attempting to move the control surface from the outside has little or no effect on its' cockpit control). Much of the terminology and ideas given in this chapter give the appearance of being the same as that used on large airplanes, however, the application of these ideas can be quite different on large airplanes and is not discussed in this book.

Flight control systems may be further broken down into open-loop or closed-loop systems. Most reversible flight control systems are closed-loop systems meaning that the actuator for a particular control surface cannot be moved in any direction if the control surface to which it is attached is held in a fixed position. Many rudder-pedal systems on small airplanes are open-loop, being attached to springs rather than to each other.

Aircraft Axes

Figure 1-1 illustrates the aircraft axes for the purpose of describing the layout. For layout and design, the axes are selected to be whatever point is convenient to reference drawings to, for example a structural member that is straight and approximately aligned with the axis in question. Rigging specifications are then made in reference to these axes. Because they lie at least in part inside the aircraft, designers will specify more convenient places from which to take measurements, or even add a structural member(s) to aid in measurements. The flight axes are discussed in more detail in Chapter 2.

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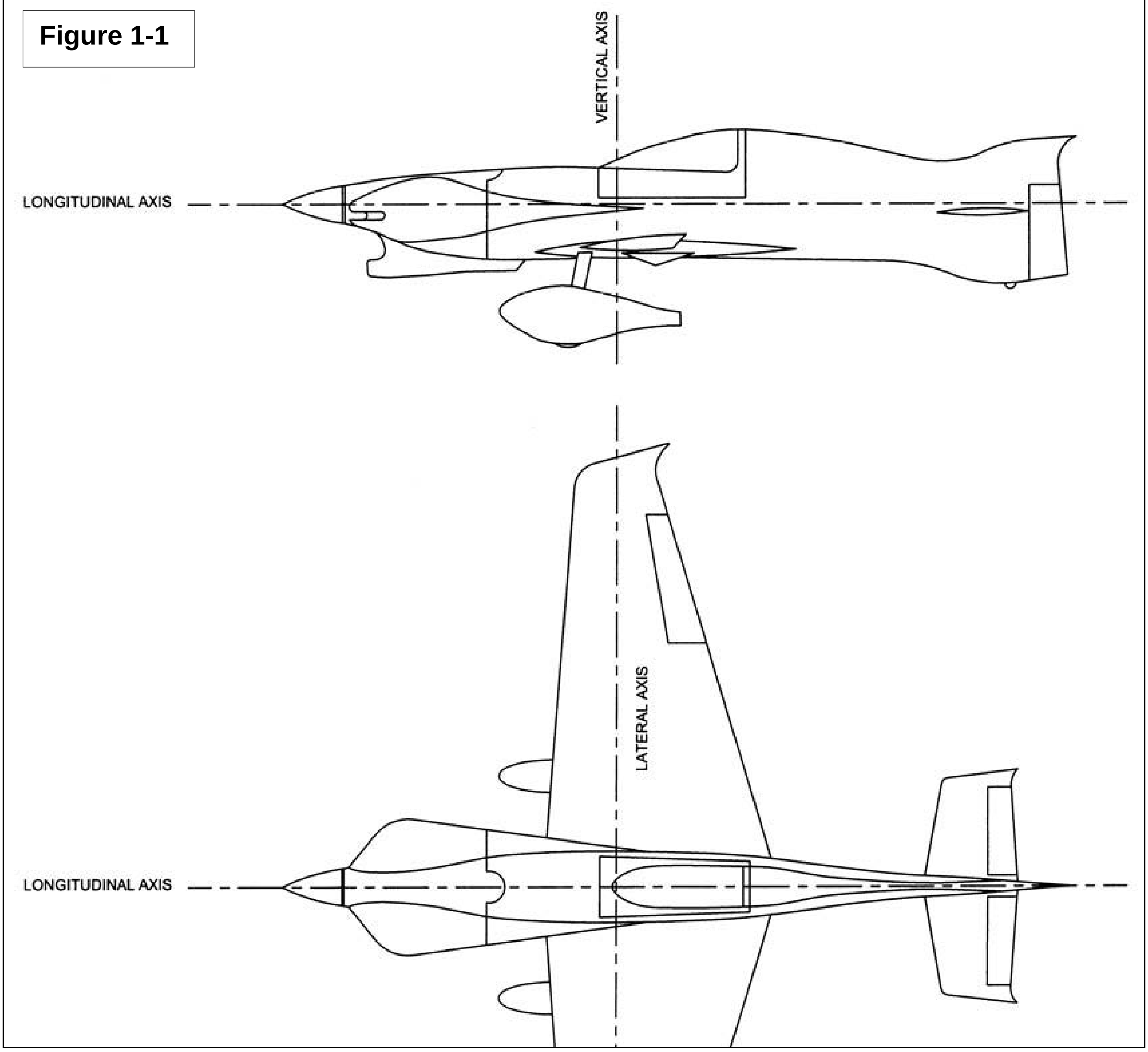
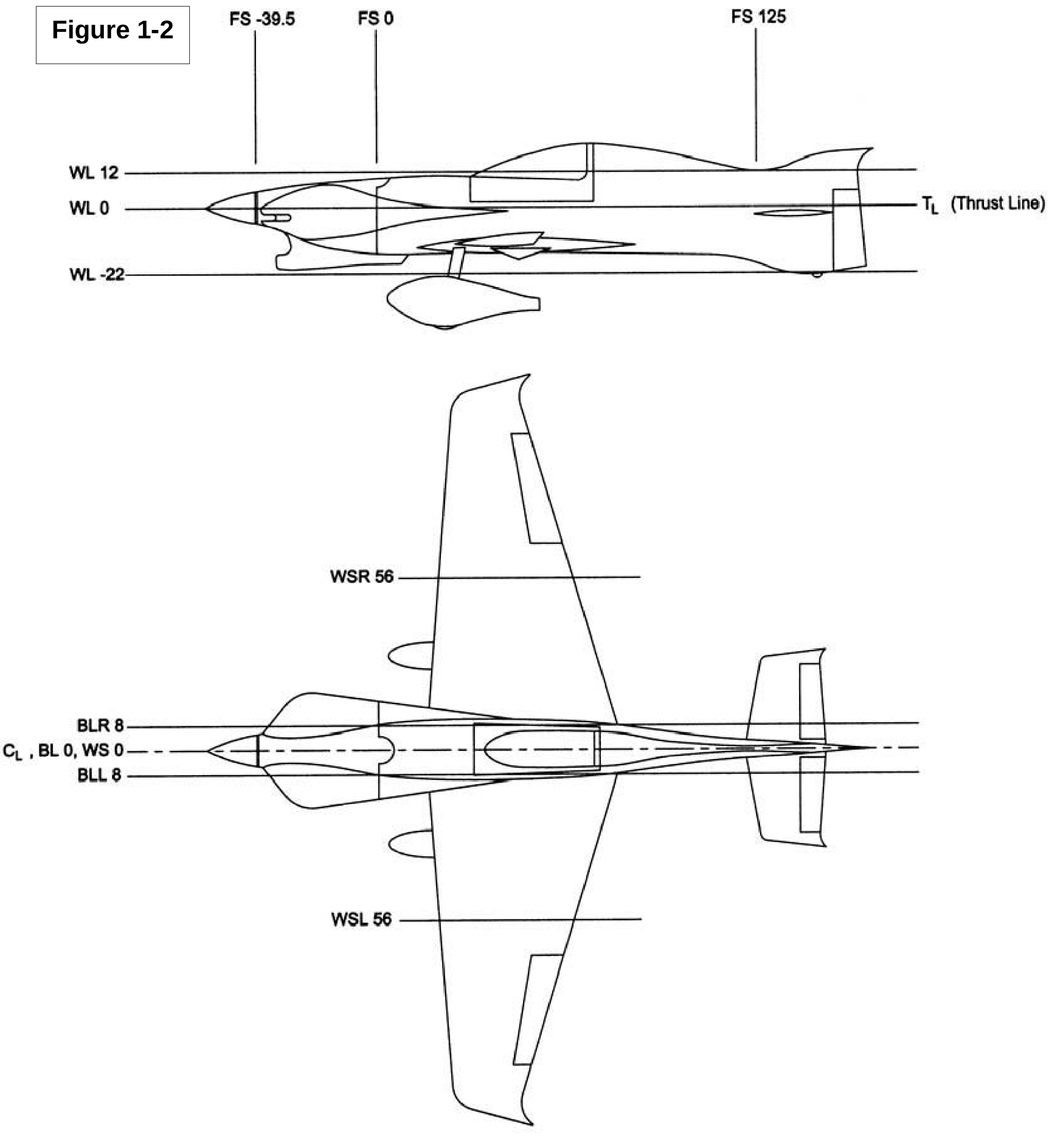
Figure 1-1



Airframe Drawings

Any point in or on an airframe can be identified by three coordinates. The coordinates are generally given in inches in relation to a fixed reference point. Aircraft drawings use particular terminology to identify these points. One may encounter some or all of the following terms in looking at the drawings or specifications. The exact wording and abbreviations have not always been strictly standardized, so it is likely one will encounter some variation of what is discussed here. Refer to Figure 1-2 for the following discussion.

Figure 1-2



Center Line

The centerline, C_L, divides the aircraft into two symmetrical halves. It is the same as Buttock Line 0 (see Buttock Lines in the section), and is the longitudinal axis of the aircraft from which certain rigging measurements are made.

Reference Datum

The fixed reference point known as the reference datum is used to mark the zero location for measurements along the length of the fuselage. The aircraft designer will typically specify the location of the reference datum that is to be used for taking measurements. Often it is the forward side of the firewall. This may or may not be the same as the reference datum used for calculating weight and balance of the completed aircraft.

Stations

A fuselage station (FS or Sta.) is any point that is forward of, or behind the reference datum, along the longitudinal axis, and is usually measured in inches. Station numbers aft of the reference datum are positive numbers, and station numbers forward of the reference datum are negative numbers. If the firewall is station 0 (reference datum), then the horizontal stabilizer will have a fairly large positive station number and the engine mount will have a small negative station number.

A wing station is a point on a wing measured right or left from the aircraft centerline, C_L. Where a wing station is given, it is assumed that the reference datum is the aircraft centerline. Wing stations may be addressed as Wing Station Left (WSL) or Wing Station Right (WSR), or by a numbering system where the station lines on the right side of the aircraft are positive numbers, and station lines on the left side of the aircraft are negative numbers.

There may be more stations identified for the horizontal stabilizer (HS), aileron (AS), etc., with those also referenced to the aircraft centerline, C_L.

Buttock Lines

A buttock line is a distance right or left of the aircraft centerline, as viewed from the top. This is the almost the same as wing stations, except buttock lines are used to address locations in the fuselage (usually, they sometimes are used to address locations in the wing and horizontal stabilizer as well). They are abbreviated as Buttock Line Left (BLL) or Buttock Line Right (BLR), or by a numbering system where buttock lines on the right side of the aircraft are positive numbers, and buttock lines on the left side of the aircraft are negative numbers. Buttock Line 0 coincides with the aircraft centerline, C_L.

Water Lines

A water line (W_L) is a vertical distance in the fuselage, as viewed from the side. The 0 Water Line is typically through the fuselage about in the middle as viewed from the side, and parallel to the flight path. It may or may not coincide with the thrust line (T_L) shown on the drawing. Water lines above the zero water line are positive numbers and water lines below are negative numbers.

Airplane Components and Definitions

The followings concepts and terms are used extensively in this manual.

Powerplant

The engine and propeller combined.

Fuselage

The airplane structure *not* including;

- the wings, and parts that attach to the wings,
- the horizontal and vertical stabilizers, and the parts that attach to them,
- the powerplant or the engine mount (where the engine mount is removable from the airplane).

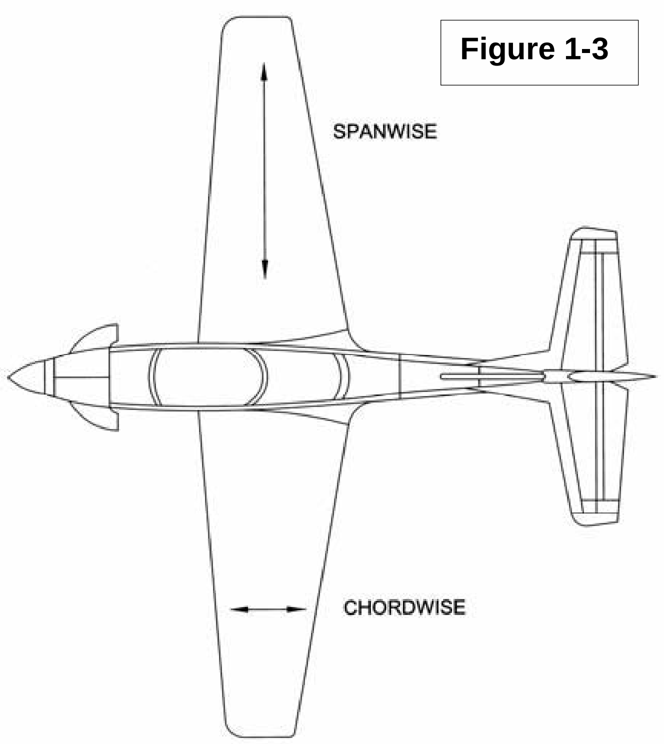


Figure 1-3

Airframe

The whole airplane structure not including the powerplant.

Wing

The entire component designed to produce the majority of lift. In aircraft design it also typically includes the portion of the wing in the fuselage, but for rigging it is that wing area which is exposed to the airflow. The tail components should also be thought of as wings although they will be addressed specifically when discussing them. In discussing wings (including tails), the terminology seen in Figure 1-3 will be encountered frequently. The terms are used loosely to indicate a general direction along the arrows.

Wing Panel

Used to describe the individual sections of a wing which is not a one piece wing.

Wing Section

The airfoil or cross-section of a lifting surface (lifting surfaces include wings, canards, vertical stabilizer/rudder, horizontal stabilizer/elevator, etc.). See Airfoil Geometry in this chapter.

Wing Planform

The shape of a wing or other lifting surface as viewed from above (along the vertical axis). Some examples are given in Figure 1-4.

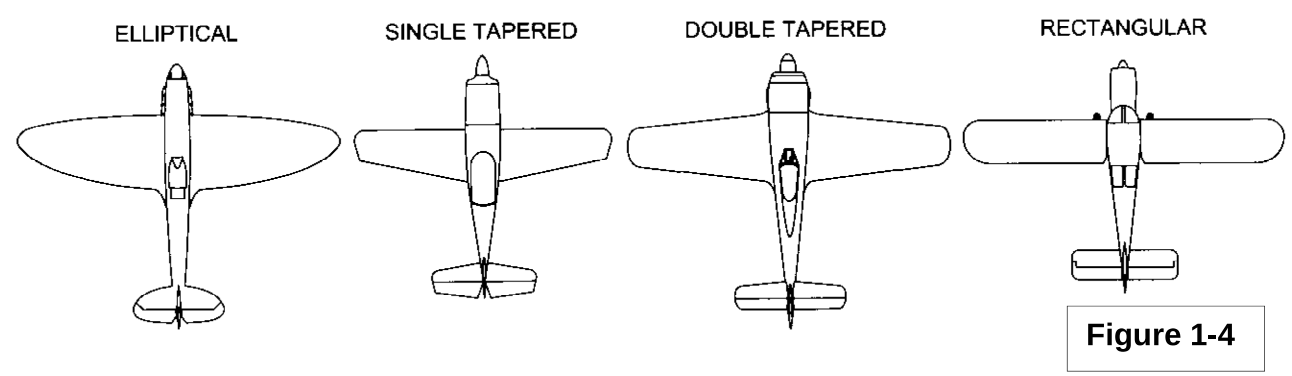


Figure 1-4

Wing Root and Wing Tip

The *wing root* may mean two different things, taken in context;

- the area of the junction of the wing and fuselage, perhaps aerodynamically faired to reduce interference drag, or;
- the physical attach point(s) of the wing to the fuselage (spar fittings).

The *wing tip* may mean two different things, again taken in context;

- the most outboard section of wing, aerodynamically shaped to minimize performance losses from vortices, and generally carries little or no structural loads, or;
- the most outboard rib or other structural piece that defines the wing section, exclusive of a nonstructural tip.

Aileron

That movable portion of the wing that is used to control roll. The combined wing and aileron are considered to be a [flapped] wing in aerodynamics.

Vertical Stabilizer and Rudder

The combined vertical stabilizer and rudder are a [flapped] wing. The vertical stabilizer is the fixed (unmovable) section used to create directional stability. The rudder is the rotating (movable) section that is used to control yaw.

Horizontal Stabilizer and Elevator

The combined horizontal stabilizer and elevator are a [flapped] wing. The horizontal stabilizer is the fixed (unmovable) section used to create longitudinal stability. The elevator is the rotating (movable) section that is used to control pitch.

Stabilator

The stabilator is found on some aircraft designs. It is a horizontal stabilizer and elevator combined (Figure 1-5). The entire horizontal stabilizer pivots to produce pitch control while still acting to produce the necessary longitudinal stability for the airplane. Stabilators are advantageous, on some aircraft, because they require less area to provide the same aerodynamic forces. The anti-servo tab in the figure is discussed later.

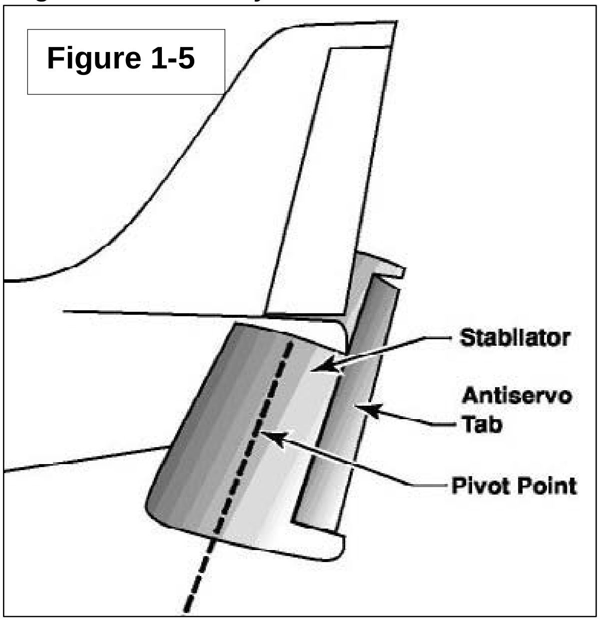


Figure 1-5

Trim Tab

A trim tab is the portion of a control surface that is used to force that control surface, aerodynamically, to a desired position (Figure 1-6). They are used to relieve control forces during flight. A few small aircraft may not have any trim tabs, but most aircraft have them on at least the elevator. The *geometric* neutral position of the trim tab is when it is aligned with the control surface that it influences. The neutral setting for elevator trim tabs that is indicated in the cockpit on small planes is; the position that results in the aircraft having desirable control forces during takeoff, at some center of gravity position. This may or may not be streamlined with the elevator, depending on the airplane design. Aircraft with large CG ranges have different takeoff trim settings for different CG locations.

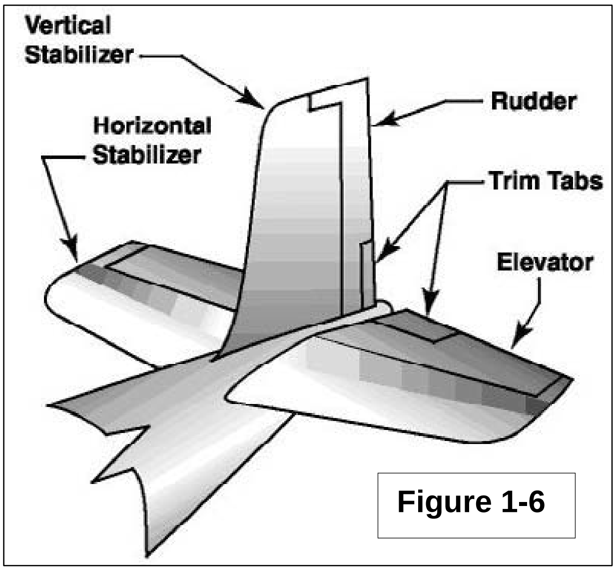


Figure 1-6

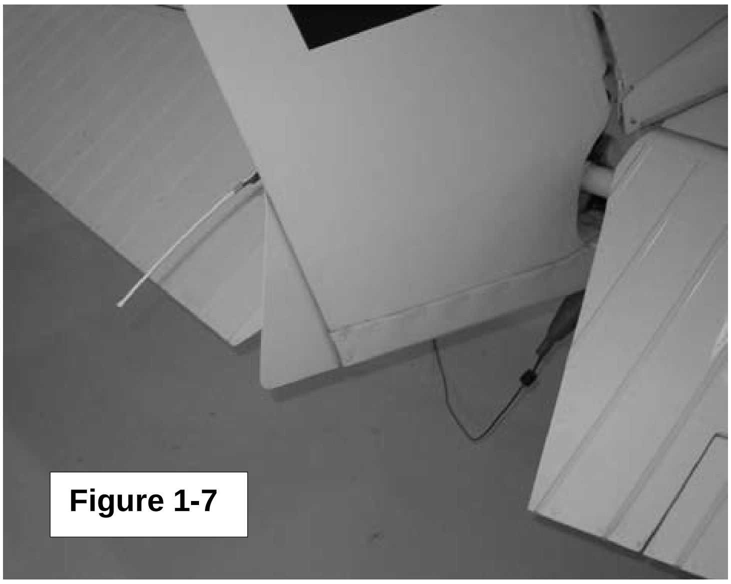


Figure 1-7

Trim tabs may be adjustable from the cockpit or only adjustable on the ground. The elevator trim tab is usually adjustable from the cockpit to allow the pilot to relieve the constantly changing elevator control forces caused by speed and configuration changes of the airplane.

Fixed trim tabs are simply pieces of aluminum attached to the control surface which may be bent on the ground to provide a trim condition for one airspeed (often cruise flight where it is desirable to be able to relax the hands and feet without the airplane going off in an undesired direction). An example of a fixed trim tab is shown on the rudder in Figure 1-7.

NOTE

Force trim is an alternate method to hold the control surface in a desired position by mechanical means. It works by applying a force on the control surface through a spring, whose tension is cockpit adjustable.

A few small airplanes are trimmed longitudinally by adjusting the incidence of the horizontal stabilizer (Figure 1-8) (incidence is discussed later in this chapter).

Servo and Anti-Servo tabs

Servo/anti-servo tabs are not found on all airplanes. A servo tab is a second rotating [movable section] of an elevator that deflects in the opposite direction of the elevator to assist the elevator in movement (Figure 1-9). It deflects automatically as the elevator is moved and is used to reduce the pilot effort necessary to deflect the elevator.

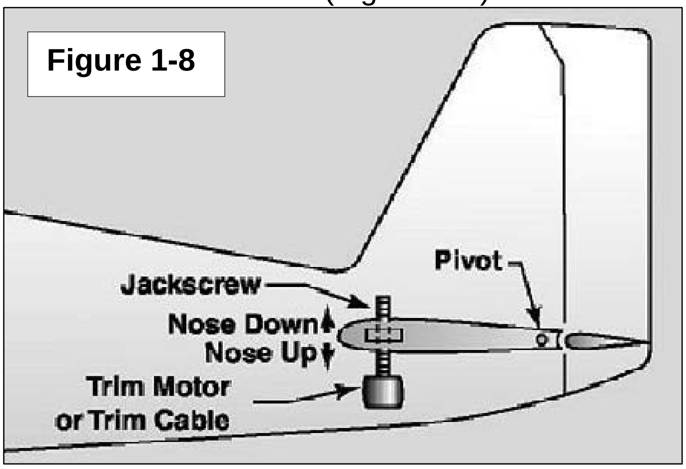


Figure 1-8

An anti-servo tab is a second rotating (movable section) of an elevator that deflects in the same direction as the elevator. It deflects automatically as the elevator is moved and is used to increase the pilot effort required to deflect the elevator. It is commonly used on stabilators to provide some stability to the 'floating' horizontal stabilizer (Figure 1-5).

Servo or anti-servo tabs may also function as a trim tab when equipped with a method of changing their angle separately from the elevator.