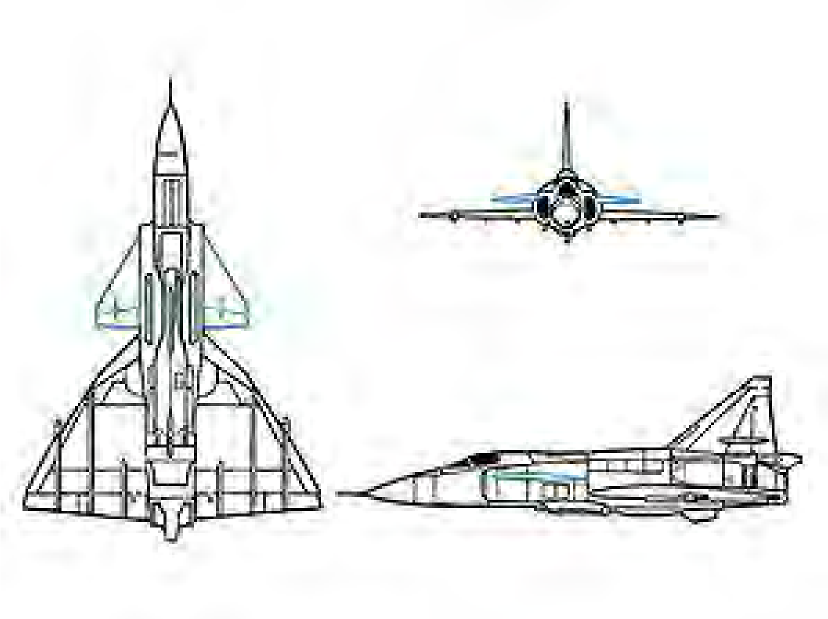
Canard



A **canard** is a fixed-wing aircraft configuration in which a small horizontal surface, also named the canard or foreplane, is positioned forward of the main wing in contrast to the conventional position at the tail.

A canard foreplane may be used for various reasons such as lift, (in)stability, trim, flight control, or to modify airflow over the main wing. Design analysis has been divided into two main classes, for the lifting-canard and the control-canard. These classes may follow the close-coupled type or not, and a given design may provide either or both of lift and control.

Lifting Canard:

In the lifting-canard configuration, the weight of the aircraft is shared between the wing and the canard. It has been described as an extreme conventional configuration but with a small highly-loaded wing and an enormous lifting tail which enables the centre of mass to be very far aft relative to the front surface.

A lifting canard generates an upload, in contrast to a conventional aft-tail which generates negative lift that must be counteracted by extra lift on the main wing.

As the canard lift appears to increase the overall lift capability of the aircraft, this may appear to favor the canard layout. In particular, at takeoff the wing is most heavily loaded and where a conventional tail exerts a downforce worsening the load, a canard exerts an upward force relieving the load. This allows a smaller main wing.

A danger associated with an insufficiently-loaded canard—i.e. when the center of gravity too far aft—is that when approaching stall, the main wing may stall first. This causes the rear of the craft to drop, deepening the stall and sometimes preventing recovery.

With a lifting-canard type, the main wing must be located further aft of the center of gravity than a conventional wing, and this increases the downward pitching moment caused by the deflection of trailing-edge flaps. Small, highly loaded canards do not have sufficient extra lift available to balance this moment, so lifting-canard aircraft cannot readily be designed with powerful trailing-edge flaps.

Canard Control:

In a control-canard design, most of the weight of the aircraft is carried by the wing and the canard is used primarily for longitudinal control during maneuvering. Thus, a control-canard mostly operates only as a control surface and is usually at zero angle of attack, carrying no aircraft weight in normal flight. Modern combat aircraft of canard configuration typically have a control-canard. In modern combat aircraft, the canard is usually driven by a computerized flight control system.

One benefit obtainable from a control-canard is the avoidance of pitch-up. An all-moving canard capable of a significant nose-down deflection will protect against pitch-up. As a result, the aspect ratio and wing-sweep of the wing can be optimized without having to guard against pitch-up.

They are used to intentionally destabilize some combat aircraft in order to make them more maneuverable. In this case, electronic flight control systems use the pitch control function of the canard foreplane to create artificial static and dynamic stability.

Stability

A canard foreplane may be used as a horizontal stabiliser, whether stability is achieved statically or artificially (fly-by-wire).

Being placed ahead of the center of gravity, a canard foreplane acts directly to reduce Longitudinal static stability (stability in pitch).

Nevertheless, a canard stabilizer may be added to an otherwise unstable design to obtain overall static pitch stability. To achieve this stability, the change in canard lift coefficient with angle of attack (lift coefficient slope) should be less than that for the main plane. A number of factors affect this characteristic.

For most airfoils, lift slope decreases at high lift coefficients. Therefore, the most common way in which pitch stability can be achieved is to increase the lift coefficient (so the wing loading) of the canard. This tends to increase the lift-induced drag of the foreplane, which may be given a high aspect ratio in order to limit drag. Such a canard airfoil has a greater airfoil camber than the wing.

Another possibility is to decrease the aspect ratio of the canard, with again more lift-induced drag and possibly a higher stall angle than the wing.

Close coupling

Saab 37 Viggen of the Swedish Air Force

In the close-coupled canard, the foreplane is located just above and forward of the wing. At high angles of attack (and therefore typically at low speeds) the canard surface directs airflow downward over the wing, reducing turbulence which results in reduced drag and increased lift.[27] Typically the foreplane creates a vortex which attaches to the upper surface of the wing, stabilising and re-energising the airflow over the wing and delaying or preventing the stall.

The canard foreplane may be fixed as on the IAI Kfir, have landing flaps as on the Saab Viggen, or be moveable and also act as a control-canard during normal flight as on the Dassault Rafale.

A close-coupled canard has been shown to benefit a supersonic delta wing design which gains lift in both transonic flight (such as for supercruise) and also in low speed flight (such as take offs and landings).[28]