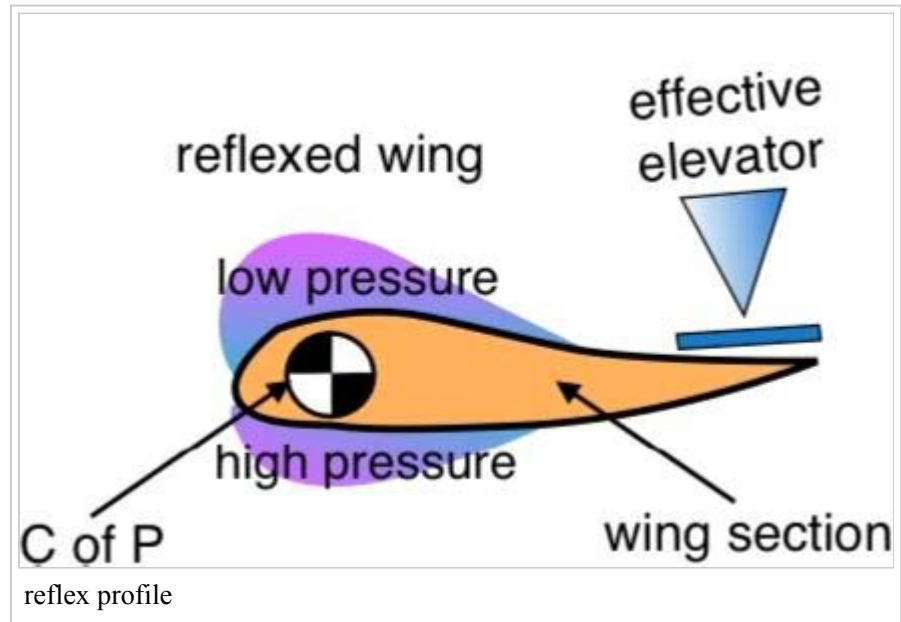


Paramotor Reflex Wing Profile

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Reflex Wing technology (paramotor)

In the late 1980's pilots and engineers started to experiment with attaching engines with propellers to their paragliding wings or parafoils. As the development of this new aviation activity progressed paramotor engines improved and became increasingly efficient and usable. As a result, specific wings for this activity were required. Designers made wings that were stronger, had different handling, and most importantly improved pitch stability over the standard paraglider. This process resulted in the introduction of wings with a reflex profile or Reflex Wing Technology into this industry.



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What is a reflex profile

A reflex profile is effectively a front loaded wing with a tail where the wing constantly wants to fly away from you, creating increased speed, stability and safety in turbulent conditions.

Overview

Reflex profiles are not new, these airfoil profiles were first used as far back as the 1930's on tail-less aircraft, such as the HO 229 by the Horten brothers, or the Fauvel tail-less glider. Reflex is also associated with camber and the reflexed camber line discovered by Sir George Cayley in the 19th Century. Reflex provides aircraft with aerodynamic pitch stability without the use of a traditional

fuselage and elevator. For example, the Northrop flying wing of the 1950s. In the 1980s it was introduced into hang gliding, which helped prevent tumbling. In 1994 it was designed into ram-air paraglider wings for paramotoring by Mike Campbell-Jones with the first production reflex wing. This technology is now standard with many wing manufacturers and has become the norm in the sport. Reflex technology or use of pitch positive wing sections in soft wing designs has enabled pilots to fly more safely in rougher conditions and stronger winds. This has helped powered paragliding/paramotoring become an accepted aviation category and a popular sport.

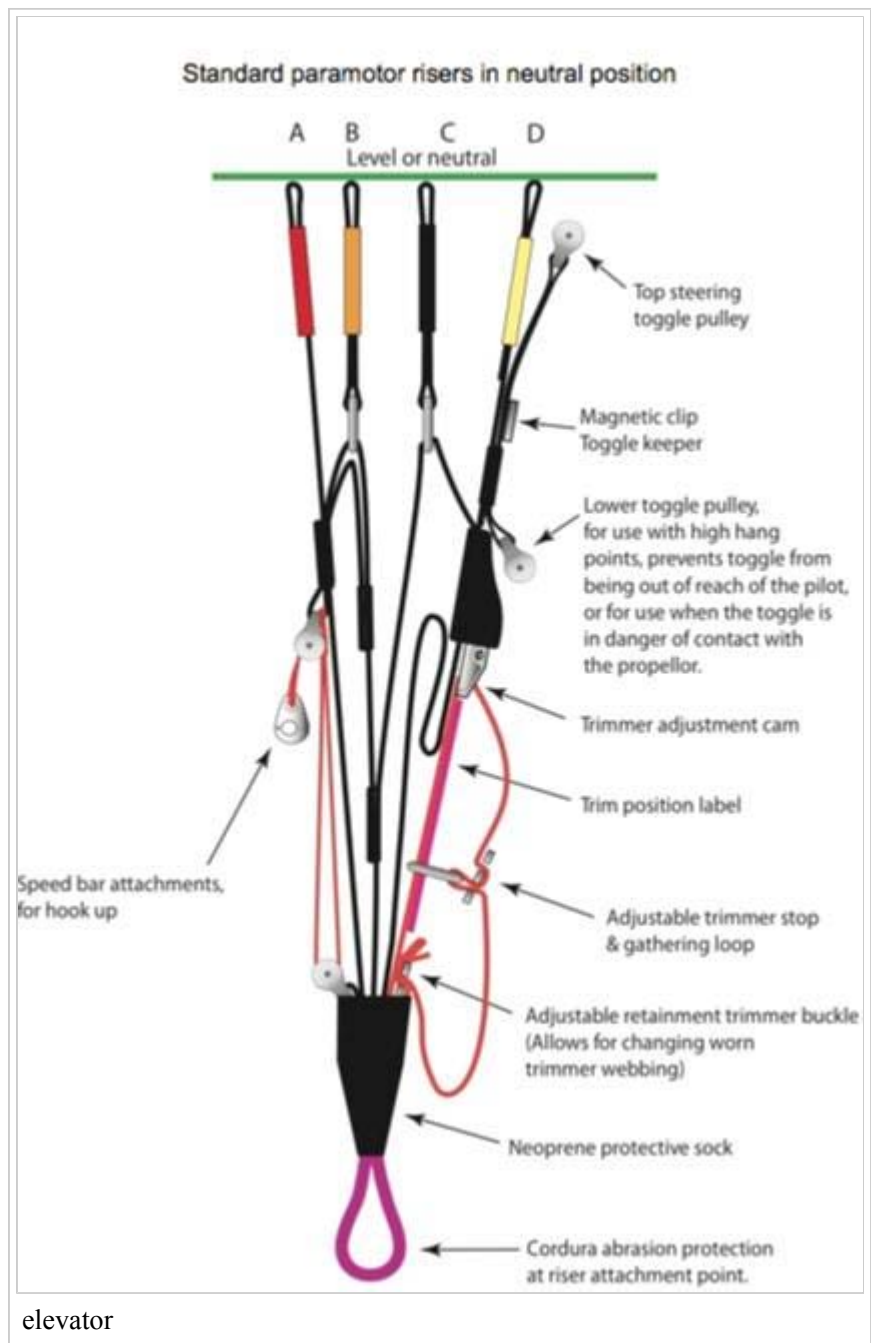
Reflex Technology - How does it work?

A reflex wing has a form or 'profile' that can

be adjusted by the pilot with a trim system, similar to an airplane. In full reflex two things happen: airspeed increases due to the creation of a higher Aspect ratio and the Center of Pressure (CP) of the wing is moved forward loading the A and B risers and leaving the C and D risers less tensioned. This differs from the wing of a traditional paraglider, in which increased airspeed causes the CP to move backwards towards the C and D risers offloading the A's and B's and presenting more possibility of collapse or a frontal stall (please view the diagram to the right).

Reflex profiles provide pitch stability, by adding a tail piece or an 'elevator' into the wing similar to that of an airplane, whilst keeping the CP close to the leading edge. The wing loading is increased as less of the wing is used for lift and a higher aspect ratio is created. So the speed is increased without the need to change the angle of attack.

The angle of attack on a reflex wing is maintained through the lines connected to the pendulum weight of the pilot suspended



below, in the same way as a fixed wing with a fuselage and a tail-plane acts as a lever, controlling the wing moment and stabilizing the aerodynamic center.

There are many other factors but the end result is more efficiency at speed and a greater range of performance between Mid sink and Max glide essentially a flatter polar curve. In other words, a greater range between stall and full speeds and thus a reduced likelihood of being robbed of air speed in turbulence. The enhanced stability in both pitch and roll are vital in paramotoring, because of the low mass of engine/pilot and thrust line that generates all the associated gyroscopic and torque effects.

About wing stability

There are three types of stability vital to any aircraft, Pitch, Roll and Yaw. They make up the three axes by which most aircraft are controllable in a 3D space. For paragliders the first two matter most.

Pitch stability

The inherent pitch stability of an aircraft is easily identified when flying through thermals or areas of turbulence.

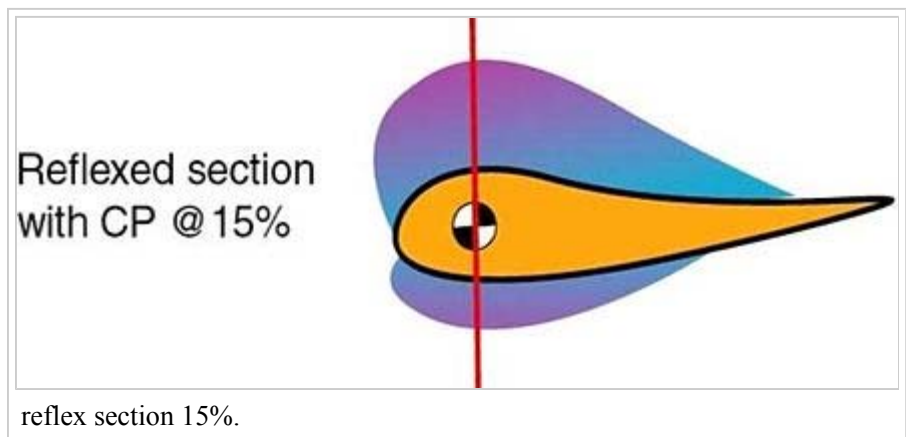
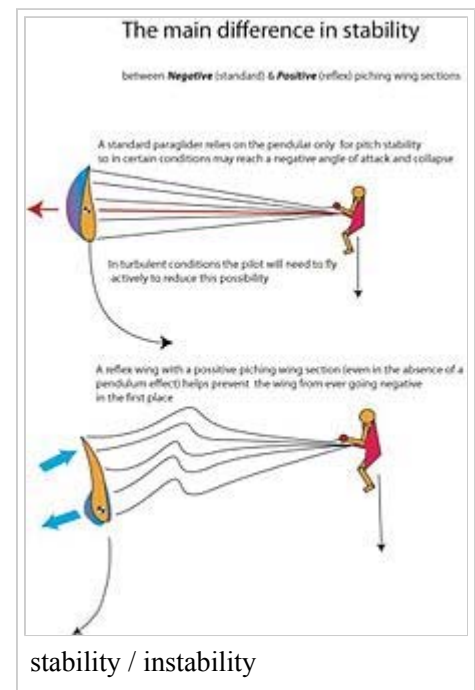
- If the aircraft pitches **forward** as it enters the thermal and **rearward** as it exits then it is pitch positive.
- If the aircraft pitches **rearward** as it enters and **forward** as it exits then it is pitch negative.

This movement is particularly noticeable in paragliders because the Center of Gravity (CG) is so far below the wing, which is a long way from the CP compared to most aircraft. The role of the fuselage and tail-plane on a traditional fixed wing is carried out by the pendulum effect of the pilot and engine unit (CG).

The qualities of function offered by reflex wings

In a reflex wing, the CP is

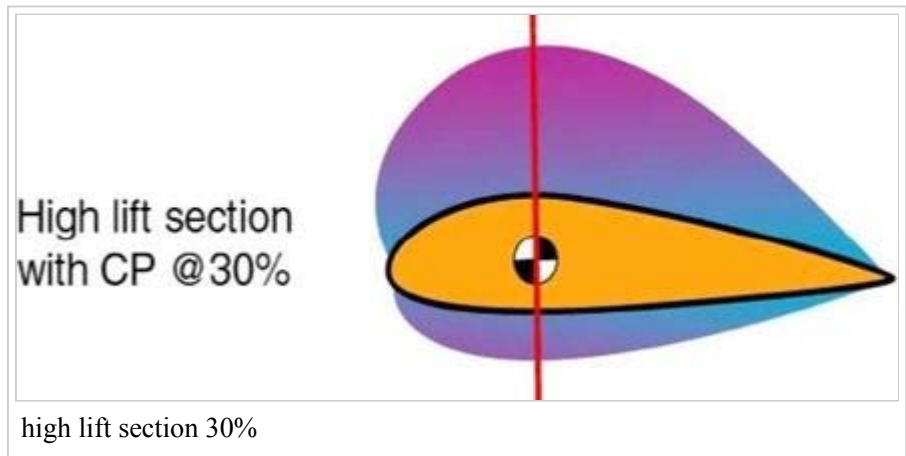
very far forward (at 15-20% of the 'chord' - the distance between the leading edge and the trailing edge) and there is the added stability of the reflex profile curving the wing up, close to the trailing edge. The wing is now pitch positive in turbulence. This has proved ideal for wings used with power.



It means the pilot should not fly actively using the brakes to maintain stability, but rather, can and should, fly 'hands off' safely. NB This is the opposite to how a traditional paraglider is flown. When brakes are pulled, pitch stability is partially reduced as the reflex profile is removed and the CP moves further back from the leading edge.

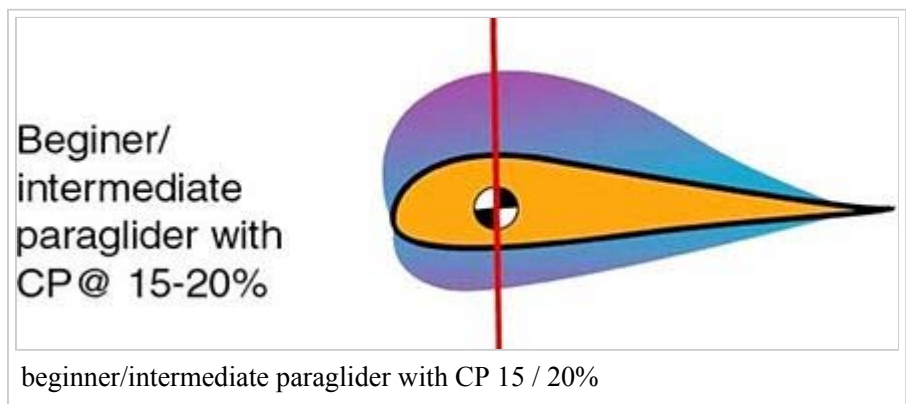
Most performance paragliders without reflex technology have a CP near 30% of the chord for maximum efficiency. They are inherently pitch negative, the wing's stability is more dependent on the pendulum effect of CG to control the angle of attack. In turbulence the CG may change position, imagine flying an aircraft where the size of the tail-plane changes in flight! So the pilot

may also **need to intervene** to control the movement. Generally, paragliding pilots are taught to fly actively to cope with this. Otherwise the big changes in angle of attack may cause collapses. Indeed some wings are designed with higher pitch sensitivity, to enhance pilot feedback in thermals.



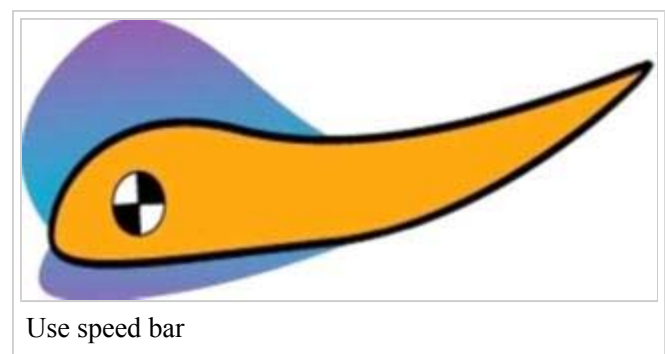
Beginner paragliders

generally have greater pitch stability to match the pilot skill level, this is considered to be safer. Wing designs achieve this by using flatter wing sections, so the CP is further forward at around 20% of the chord - whilst giving more stability it is still negative pitching.



Use of the speed bar

Another contrast of a traditional paraglider, occurs with a reflex wing when the speed bar is applied. In a reflex profile wing the stability actually increases as more reflex is introduced with the depression of the speedbar, because the CP is pushed even further forward and more elevator effect is created close to the trailing edge of the wing. The resulting extra speed also enables the wing to cut through turbulent air better.



Testing and Safety /The need for appropriate/standardized testing/ A note on testing...

An unresolved issue with the safety testing of paramotor wings and reflex wings is that minimal appropriate testing for wings with motors currently exists. This is regardless of whether the wing is reflex or not. The anomaly is that the European norms actually used for certification are in fact only valid for wings without motors and furthermore they are only valid for wings in fully closed trim positions i.e. out of reflex.

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Categories: Aircraft wing design

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