EQUIPMENT

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The Main Parts of A Paraglider

There are four main parts of a glider, see figure C1: **(a) the wing** itself, made of low porosity, lightweight and waterproof fabric forming an airfoil about 30 - 40cm thick. The wing has an upper and lower surface. The upper is highly convex, whilst the lower has slightly less curvature. **(b) The lines** are very strong with low elasticity solid, and are attached at regularly intervals to the lower wing surface. **(c) The risers** are a set of flexible webbing straps that connect the lines to the harness. **(d) The harness** consists of a comfortable seat equipped with multiple attachment straps which are located to completely secure the pilot. Contemporary harnesses are equipped with protective cushioning under the pilot's bottom (foam or air bag), and an easy access pouch which contains a folded reserve parachute.

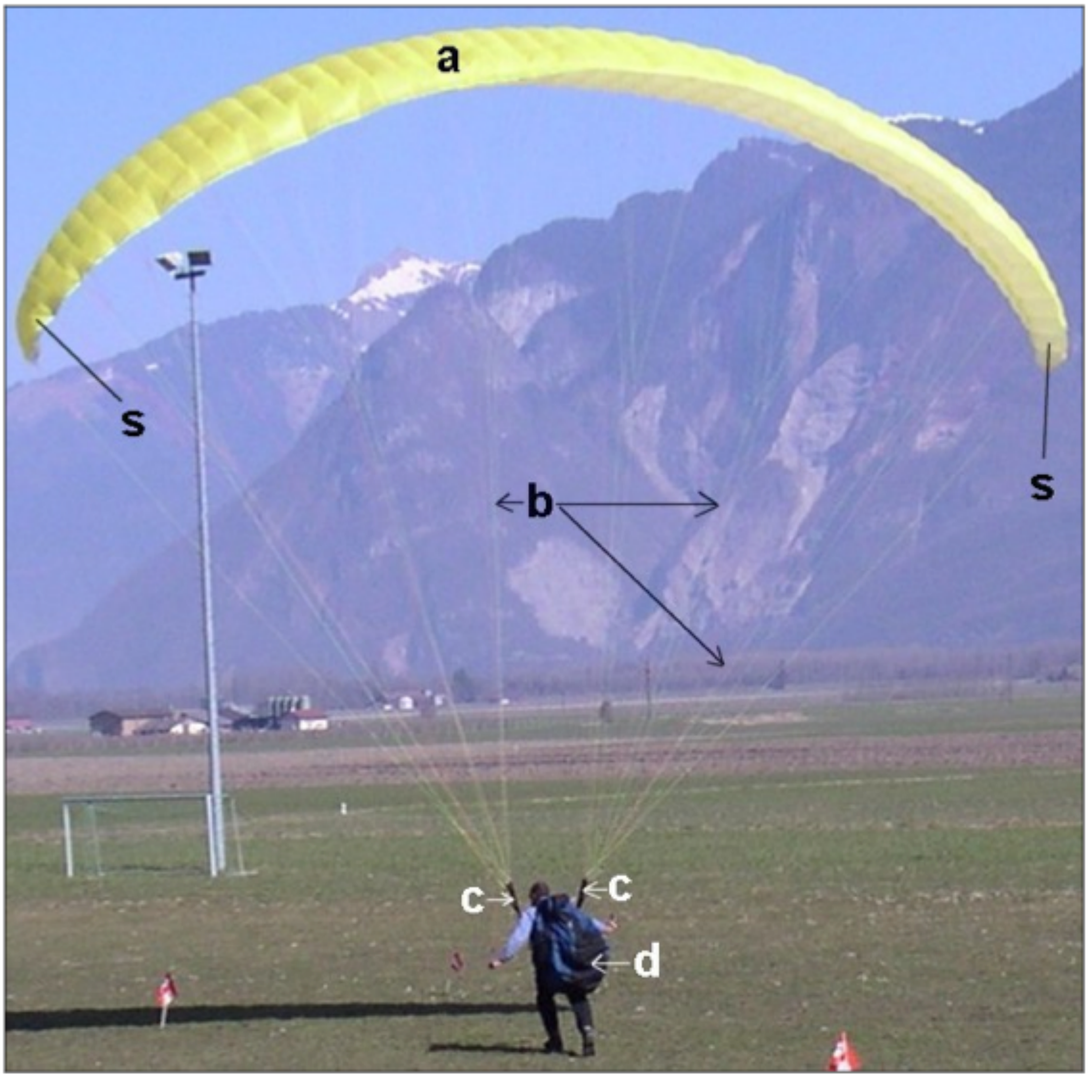

Figure C1: the 4 main parts of a paraglider. a = wing, b= lines, c = risers, d = harness, s = stabilisers.

The Wing

The wing is constructed of a fabric of synthetic **polyamide** (Nylon) or (less often) polyester (Dacron). **Question 001**. The lines are made from polyethylene (Dyneema) or aramid (Kevlar). This is discussed in more detail later. A key feature of the wing fabric is its mechanical strength, particularly its resistance to tearing. This is achieved through a **ripstop** weave technique, where a stronger thread is inserted at regular intervals in the weave, and in two perpendicular directions. This may not prevent a tear forming, but it prevents its propagation beyond a few mm. **Questions 002 and 003**. A ripstop fabric has a characteristic, finely squared visual appearance, with the stronger threads clearly visible. See figure C2. Ripstop can be most easily deformed when subject to a diagonal tension. **Question 027.**

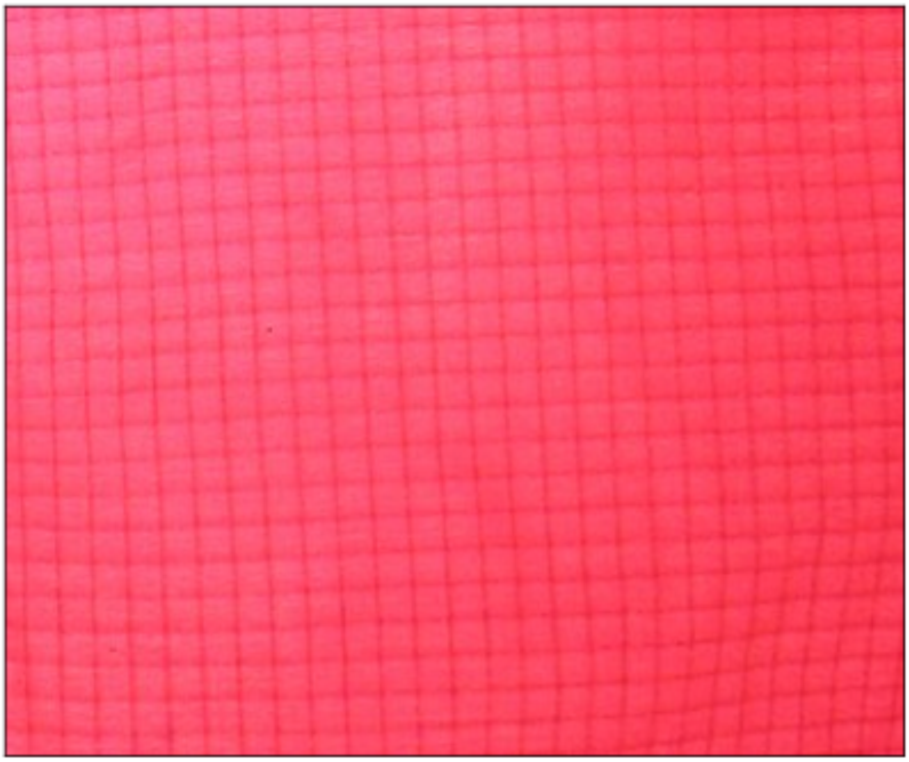

Figure C2: ripstop fabric with finely squared appearance. One direction is called the weft, the other (perpendicular) iscalled the warp.

The permeability of fabric to air is measured by its porosity. Low porosity materials have low permeability and vice versa. The porosity of a fabric of a glider must be as small as possible. **Questions 004 and 005**.

Other important fabric characteristics are: (1) Low elasticity (the wing profile should remain unchanged) and (2) reduced sensitivity to sunlight (UV). To achieve these characteristics the fabrics are treated with coatings (by impregnation of the fabric by a synthetic resin). The coatings are typically polyurethane or less often silicone or Mylar. The coating does not impede the load capacity (mechanical resistance) of the fabric, and may even improve it. **Questions 006 and 008 to 011.** Polyester fabric coated with Mylar differs from that coated with polyurethane or silicone in that has lower diagonal extension. **Question 007**.

The aging of the fabric of a paraglider can be identified by a deterioration and erosion of the coating resulting in increased porosity. The effect of this is that the fight behavior changes, with increased tendency for stalls which also occur earlier (at higher air speeds than expected). A parachutal stall is defined by a greater rate of fall and a horizontal velocity less than the normal gliding flight. **Questions 012 and 019.**

A paraglider's coating can be affected by the following: **Questions 013 to 017**.

- Cleaning the wing with strong detergents.
- Storage of the folded wing in humid areas subject to significant temperature variations. Such conditions encourage the growth of mold on the fabric surface, affecting the coating.
- Friction of the fabric on sand, gravel, salt, tar, etc…
- Storage of the wing tin sunlight and/or in a hot place (e.g. car in summer).
- Contact with aggressive materials; sea water, cow dung, fuel, and dying insects trapped in the folded wing, etc… A paraglider in contact with seawater should be immediately rinsed thoroughly with fresh water and then dried in the shade. **Question 017**.

The coating is not affected by: **Questions 013 to 017**.

- Extreme flight maneuvers.
- Gentle cleansing with cold water.
- Storage of the wing in the dark, even in slightly moist and cool conditions.

In the section on aerodynamics, we have seen that the aerodynamic lift is greatest on the anterior (toward the leading edge) of the wing. This is therefore the point of greatest load on the wing during flight. **Question 018.**

Like any wing (see part one, aerodynamics) a paragliding wing (see figure C3) has a leading edge, a trailing edge, an upper and a lower surface. In addition, the wing has, at the sides, stabilizers or outriggers (see Figure C1). These features across the lateral section of the wing are almost vertical. Their function is to directed lift outward at this level, and to keep the wing open in the direction of the transverse axis.

Just below and along the leading edge, there is an opening in the profile divided by internal partitions. These are referred to as "cells" (see Figure C3). They allow air to fill the wing during the flight to maintain the internal pressure. This, in turn ensures that the wing remains firm and inflated. Between the upper and lower surfaces of the wing are numerous partitions, aligned vertically (or oblique), parallel to the chord line. These are referred variously to as ribs, walls, diagonal bracing or cell walls (see Figure C3). These walls are designed to transmit the load evenly to the upper surface of the wing, and so ensure a uniform distribution of the wing loading. This also keeps the profile as accurate and rigid as possible, with a minimum of lines, since the lines all contribute to parasitic drag. **Questions 020 and 024.** The ribs thus define the cells of the wing. To compensate for the pressure evenly across the wing and facilitate the movement of internal air (including reopening a partial closure of the wing), the walls are not solid, but are include holes (vents). **Question 025**. See figure C3. The greater the number of cells in a wing, the more accurately it will maintain its profile but the extra fabric contributes to the weight and increases the volume of the folded glider. **Question 026.** Figure C4 shows examples of different gliders, the arrangement of cell walls and their relationship with the lines on the underside of the wing.

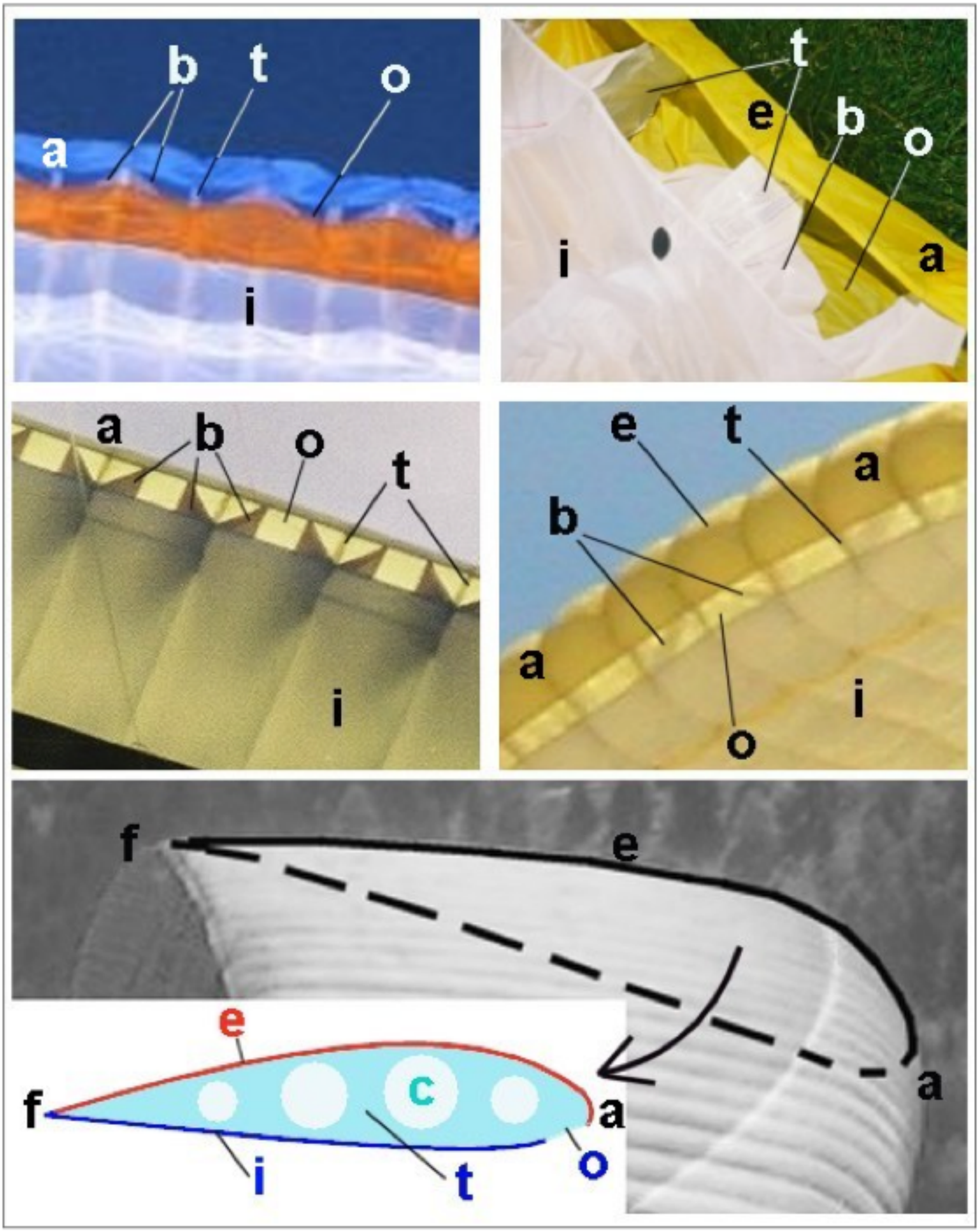

Figure C3: Structure of a wing: a = leading edge, f = trailing edge, e = upper surface, I = lower surface, t = cell walls, o = cell openings, b = diagonal bracing, c = hole (vents) in cell walls.

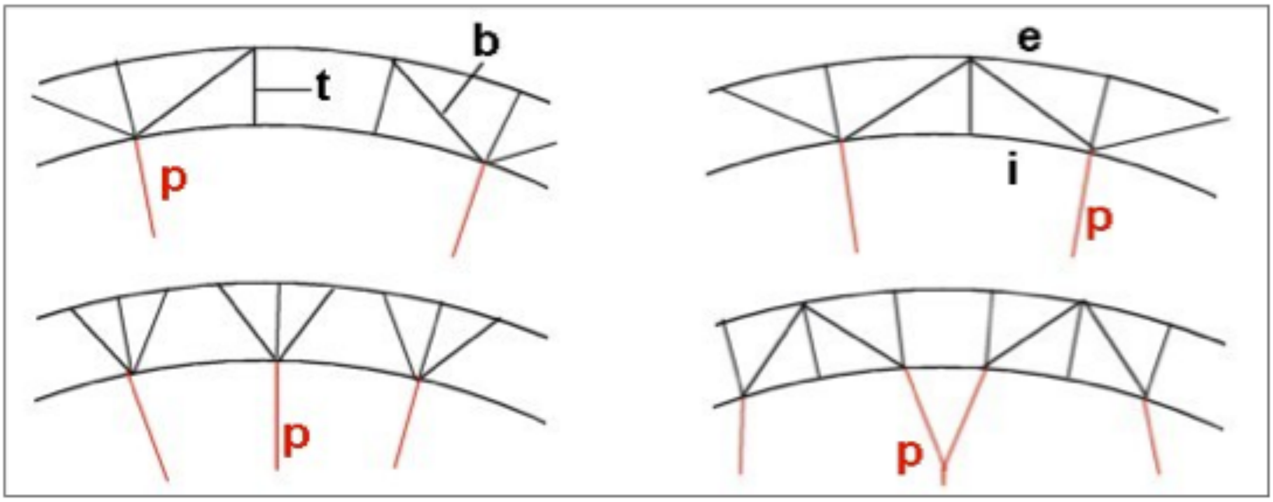

Figure C4: Schematic side view of a wing with illustrating different kinds of arrangement of vertical walls and diagonal bracing. t = cell walls, b = diagonal bracing, p = lines, e = upper surface, i = lower surface.

Since the lift forces are maximal on the anterior part of the profile (see aerodynamics section), the loading on the walls is greatest on the front half of the wing and obviously at the point of attachment lines to the cells. **Question 021**. To protect the walls and prevent the cells deforming near the attachment points of the lines, the cells walls with the highest load are reinforced or diagonal (or triangular) bracing is used. **Question 023.** This spreads the load over a wider area (see figure C5). The B-line stall (see part 5, a practice flight), is a flight maneuver which deliberately deforms the wing by pulling down on all the B-lines. In this maneuver, the cell walls suffer the most stress. **Question 022.**

Figure C5: Example of triangulation.

If the stitching of the sail is too tight, the fabric will have close perforations and thus loses its mechanical strength. **Question 028**. Some manufacturers install nets to cover the cell openings. This keeps the leading edge more uniform and rigid but makes cleaning the wing and repair more difficult. **Question 029.**

The anterior cell wall, near the openings of these cells, is often reinforced with Mylar-coated fabric. This has a smooth, shiny and somewhat rigid appearance. This imparts a stiffness and strength of this portion of the wing, and increases the accuracy and stability of the aerodynamic profile. Mylar is however quite brittle and can therefore easily be damaged during repeated or careless bending. See figure C6.

Figure C6: fabric reinforcements coated with Mylar.

The Lines

We distinguish the lines in 3-5 groups depending on their point of attachment to the wing. See figure C7. **Question 030**. The (A) lines are attached to the leading edge (**question 031**), they are followed by lines (B), (C), and (D) and finally the control (brake) lines (F). Typically manufacturers color each group differently to help distinguish them. This is useful for some maneuvers as well as for disentangling. This is not universal and is not the basis of to distinguish the groups of lines. Sometimes there is no group (D). To support the two stabilizers on each side of the wing, there is a particular group of lines that connects the stabilizer to the lift lines of (B) or (C). See figure C7.

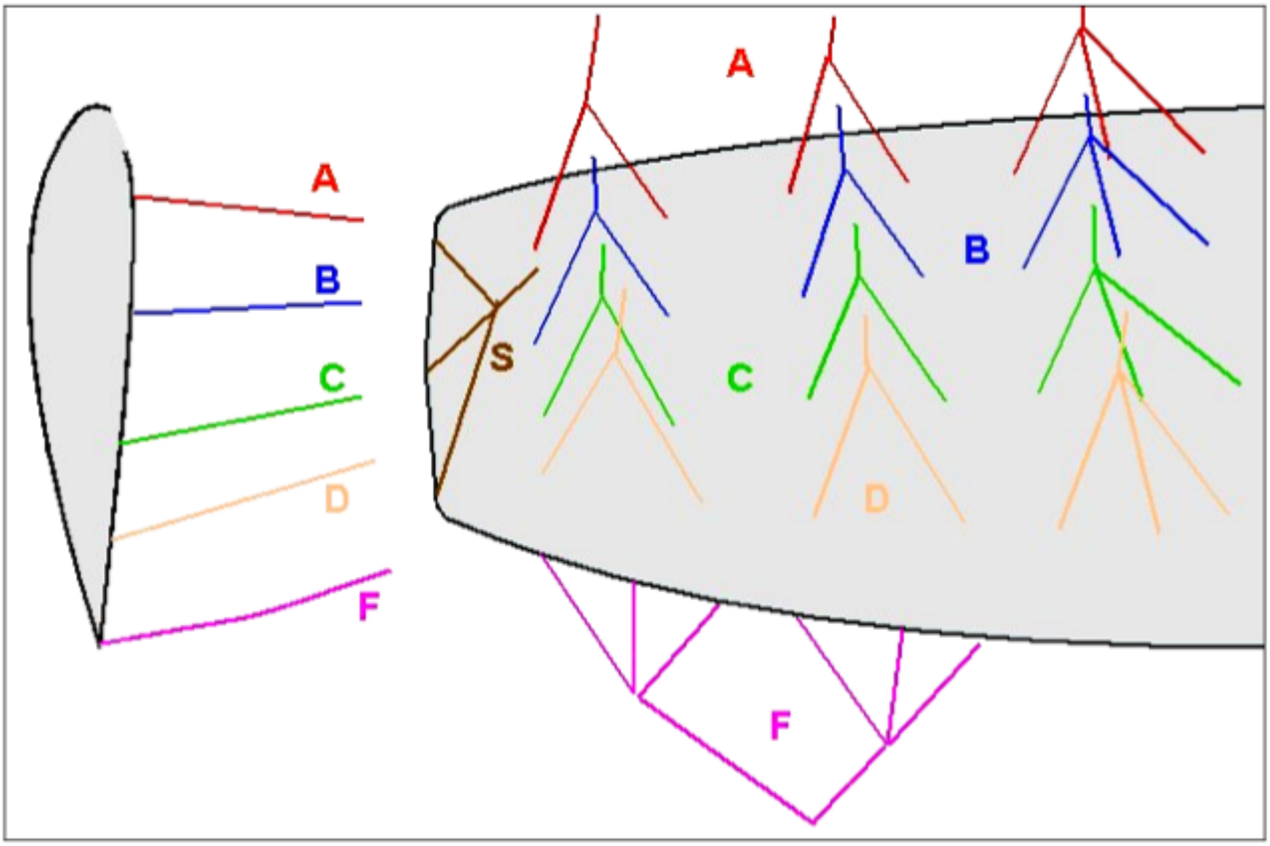

Figure C7: The groups of lines and sample line plan (underside view). Groups A to D on the underside. F = control lines (brakes). S = suspension of stabilizer.

To maintain an accurate wing profile that changes little in flight, the lines must be as *inelastic* as possible. Moreover, for a parasitic drag to be as low as possible, they must have a diameter as small as possible but continue to have a high strength (load capacity as large as possible). **Question 032.** As order of magnitude for the elasticity of a line, the accepted current tolerance is an extension of 3 cm for a line of 6m loaded at 50N (approx. 5 kg). **Question 033.**

Usually, the lines consist of a core of solid synthetic, inelastic fibers, surrounded by a sheath or mantle. See figure C8. The sheath, usually made of braided nylon (polyester), serves to protect the core from the harmful effects of solar radiation and mechanical friction. **Question 035.**

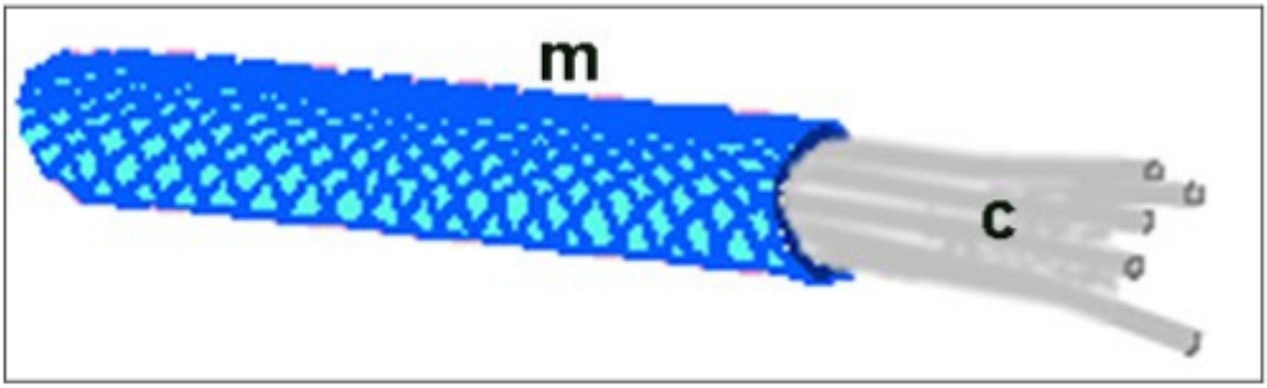

Figure C8: structure of a liner. m = mantle, c = core.

The core usually comprises several thin polyethylene fibers (“Dyneema” - white) or rarely Aramid (“Kevlar” – light brown or yellow). **Question 034**. Kevlar is perhaps a little stronger and less elastic for the same diameter, but it is also more sensitive to wear and becomes more fragile over time. In addition, the technique of sewing the loops in the lines may decrease the strength of aramid lines up to 40%. **Question 037**. It is preferable to use the technique of splicing for looping lines of aramid fibres so as not to significantly reduce their strength. **Question 038**. See figure C9. Splice is the technique of joining two ends of lines by intertwining fibers of the core.

A single knot on a line (see figure C9) can cause a decrease of more than half the strength of the line.

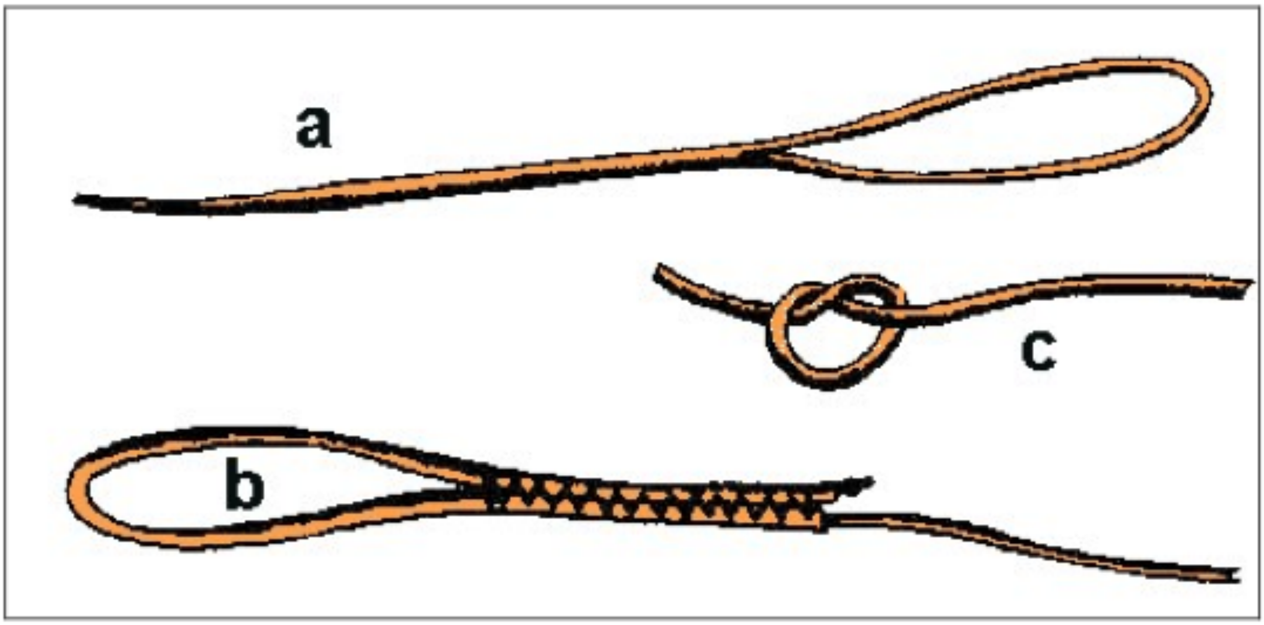

Figure C9: a = splice, b = sewing, c = knot.

Because the sheath is made of different fibers from the core, even if it is composed of materials with low expansion (inelastic), the length of the lines is likely to change substantially with weather. **Question 036.** For example, a sheath subjected to dirt and moisture can retract and thus shorten the line. **Question 046.**

A drawback of the core/sheath structure of the lines is that it can mask a serious deterioration in the core of the line (e.g. breakpoints) which can seriously weaken the line. This kind of incident can happen when you stress the lines (for example by walking on them). Another classic example is the freezing of a wet line. **Question 039.**

Whatever the ultimate tensile strength, a line with small diameter (e.g. 1mm) will have a smaller drag and a higher tendency to form a knot than a line of a larger diameter (e.g. 1.5mm). **Question 040.**

Since the lift forces are greatest on the anterior part of the profile (see aerodynamics section), the lines (A) and (B) carry twice the load of the lines (C) and (D). **Question 041.**

While knots (see figure C9) weakening a line, sewn loops (see figures C9 and C10) used on the attachment points with the wing fabric offer the advantage easier maintenance without significant weakening of the material, since the defective lines can be easily replaced. **Question 042**. However, when replacing a line, only original spare parts supplied by the manufacturer should be used. **Question 043.** The suspension lines can undergo a permanent change in their initial length (final elongation) by episodes of significant stress, such as attachment to the ground during the inflation of the wing (**question 045**), but also by high loads during normal use. **Question 044**. The extension of one or more lines causes a change in flight behavior of the paraglider.

Figure C10: Fixing a line to the underside of a wing.

Questions 047 to 055 deal with the consequences of changes in length the lines of groups (A) to (D), in terms of the angle of attack, profile shape and hence the flight behavior. See figure C11. See also the section on aerodynamics.

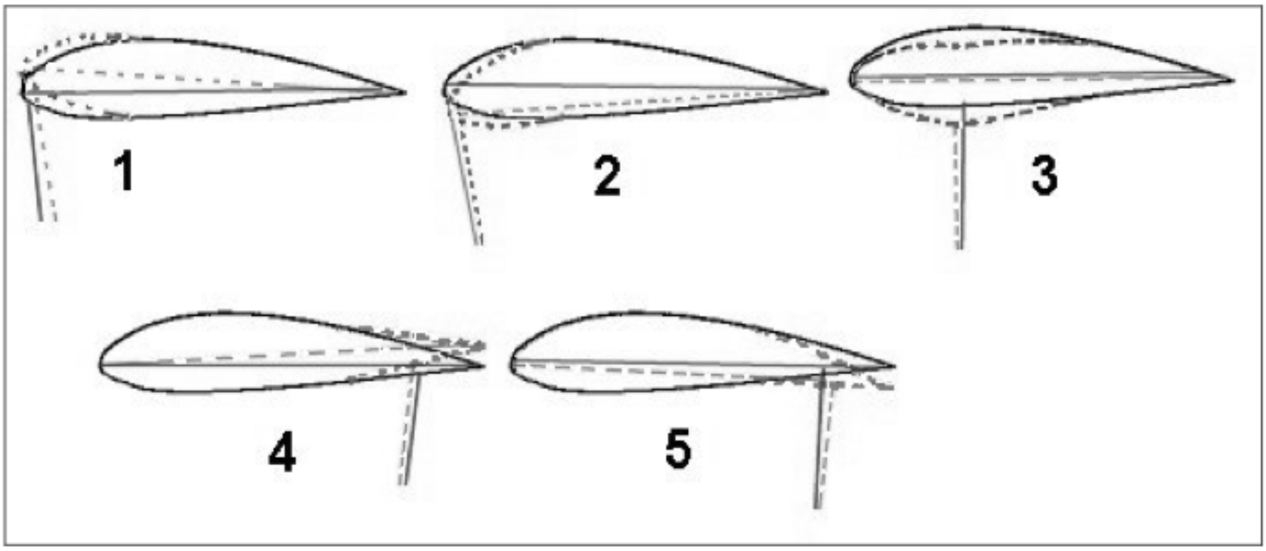

Figure C11: Dotted line, change in the angle of attack when the length of group A, B or D lines changse. Solid line, the angle of attack before modification.

In all cases, the profile and therefore the flight behavior changes. If (A) lines stretch (1) or (D) lines shorten (5) the angle of attack increases. Conversely, if (D) lines stretch (4) or the (A) lines shorten (2) the angle of attack declines. If the (B) lines shorten (3), there is only the modification to the profile, and the angle of attack is not materially changed.

If the (A) lines lengthen or (D) lines shorten, the angle of attack increases, so the wing is more difficult to inflate on takeoff (inflation is slower and requires more power, as if it the brakes are applied) and the glider flies more slowly. A front closure (across the leading edge) of the sail is less likely but the risk of a parachutal stall increases (increased sink rate and decrease the horizontal velocity). If the (D) lines stretch or (A) lines shorten, the angle of attack decreases, making the wing is easier to inflate and takeoff faster. A front closure of the wing is more likely but the risk of a parachutal stall flight is reduced.

The longer the lines are, the lower the centre of gravity is. This increases the amplitude of oscillations around the flight laxes, and vice versa. **Questions 057 and 058**.

if a line is severed or severely damaged, especially if it is one of the heavily loaded lines like (A) and (B), the glider should not be flown, and the line(s) replaced by an authorized service centre. Never fly with missing lines or repair/adjust them with knots or strings, as the length of the line as well as its strength cannot be guaranteed under any circumstances! **Question 056.**

Risers, Controls, Displays and Accelerators

The risers are made of polyamide or polyester webbing straps that connect the lines to the harness. The risers are classified similarly to the lines: from the front (A) to rear (D). See figure C12. The brake strap (control handle) is smaller and is threaded through a small pulley wheel to reduce friction on the control line.

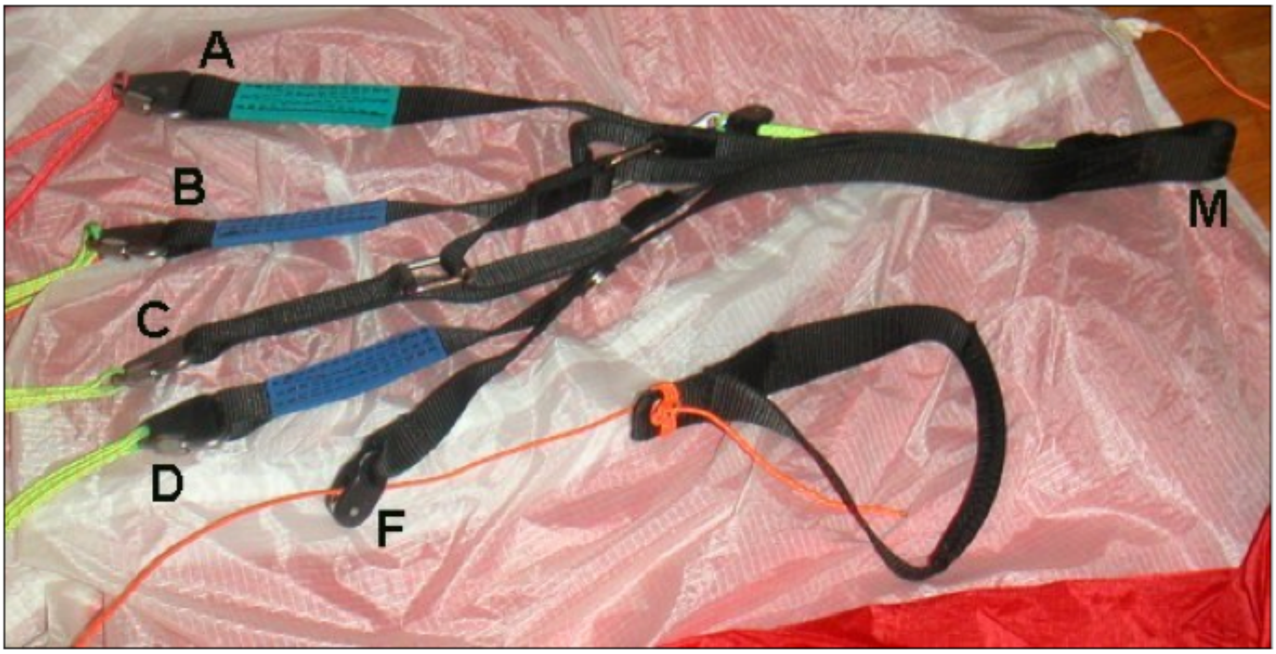

Figure C12: 4 Risers A to D. F = small brake handle (control). M = end loop that attaches to the harness.

Quick links (screw locking links) are small metal loops linking groups of lines to the respective risers. **Question 063**. See figures C12 and C13.

Figure C13: quick link

The screws of these links should be tightened by hand and then with an additional 1/4 turn. **Question 064**. Since the lift forces are greatest on the anterior part of the profile (see part one, aerodynamics) and least on the back, the (D) risers experience the least load in flight. **Question 065.**

At the anterior position the webbing risers, there is a pulley system the function of which is, to shorten the (A) riser and to a lesser extent, (B) and possibly (C) risers. This is the **accelerator system**. This system is connected by a cord to a stirrup which can be actuated by the pilot's feet ("**speed bar**"). See figures C14 to C16. When the pilot pushes the speed bar forward with his legs, he can thus indirectly shorten the 2 or 3 groups of risers. This shortening and pre-defined differential in the shortening of (A), (B) and (possibly) (C) risers is achieved through a system of pulleys. This results in a decreased angle of attack and thus an increase in speed (see part one, aerodynamic) without significant change in the profile. **Question 067.**

The accelerator system and controls (brakes) are the 2 devices that enable the glider to fly over its entire speed range. See figure C17 & part one, aerodynamics. The greatest glide ratio in calm air is generally obtained with no action on the controls (arm up) or the accelerator (foot off). Some wings require slight application of brakes or accelerator to achieve the maximum glide ratio. Regardless of this, if a pilot flies straight, without acceleration or brakes, the glider will be very close to its maximum glide ratio. On the left of the polar curve (angle of attack between 12° and 20°) is the "low speed" range, obtained by applying the brakes. The more the brakes are applied (i.e. pulled), the glider behavior shifts further to the left of the polar curve, the angle of attack increases, the slower the airspeed, and with it gradual decrease in the glide ratio. See figure C17 left. Conversely, at the right of the polar curve (angle of attack between 5° and 10°) is "high speed" range, obtained by applying the accelerator system. The more the accelerator is applied with the legs, the further the glider's behavior shifts to the right of the polar curve, the more the angle of attack decreases, it wing accelerates but with also a progressive decrease in glide ratio.

Figure C14: O = cord connection. E = stirrup.
X = Detailed view of an accelerator system (pulley multiplier). T = Connection hook.

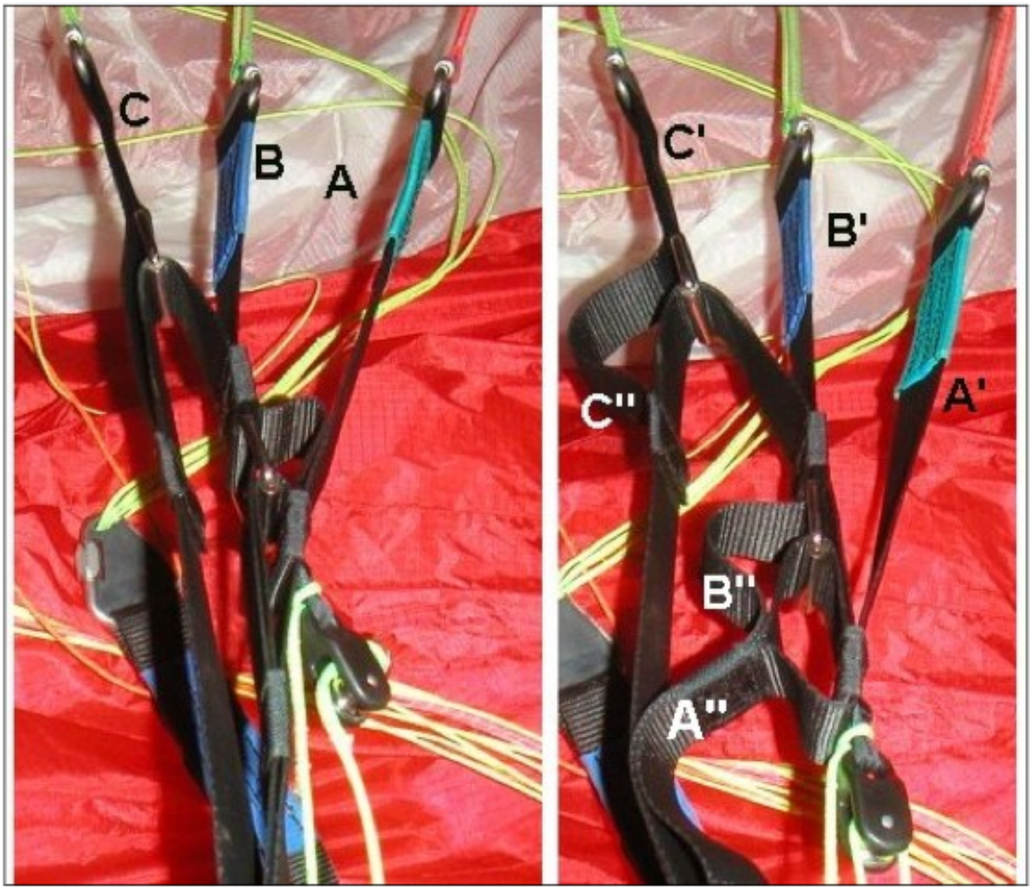

Figure C15: Accelerator system, before (left) and after (right) application. Shortening of A, B, C to new positions of A', B' and C'. The bottom riser is pleated A'', B'', C'' after application of the accelerator.

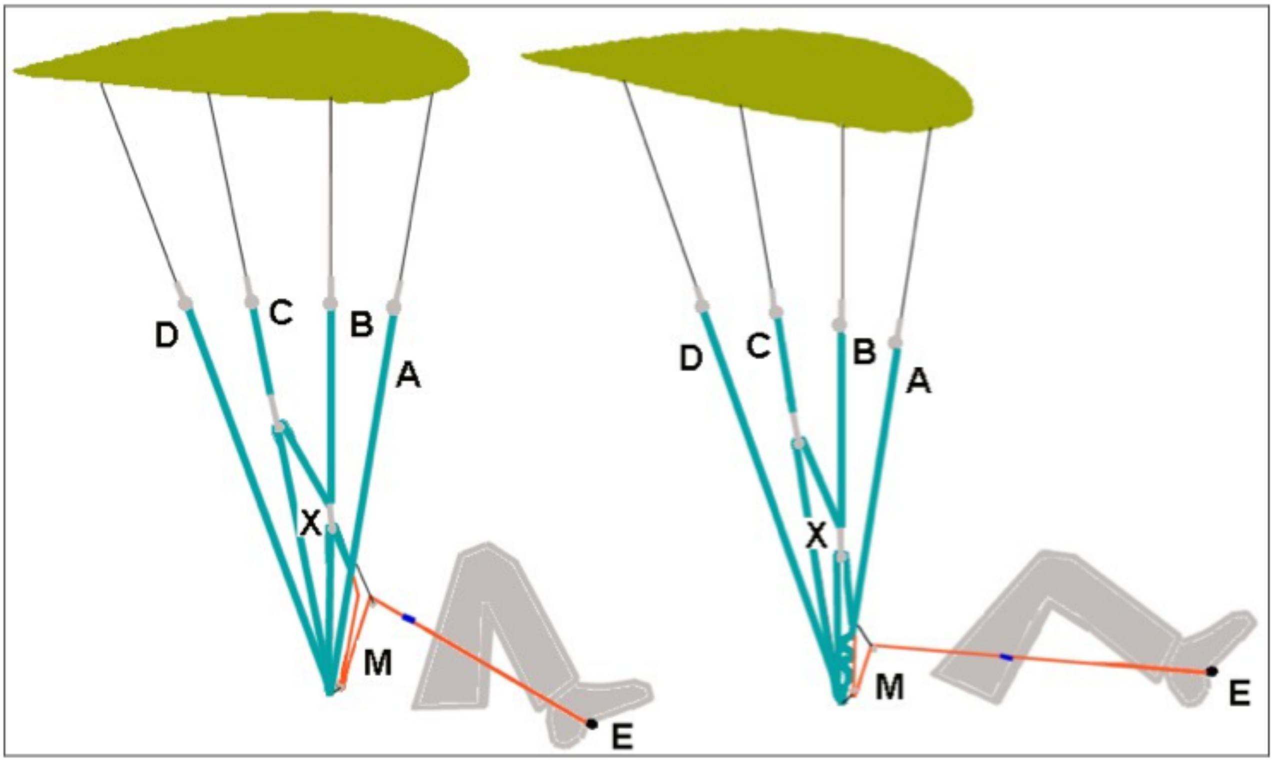

Figure C16: Schematic of a riser before (left) and after (right) application of the foot control. On the right, the systematic, progressive shortening of the risers D to A. X = differential in shortening of the risers. M = multiplier accelerator. E = accelerator bar.

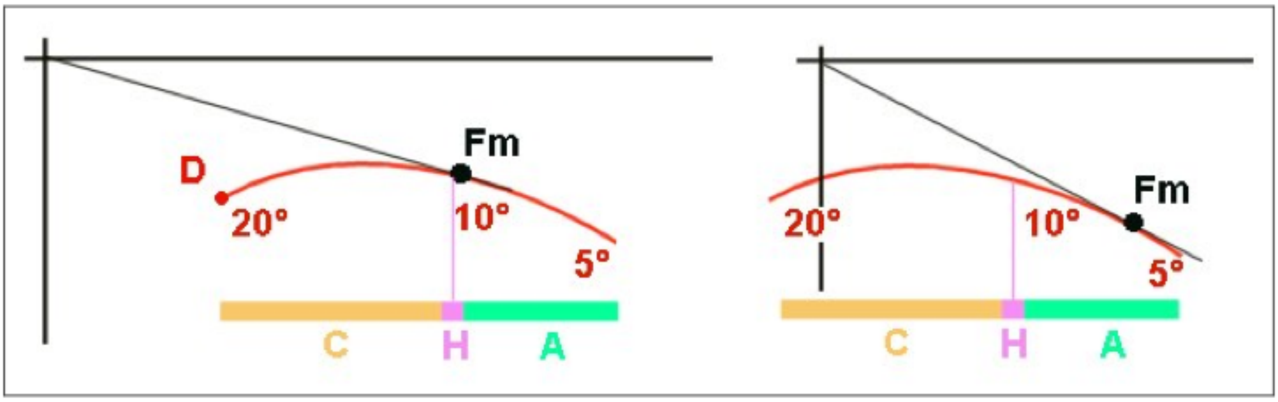

Figure C17: Polar curve of a paraglider in still air (left) and a 25km/h headwind (right). D = stall. C = flight range with the brakes. H = range of "hands up" flight. A = area of flight with the accelerator. Fm = maximum glide ratio.

In figure C17 (left), if the accelerator is depressed to its full extent in calm air, the horizontal velocity (penetration) and rate of fall (sink rate) increases and the glide ratio decreases. **Question 068**. In contrast, in a 25km/h headwind (figure C17, right), the glide ratio is improved if moderate to strong acceleration is applied, without use of the brakes (arms up). In these circumstances, the use of the accelerator improves the glide ratio and speed of penetration, but also increases the rate of fall. **Question 069.**

Trim-tabs are devices that have the same effect as the foot accelerator but which involve changes in length of (usually) the final group(s) of risers, that is (D) (and possibly C) risers.

Question 070. The flight behavior is then modified to increase the glider's speed. A paraglider equipped with trim-tabs is approved for flight only if the certification tests have been conducted with this device active. **Question 071**. See figures C18 and C19.

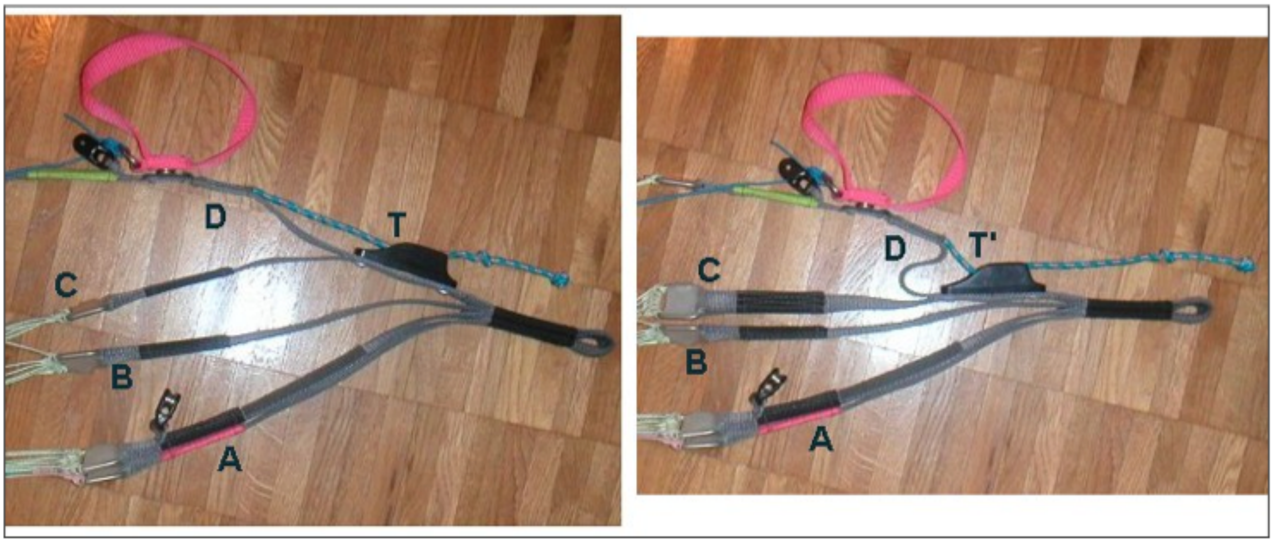

Fig C18: Glider equipped with trim-tabs. T = inactive and T' = active. Riser groups A to C are not affected by the trim-tabs. When the trim-tab is engaged, the lower part of the D risers folds and shortens.

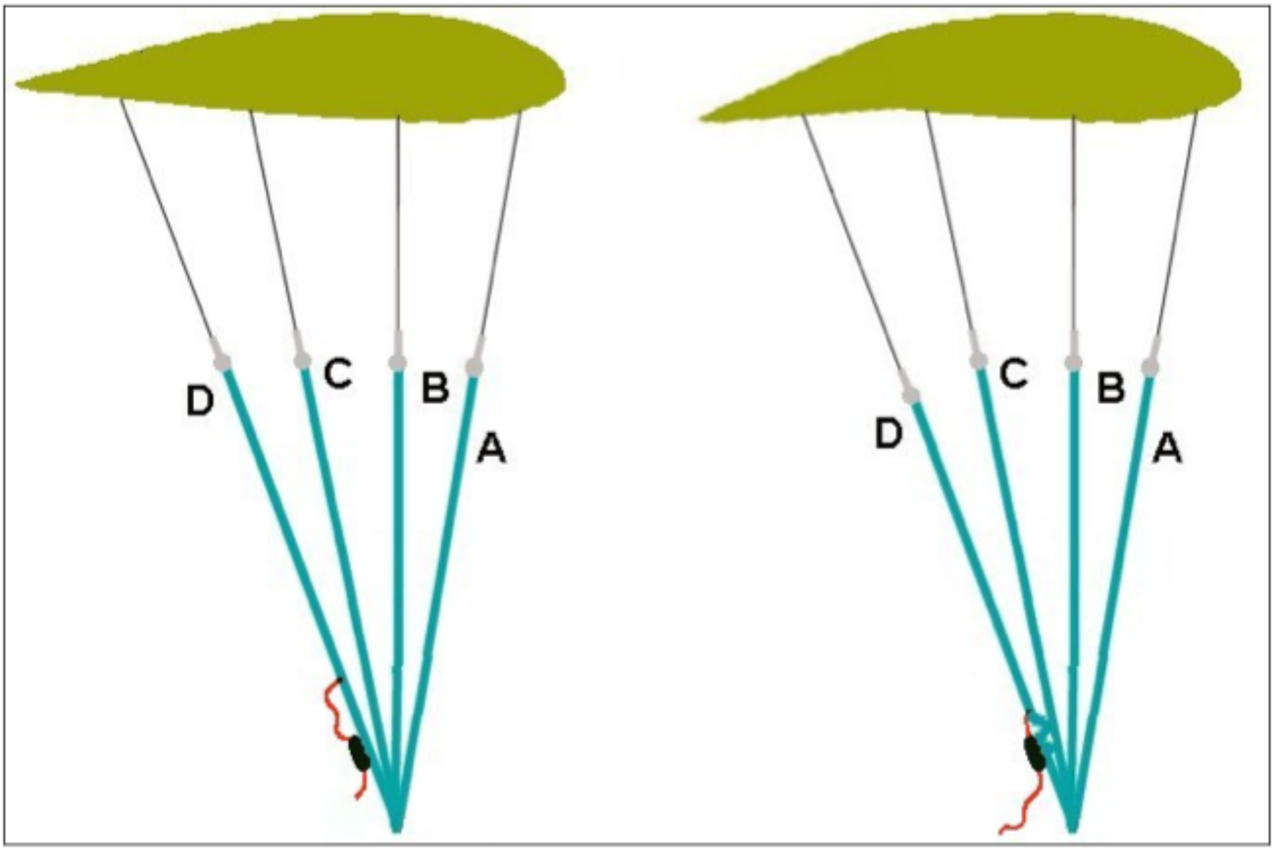

Figure C19: Schematic of a glider with trim-tabs inactive (right) and engaged (right).

For normal flights, trim-tabs can be engaged to slow the glider: the (D) risers are shortened, increasing the angle of attack and lowering the profile at the trailing edge. To regain speed, the tabs are released (relaxed) to reduce the angle of attack and raise the profile at the rear. **Question 072**. In this later flight configuration, the wing is more prone to frontal collapses and greater control movements (more brakes) are required than in the tabs are active. **Question 073.**

Manufacturers use trim-tabs (above) particularly in tandem wings (two-seaters) where obviously the foot accelerator is not viable (passenger in front) and occasionally for paragliders that do not require exceptional pilot skills**. Question 074.**

In summary, the pilot can use the full flight envelope of the glider (i.e. entire speed range) with the brakes (controls) for the low-speed and acceleration system for the high-speed range. **Question 075.** See figure C17. To speed up, the angle of attack is increased though increased tension on the forward risers (accelerator bar), or by relaxing the rear risers (trim-tabs).

Controls or brake lines are connected to the trailing edge of each side of the wing. See figure C7. At the lower end of each brake, the lines converge onto a single line, passing through a small pulley which in turn is connected to the D riser. See figure C12. The pulley guides the control line and protects both the brake line and the riser against mechanical wear (friction). **Question 076.** Finally, at the end of each control line, there is a handle to grasp, and to control each side independently. For safety, it is very important not to change the brake lines: Their length is determined by the manufacturer. **Question 077.** The brake line length has been adjusted so that the glider can fly through the entire speed range (from minimum to maximum). **Question 079.** In normal “arms up” flight (without pulling on the contols), the brake lines describe a smooth arc toward the rear. See figure C20.

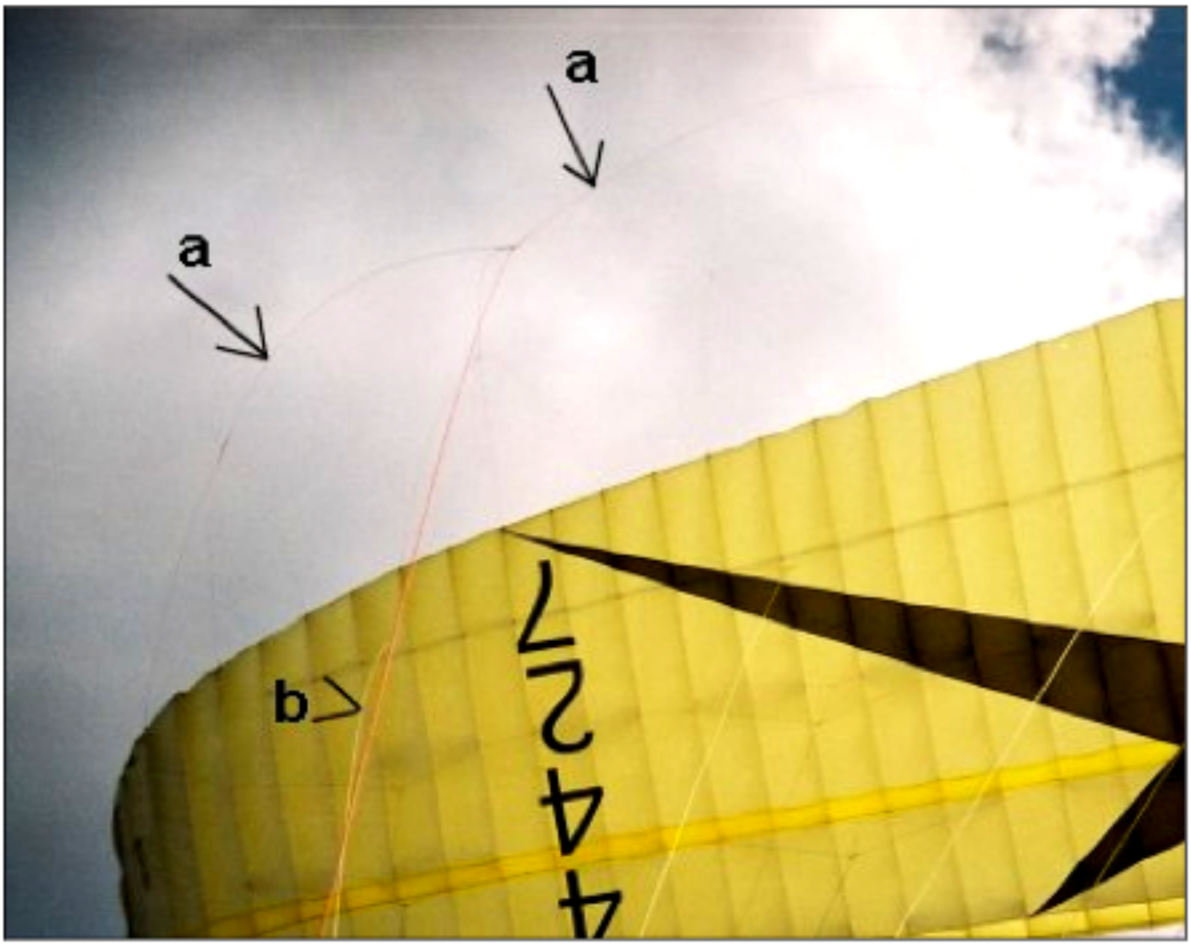

Figure C20: a = left brake lines curved backwards, b = D lines slightly curved.

This is due to the fact that the brake lines are subject to drag during flight, and without tension (pulling) on the brakes, they are forced backwards. If the brakes do not display this arc in the relaxed state (arms up), but rather descend straight from the trailing edge to the handles, then the brake lines are too short, the controls are poorly adjusted and the pilot is in danger (risk of stalling). **Question 078**. For similar reasons, the (D) lines, to a lesser extent ,also show a (less pronounced) rearward arc. The arc is less, due to the fact that the (D) lines are under more tension than the controls in relaxed flight. See figure C20. This is even clearer when the glider slows down, because if the brakes applied (and hence in tension), the tension in the (D) lines reduces. **Question 080**. If a set of control lines breaks during the flight, the glider can still be flown. If the controls are ineffective, the glider can be controlled by cautiously pulling on the (D) risers (this presents the highest risk of stalling).

The Harness and The Reserve Parachute

The harness of a paraglider is like the cabin of an airplane. See figure C21. We must be able to sit comfortably for several hours.

Figure C21: Example of harness with airbag, a = lower (rigid) seat, b = side straps converging on the karabiner (c). s = speed bar, e = back protection, f = rescue parachute (in pouch), g = storage pockets, side and rear.

Straps around the thighs, front of the trunk and shoulders keep the driver in the harness. On the sides, straps from several attachment points on the harness, converge on a karabiner that quickly and safely connects the risers to the harness. Modern harnesses are usually equipped with a pouch sewn into the fabric of the harness, and designed for the emergency parachute (in an external container). See figure C22. The most important principle for choosing the position of the pouch for the emergency parachute, is that the pilot must be able to see and easily reach the release handle. **Question 098**. Each position has advantages and disadvantages. The pouch is sewn into the harness, but attached by straps to the two karabiners.

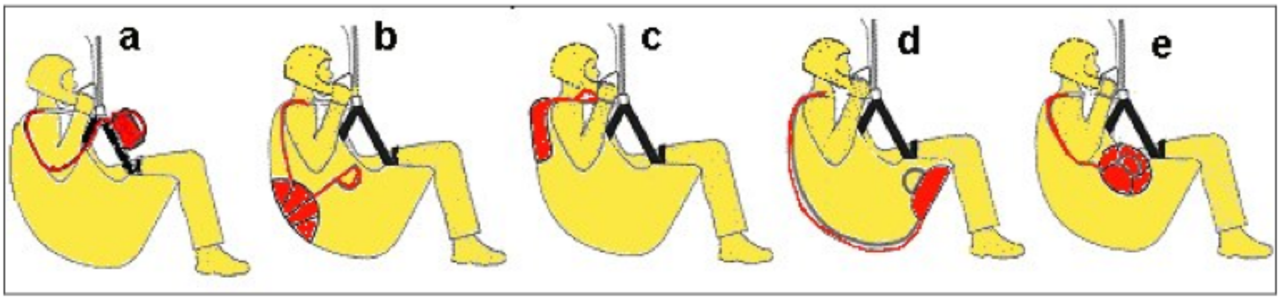

Figure C22: Different positions of the pockets of relief on the spot: a = ventral posterior b = c = dorsal, d = lower, e = side.

Harnesses also typically have some form of back protection provided by a large shock absorber of air (air bag) or foam (foam bag). These devices increase the passive protection (as do helmets and gloves), but are no substitute for active protection (piloting rules, training, proper analysis of weather situations, etc…) and should not be an excuse for risk taking. **Question 091**. An air bag, which fills with air during the flight through an anterior opening with a valve, seems to be more effective against the shock than a foam protection. **Question 092.** Conversely, the foam protection is effective immediately, which is not always the case for the airbag, which needs time to inflate. **Question 093.**

Depending on the position and type of the karabiners, there are different harness configurations. See figures C23 to C25. Contemporary harnesses increasing use a lattice, or cross-brace structure. This system blocks lateral oscillation of the harness, impedes the sensation of the movements of the wing in turbulence and hinders steering by weight shifting. **Question 082.**

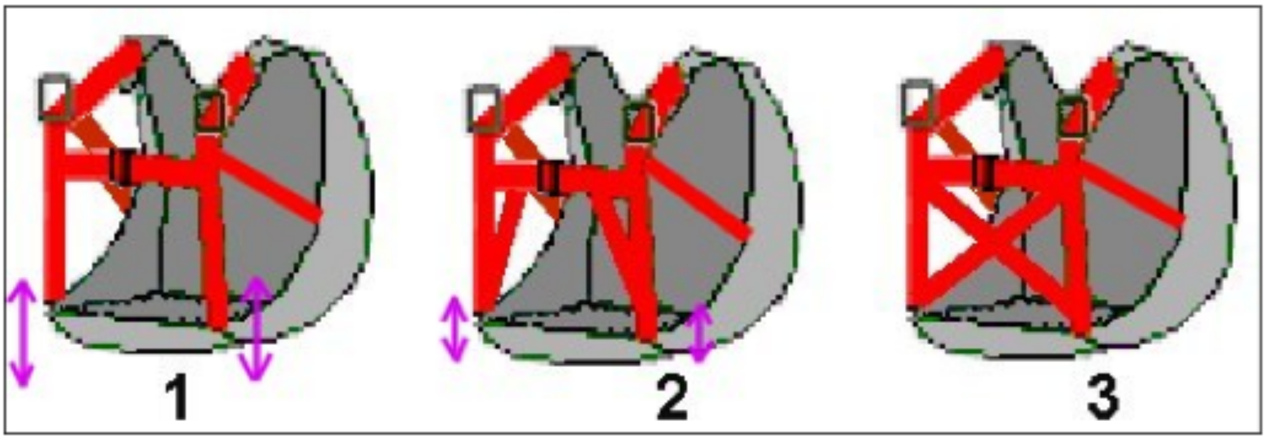

Figure C23: 1 = no cross bracing, 2 = ABS (anti balance system), 3 = lattice (or cross braced) harness. In turbulence, the arrows represent the amplitude of lateral oscillating movements.

A harness without diagonal bracing does not block lateral oscillations of the harness. This permits the sensation of motion of the wing in turbulence. In addition the driver can more easily steer by weight shifting. **Question 083.** The behavior of the wing in turbulent situation may be more “alive” with a harness without cross-bracing than one fitted with braces. **Question 088.** The ABS system is a compromise and is the most common currently used. The amplitude of the oscillations also depends a little in the vertical positioning of the karabiners and the difference between them. See figures C24 and C25.

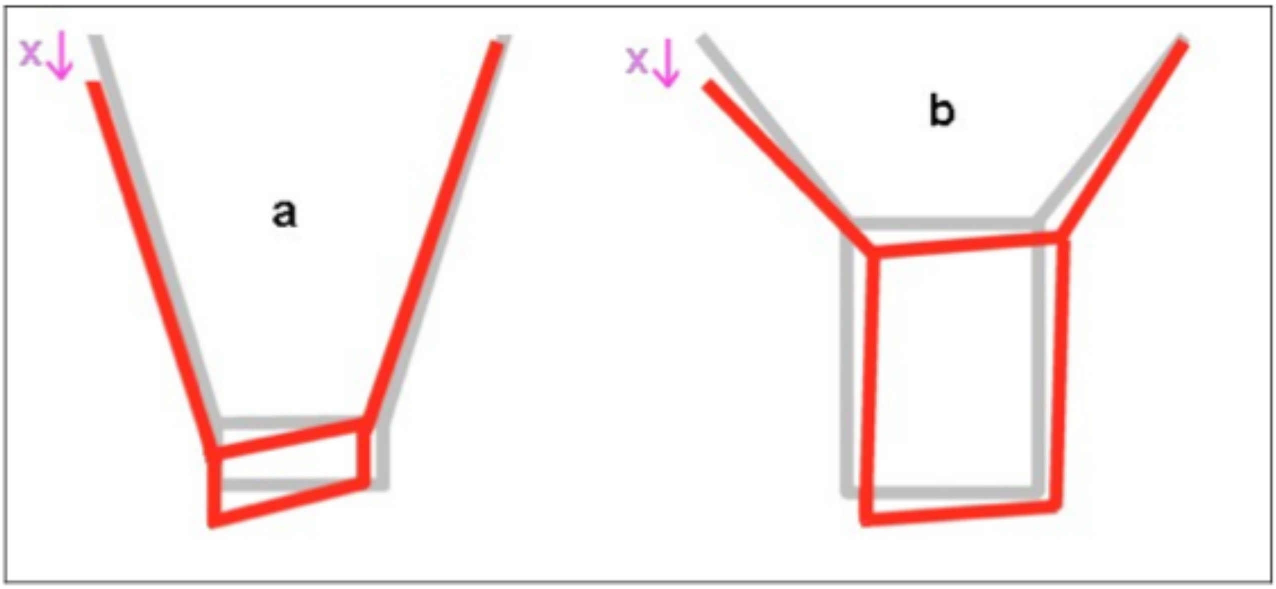

Figure C24: Influence of the gap between runners, not the principle adjustable waist belt. a = small gap, b = larger gap, x = lateral oscillation amplitude transmitted through the veil lifts, z = axis of plate rotation (axis of moment of force couple) holding the twist.

If the separation between the karabiners is small, the harness will be less susceptible to oscillations around a vertical axis than if there is a large separation between the karabiners. In other words, bringing together the karabiners (chest strap tight), the sensation of turbulence is reduced. Conversely, the moment of torque (rotational force) preventing a twist is greater when the karabiners are separated (chest strap released) which reduces the tendency to twist (rotation of the pilot and harness around the vertical axis). **Questions 084 and 085.**

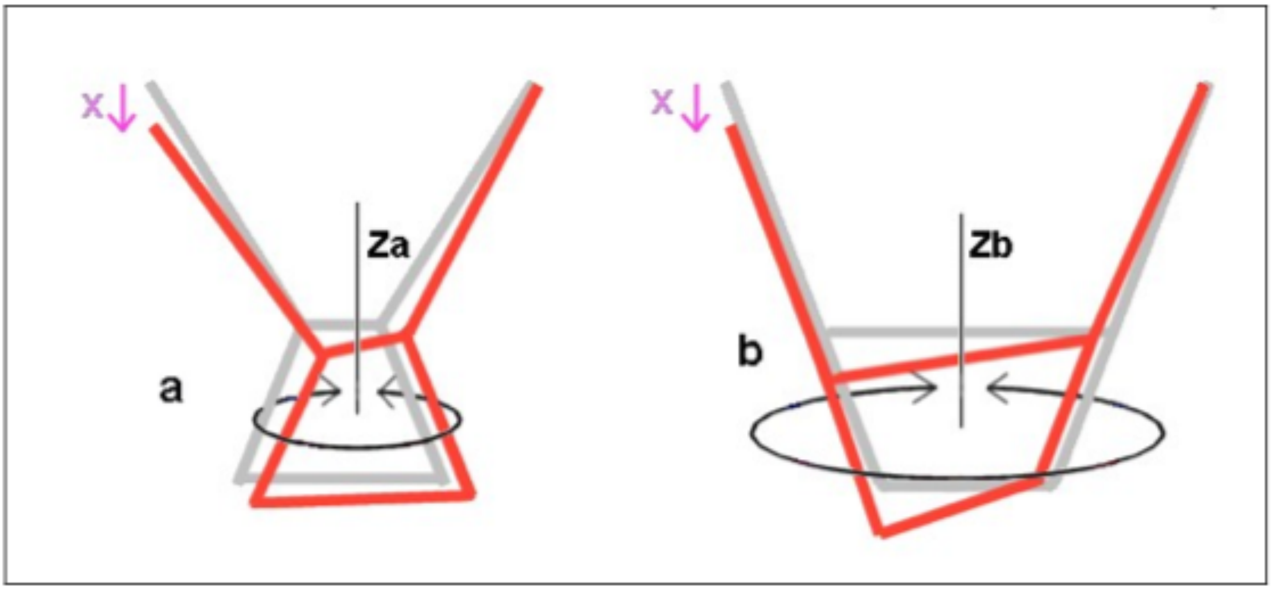

Figure C25: Influence of the height of karabiners. a = low karabiners, b = high karabiners. , X = amplitude of lateral oscillation transmitted by wing through the risers.

When the karabiners are located high on the harness (points of attachment are raised), the vertical projection against lateral oscillation low, so the turbulence is less obvious than for a low karabiner attachment point. **Questions 086 and 087**. On the other hand, low attachment of the karabiners, generates a greater moment of force around the shoulder and therefore less effort is rewired when leaning forward during take-off than for higher located karabiners. **Questions 086 and 087.** See figure C26.

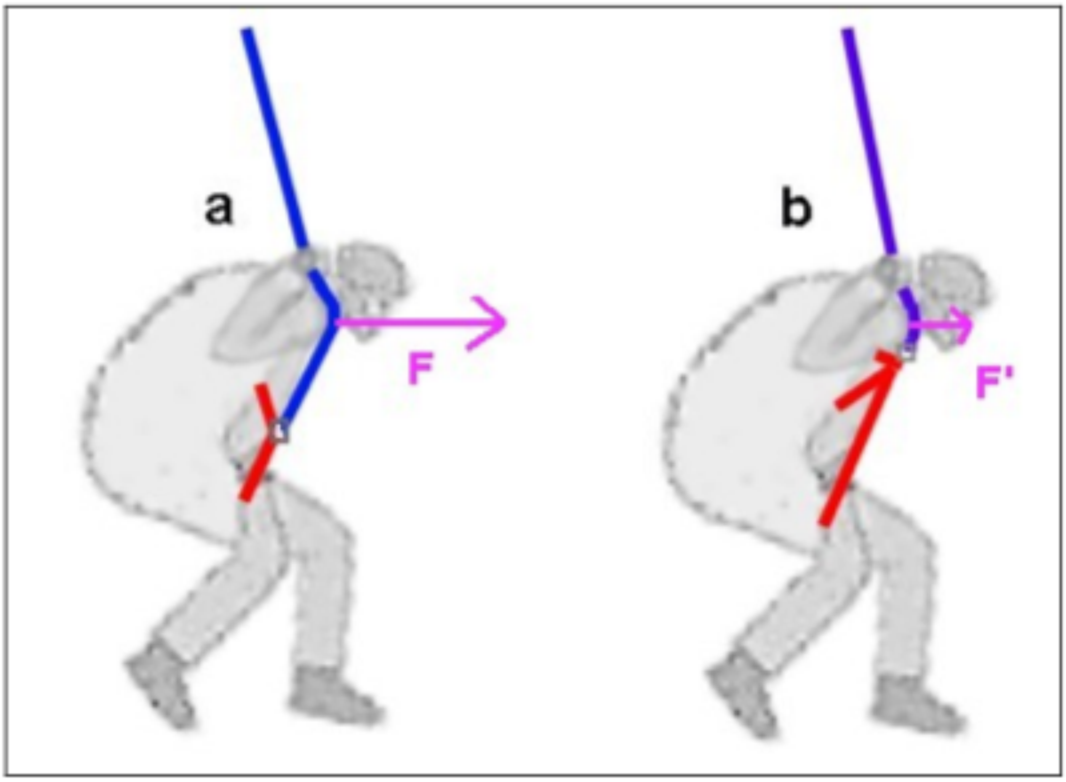

Figure C26: Influence of the height of the position of the karabiner on the pilot's take-off position. a = karabiner located low, b = karabiner located high. F and F '= moment of torque at pilot's shoulders.

A reclined position in the harness presents a smaller area to the wind, and therefore generates less drag a sitting position. See figure C27. Conversely, the moment of torque of pilot and harness is greater in the reclined position, (compared to the seated position). The risk of a twist (so that the direction the pilot if facing and the glider's path differ) is larger in the reclined position. **Questions 089 and 090.**

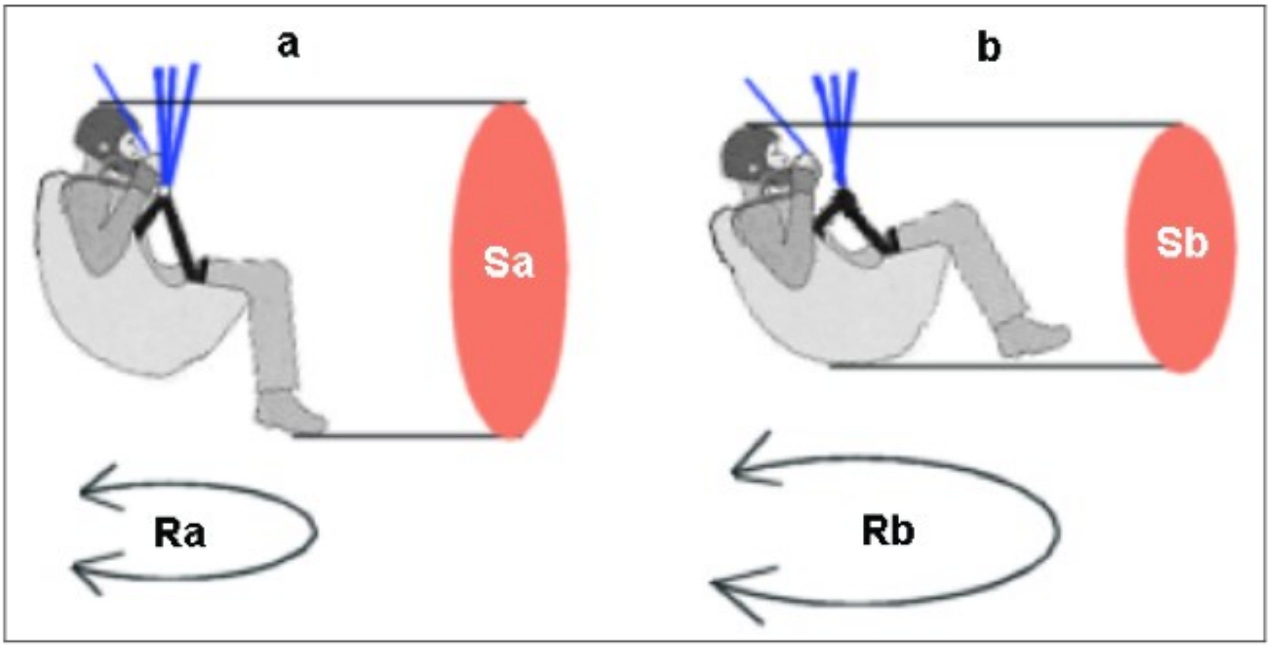

Figure C27: Influence of the pilot's position on the drag and the tendency to twist. a = sitting, b = lying down, S = surface projected to the wind by the pilot & harness, R = moment of torque (rotational power) of pilot and harness inducing a twist.

Just as the back protector and helmet, the emergency parachute is not a gimmick and should be part of any paragliding equipment. Its usefulness has been demonstrated repeatedly, even among the best pilots. Its consists of 3 main parts (1) a general hemispherical dome with opening at the apex, where one or two strong central lines attach, and pull the apex downwards. This design is called a “pull down apex” for obvious reasons. **Question 111**. A pull down apex parachute has a lower sink rate and perhaps slightly worse stability than simple hemispherical parachutes. **Question 112**. See figure C28.

Figure C28: Elements of the emergency parachute. a = risers (sling) branching symmetrically, b = large link attachments with trapezoidal quick links attached to the harness (usually to the shoulder straps), d = central suspension line, c = finer lateral suspension lines, e = parachute, f = vent (opening), g = cover (internal container), g' = internal container when closed, i = cntainer strap and handle for its release from the pouch (external container) in the harness.

The emergency parachute is connected to (2) a cone arrangement of lines converging at (3) a single (generally) riser which bifurcates (splits into a V) symmetrically, to fasten onto the harness, by symmetrical links. In order for the pilot's position to be automatically adjusted into an upright (standing) position when the emergency parachute is deployed, the center of gravity of the pilot must be as low as possible relative to the 2 attachment points. It is therefore typical that these attach symmetrically to the shoulder straps of the harness (i.e. as high as possible, on both sides of the neck of the pilot). **Questions 100 and 101**. See figure C29.

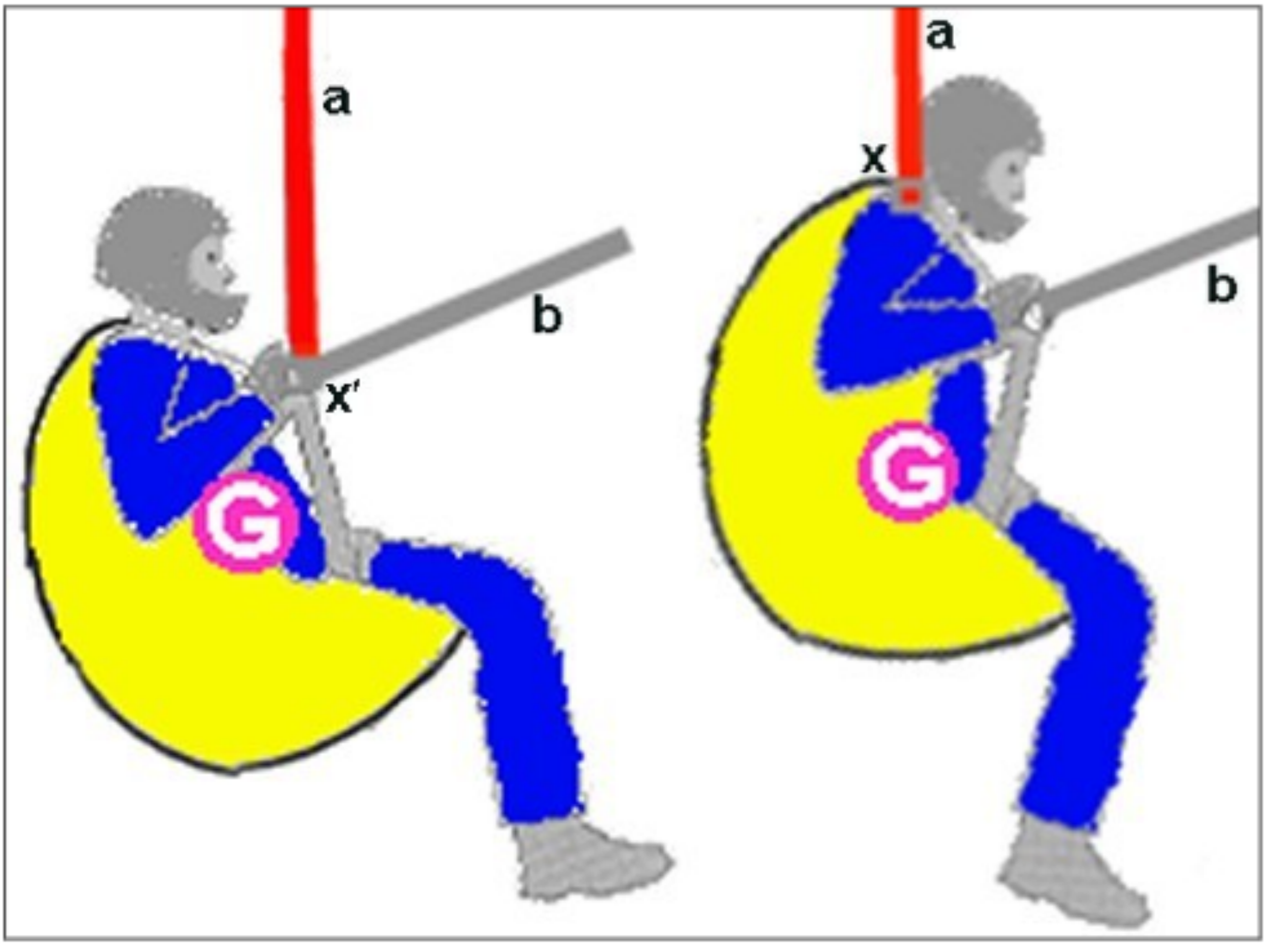

Figure C29: Influence of the positioning of attachment points in order to force the pilot into an upright position on deployment of the rescue chute. a = rescue risers, b = paragliding risers, G = center of gravity, x = attachment to karabiners resulting in a seated landing, and injury, x = attachment to the shoulder straps of the harness resulting in a better vertical position pilot.

If the points of attachment of the emergency parachute are too close to the center of gravity of the pilot and too far forward, such as the karabiners on the paragliding risers, the pilot will sit in the harness and must reposition himself before landing. **Question 099**. See figure C29.

While the wing and the glider's risers are manufactured from different materials (nylon/polyamide for the wing and polyethylene/Dyneema for the risers), both parts of the emergency parachute are usually made from nylon (polyamide). The relief parachute is also made from "ripstop" fabric. **Questions 102 and 103.** Unlike the fabric of the paraglider, which should be strong, inelastic and with low porosity (for consistent aerodynamic behavior), the fabric of the relief parachute should be elastic while being strong, in order to make the shock of opening less severe**. Question 104**. As with the glider, the fabric of the reserve is sensitive to prolonged moisture (mold) and UV from the sun, both factors decreasing the lifetime of the parachute. **Question 107.**

To make deployment (opening) of the reserve easier and crisper, the parachute is not released directly from its pouch in the harness. Rather it is carefully folded into an "S" into a lightweight nylon "pocket" (the internal container); the parachute first, then the lines. See figure C28. The packet containing the folded reserve is then placed in the outer pouch (attached to the harness) with the extraction handle, clearly visible and reachable by one or both hands, while sitting in the harness. See figure C30.

Figure C30: Example of a exterior, read pouch for the reserve parachute, attached to the harness. e = external pocket, o = foam fall protection, s = connecting strap between the internal reserve pouch (hidden in the external pouch) and p = emergency handle.

In order not to interfere in the process of opening the emergency parachute, the cover (pouch) should never be attached to the parachute. In an actual emergency, this cover will probably be lost, which is a small price to pay for your continued life. The opening sequence of reserve is therefore as follows:

1. Locate the extraction handle.
2. Grasp the handle firmly between the thumb and fingers.
3. Remove the pouch, with a firm, wide arm movement, perpendicular to the external pocket. The pouch does not open at this time.
4. Identify free air space to the rear.
5. Throwing the pouch with full force in this direction. The lines will first unfold, then the pouch will open and finally release the reserve parachute, which will begin to open.

The pocket (internal container) facilitates the extraction of the reserve from the external pocket, making the opening sequence clean, precise, smooth and with reduced risk of tangled lines. **Question 114.** To ensure the reserve functions properly, and quickly, when needed, it should be unpacked, aired (for 24 hours) then repacked regularly (approximately every 4-6 months). **Question 105**. The longer the repacking interval the increased chance that it opens slowly because, over time, moisture or static electricity (when it gets too dry) can cause the folds of the parachute to stick or cling. **Question 106.** Folding of the reserve, as its installation into the harness, requires specific training and some experience. To avoid doubt, this should be done by a someone certified by SHV/FSVL to repack reserves. **Question 108.**

Factors that can improve the opening time are: **Question 113.**
1. Low porosity of the fabric of the reserve parachute.
2. Short intervals between repacking.
3. Significant relative wind speed on opening.
4. Small area of the parachute.

Memory aid: To answer this last question, just remember the first 2 points.

A small area of the reserve facilitates the opening, however, it also increases the rate of fall. Manufacturers usually offer reserves in 3-4 sizes per model. It is important, as with the glider, to select a size appropriate to the weight of the pilot & the equipment, in order to get a good compromise between opening time and rate of fall. Normally, the rate of fall is looking around 5.5 m/s. **Question 110.** This corresponds to a fall from a height of 1.5m. On reaching the ground, it is advised that the pilot rolls on landing in order to minimize the risk of injury.

The proper use of the reserve is quite simple and requires no pre-training, but all pilots should be familiar with the procedure. If the reserve falls into the water, for example during a safety course (SIV; simulated incidents of flight), it is the lines that take the longest time to dry. **Question 109.**

Additional Equipment and Flight Instruments

Some pilots like to focus on active safety (appropriate piloting and decisions) rather than passive safety (protection, emergency parachutes, etc..). In fact, these are not mutually exclusive, and the best pilots use both. It is foolish to develop the best passive safety, only to disregard the flight rules or disregard active safety measures. The result would be mortal danger, despite the protections.

We have already seen two passive protection elements: the back protectors and emergency parachutes. Even though it requires a minimum of intervention from the pilot, the reserve is regarded as part of the passive safety. Good walking shoes, rigid enough to protect the ankles and flexible enough to run nimbly over rough ground, are very important. Similarly, a strong pair of gloves, protecting from the cold and mechanical stress possible is essential. **Question 117**. A helmet is just as important. It protects the head against falls especially during takeoff or landing. A full-face helmet is the most effective. **Questions 118 and 119.** Currently, there are many models of full-face helmets in composite materials, which are both light and strong. See figure C31.

Among potential flight instruments, a **variometer** is undoubtedly the most useful to a paraglider pilot. This instrument informs the pilot of the vertical velocity of the glider. **Question 122.** The vertical speed indicator works by measuring the difference in atmospheric pressure or more precisely the intensity of the pressure variation with time. **Question 123**. By this means we can get a good idea of the strength of thermals, as the pressure decreases steadily with altitude. An acoustic variometer is sufficient for a recreational pilot. See figure C31. The **altimeter** is not essential for a recreational pilot who is not forced to very high altitudes. It is more useful to competition pilots or distance flights where pilots must make tactical decisions (transitioning between thermals) and remain within the permissible airspace altitude limits. See figure C32. The altimeter gives an altitude value by measuring the instantaneous atmospheric pressure. Question 124.

Figure C31: Paragliding helmet. The small device with solar cells, placed at the bottom edge and side of the helmet is a small acoustic variometer (without batteries): light and efficient.

Figure C32: A collection of flight instruments: an altimeter and variometer (above), and a GPS tracker (below). Both instruments are shown placed on the outer pocket of a ventral reserve parachute.

Since atmospheric pressure decreases with altitude, a reduction in pressure due to bad weather will result in an erroneously high altitude reading from the instrument and vice versa. This is corrected by calibrating the altimeter before each flight. Instead of reporting pressure values, the altimeter is calibrated in units of length (height). If a high pressure approaches, the atmospheric pressure increases, and a calibrated altimeter, at a fixed altitude, will report lower altitude from morning to afternoon. By the afternoon the reported altitude will be too low. **Question 125**. By reverse reasoning, if the high pressure weakens, an altimeter, calibrated in the morning, will read values higher than reality during the afternoon. **Question 126.**

The **anemometer** is probably the least useful tool for paragliding. It gives a measure of wind speed and in the air. In flight this would be the relative wind speed. **Question 120.** See figure C33. It may be useful to a student who is learning to use the flight envelope (speed range) of a glider, but for an experienced pilot, the feeling the wind on your face and the wind noise is enough to give a sufficient idea of the airspeed. An anemometer in flight must be placed at least one meter below the pilot accurate readings to avoid underestimating the wind speed because of aerodynamic drag that slows the flow of air around the pilot**. Question 121.**

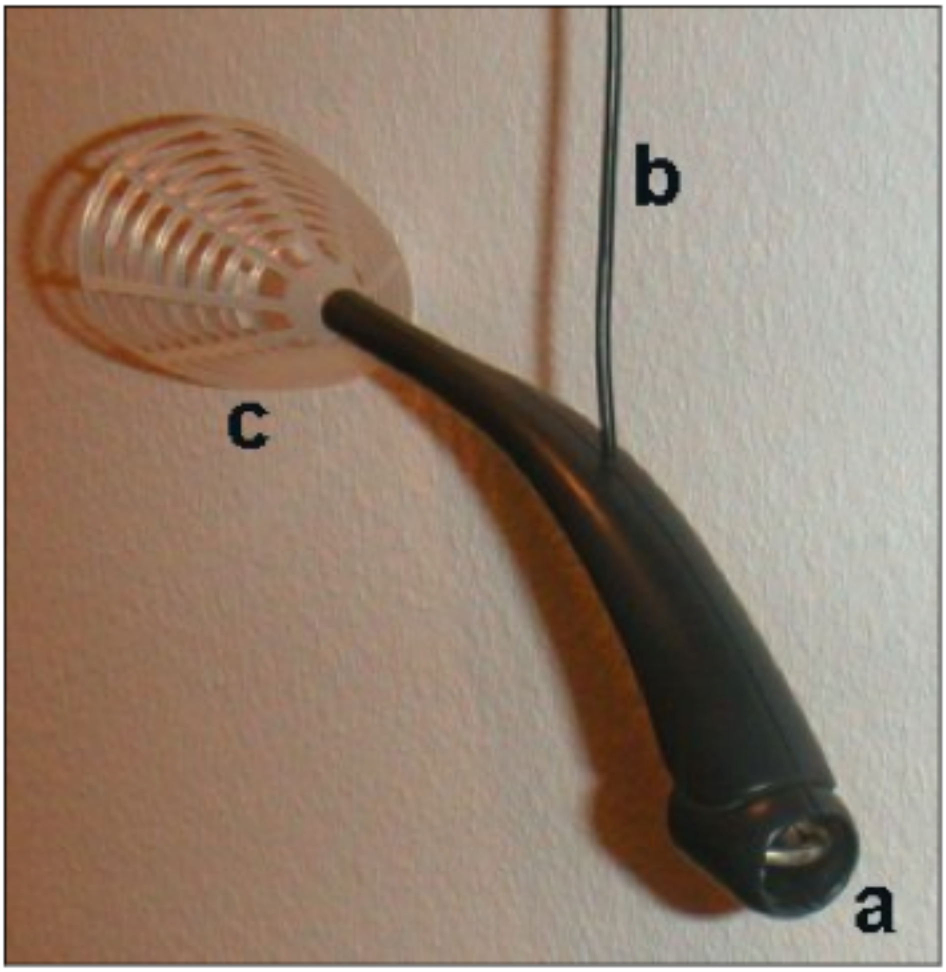

Figure C33: Anemometer. a = anterior opening in which is housed a propeller, whose speed of rotation depends on the wind. b = wire for attaching the device to the harness and containing the wires used to receive the signal. c = tailplane to provide directional stability of the instrument.

The GPS (Global Positioning System) is a small, sophisticated electronic device that uses a radio connection with permanent satellites to fix its exact position on earth. For the recreational pilot, GPS can be useful to know his speed over the ground and more accurately estimate the wind at altitude. Currently GPS is essential for competition because GPS flight path, registered in the memory of the device, is used by the organizers validate the flight path of each competitor. See figure C32.

Certification and General Recommendations

The load on the components of a glider is mainly due to tension (pulling force). See figure C34. Indeed, since only fully flexible elements (fabric, lines) are used in paraglider construction, torsional, flexural or compressive forces play little importance for a glider. **Question 062.**

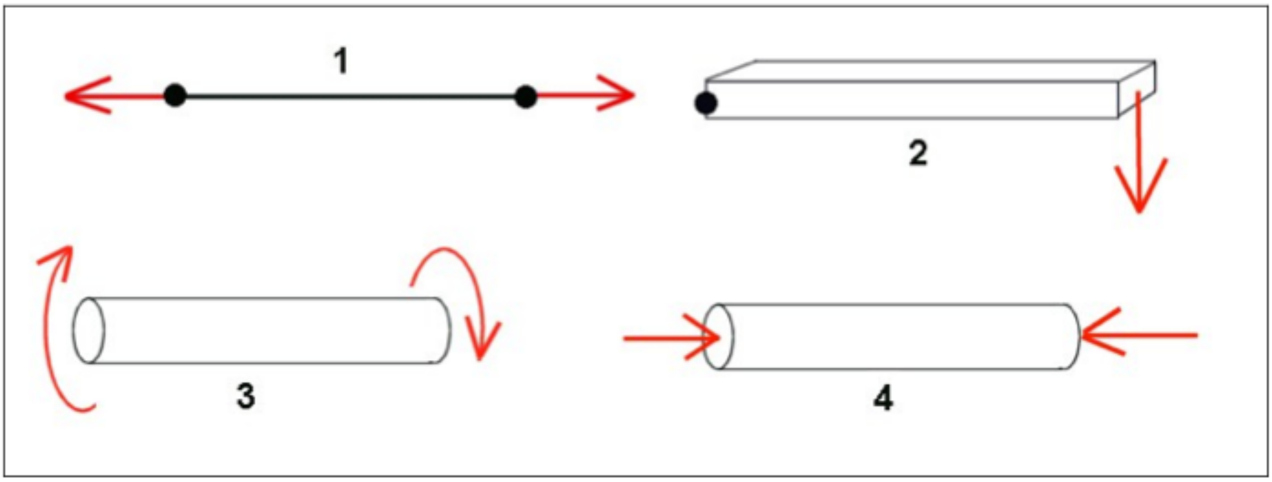

Figure C34: Classification of forces acting on a material:
1 = tension, 2 = flexion, 3 = torsion, 4 = compression.

If a material of a glider has been subjected to a load beyond its maximum tensile tolerance, we can expect that this material is no longer in its original state with respect to its dimensions and tensile strength. **Question 061**. The frequent practice of extreme flight maneuvers (acrobatics), causing heavy and sudden loads, may cause the extension of various structural parts and thus cause a change the flght characteristics of a paraglider. **Question 066.**

If, after many flights (e.g. 200), wrinkles in the wing appear (e.g. increased separation of lines between groups B and C), then the glider should be inspected by a qualified person (manufacturer, approved repairer). On no account should you try to adjust ithe length of the different groups of lines yourself. **Question 059.** On landing, just after putting the feet on the ground, we should ensure that the veil falls to the side or rear. If the wing falls suddenly forward against the ground, the air in the cells cannot escape quickly, and can damage the cells. The effect is sudden pressure in the wing, which can damage the cell walls. **Question 060.**

The size of wing suitable for a pilot is chosen by calculating the proposed wing loading, from knowing the take-off weight and the surface area of the wing. See Part One, aerodynamics. Classically the wing loading should be between 2.5 and 4kg/m^2, these values represent the lower and upper limits. Any intermediate value, e.g. 3 - 3.5kg/m^2 are considered normal. **Questions 094 and 097**. However, with the wings today, many experienced pilots recommend choosing higher wing loads ranging from about 3.5 to 4.2kg/m^2. Only the pilot of a paraglider is responsible for the condition of his wing. He decides how often the particular glider should be checked and repaired by the manufacturer or another competent person. **Question 135.**

In a car boot, paragliding equipment may come into contact with many harmful liquids such as gasoline, antifreeze and cleaning products. Distilled water is the least dangerous fluid among the products mentioned in **question 115**. We already talked about the harmful influence of solar radiation (especially ultraviolet) on paragliding fabrics (wings and rescue parachutes mainly). **Question 116.** X-rays and gamma rays are also very dangerous but do not normally occur in significant amounts in nature.

Currently there are two registrations in force: (1) AFNOR/CEN, certification French/European and (2) the DHV German certification. The SHV/FSVL theory exam refers to the AFNOR approval. Without going into details of an unfortunate competition, controversy or dispute between these 2 types of registration or taking sides, it is clear that at present (2002-2005) and in reality, the DHV is more widespread. The DHV classifies the wings as 1, 2 or 3 with intermediate ratings of 1-2 and 2-3. This provides 5 classes in total. A DHV 1 classification corresponds to the easier and safer wings and a DHV 3 wing is the most difficult, potentially dangerous and difficult to pilot especially when they operate beyond the flight range. AFNOR/CEN has only 3 grades: standard, performance and competition. The standard class corresponds to the easiest wings, while competition class are the most challenging wings to fly. It is important for everyone to choose a wing suited to his level and his piloting style. Note that the DHV 1-2 wings are currently the most sold and that their performance is more than respectable (maximum glide ratio of more than 8 while the highest performance wings hardly exceed 9).

To answer questions from the theory exam, the AFNOR/CEN certification is considered: This is an optional verification of the airworthiness of each paraglider sold in Switzerland, according to European standards. **Question 127**. It is therefore not mandatory, but a strongly recommended practice. However, during the official practical exams of SHV/FSVL, it is mandatory to fly with a wing approved under the rules of OAFC. **Question 131.** Very few pilots currently fly using wings not approved. The SHV/FSVL recognizes a paraglider approved by either CEN or DHV. **Question 128.** The CEN certification includes a battery of different tests. In summary, there is a static load test to 8G, various flight maneuvers and sudden opening under load (shock test at 600daN = 600kg). Despite some differences in methods and limits, the DHV certification tests are roughly similar to AFNOR. **Question 129**. The approval is a statement about the strength of the structure and flying characteristics of a glider in new condition. **Question 132.** Non-certified paragliders may therefore have strong differences in their strength and flight behavior compared to certification gliders. **Question 133.** A certified glider registered can be identified by an approval label (a fabric plaque) affixed to a site on the wing (usually the front side of a cell wall) and which indicates, among other things, the serial number and approval class. Do not confuse this sticker with the manufacturer's mandatory labeling. See Part Three, legislation. **Question 130**. An updated list of registered paragliders (AFNOR/CEN and DHV) and recognized by the FSVL is available at the secretariat SHV/FSVL and also on the website of the SHV/FSVL. **Question 134.**

Answers & commentary for SHV/FSVL theory exam for paragliders
Part 4: Equipment.

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Jean Oberson, March 2005 & Andy Piers, April 2010