LEPARAGLIDING 3.10 NOTES ABOUT SKIN TENSION AND 3D-SHAPING

1. Intro

Almost three years after the first idea, LEparagliding finally incorporates a 3D-shaping module (section 29). This method does not necessarily provide spectacular results, but it does provide the designer for a greater control over the shape of the nose area. 3D-shaping is closely related to skin tension. For this reason, a few months ago we developed an improved skin tension method (section 31).

If skin tension is a method of adapting the panels to their curved shape in space, adding fabric in a transverse direction, the 3D method adds fabric in the longitudinal direction (direction of the chord). The combination of the two things, is what provides the “3D” effect.

The ultimate goal is that the shapes and tensions in the fabric, provide maximum rigidity and stability.

2. General ideas about 3D-shaping

Remember and read theoretical information here:
- http://www.laboratoridenvol.com/info/shaping-3d/shaping-3d.en.html
- http://www.laboratoridenvol.com/info/shaping-3d/shaping-3d-programming.en.html

3. The skin tension

The concept of "skin tension" is the most important to understand what the surface of the panels is. When section 29 is activated, the program draws an informative plan in the box (1,8) with the representation of the intermediate profiles (black color) between two real profiles, and the ovalized profile defined by the skin tension (cyan color). It is recommended to test with different skin tension values, and see the results on the plan (1,8):

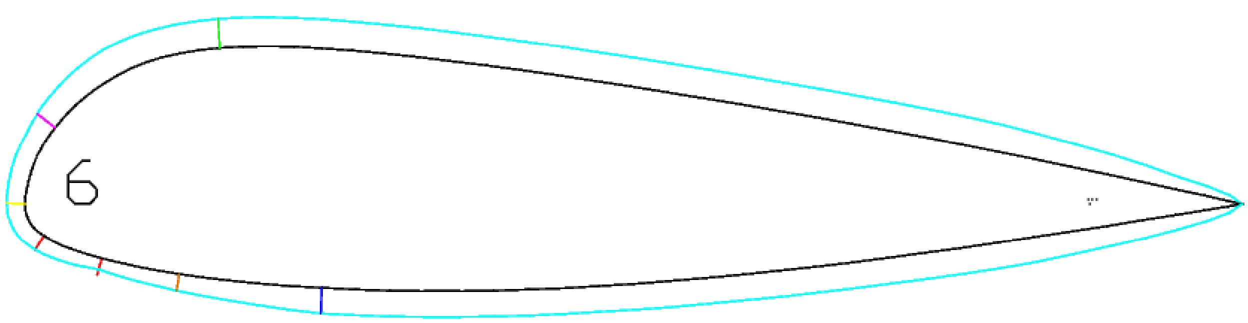

Figure 1. Intermediate and ovalized profiles.

Additionally the following points are displayed:

j1 point extrados where the 3D calculation starts (green)

j2 first cut point (magenta)

j3 second cut point (yellow)

j4 and j5 winds (red)

j6 dot cut intrados (orange)

j7 end point of the 3D calculation on the intrados (blue)

These points are crucial, and the designer must define them carefully according to their profile and write in an orderly manner in section 29, as explained below.

4. Using 3D-shapping in LEparagliding

The 3D-Shaping model proposed by the Laboratori, consists in making one or two transverse cuts in the upper surface, near the leading edge, and another optional cut on the bottom surface. We will call this model as "type 1". The edges of the transverse cuts will be modified from the straight line into an arc of a circle. In this way, we can "add fabric" lengthwise and we can control the ovalization and the tension in this direction. Ovalization in transverse direction is achieved via the module of skin tension (SECTIONS 5 or 31). In summary, we can control the amount of tissue and tension in transverse and longitudinal direction near the nose, where the curvatures are greatest.

To set the parameters of the 3D-shaping in the model "type 1" is necessary to study the profile in detail, viewing and counting the individual points that form it, thinking Laboratori style! :-) You need to view your profile in CAD (or in the .txt file), identify and count points. Remember that the points in a profile is counted starting in the trailing edge (point 1), continuing by the upper surface, nose, vents, lower surface, and ending again in the trailing edge. Exactly as described previously. We could define another model "type 2" where the position of the cut points are defined in % of the length of the panel, but in this model 1, is considered to specify exactly the points considered.

For each cut, it is necessary to define a "zone of influence". In the zones of influence is measured the length of a section of the profile and is compared with the corresponding length in the ovalized profile. This question is fundamental to understand the 3D-shaping type 1 (see figure 2).

In each zone 1,2,3,4,5,6 the program computes the length ot the arch of airfoil (d1) and the arch of the ovalized airfoil (d2). The differences of longitude (d2-d1) are calculated automatically in each zone, and then applied consistently to each cut with a value (f) obtained using the values (d2-d1) of the adjacent zones. Is provided a setting parameter around d'1.0, which serves the designer to regulate the depth of the 3D-shaping in each cut, in relation to the automatic calculation. Thus, using the coefficient of 1.0, the depth of 3D is according to the theory exposed. Using a coefficient of 0.0 does not apply the 3D effect, and using values higher or lower than 1.0 increases or decreases the effect. The control of the depth of 3D-shaping is continuous and individual for each cut. A more detailed description, and the formulas used in the calculation are described in this technical note about 3D-shaping. For each rib, a full report of the values d1, d2, d2-d1, computed in each zone, and the final values f applied in each cut are printed in tabular form in new section 9 of the file lep-out.txt. An auxiliar section 10 in lep-out.txt computes the quotients between the lengths of the corresponding panels and the profile part. Also, for verification purposes, a new section 11 is written to the lep-out.txt file with the counting of the points of each profile, to verify that they are all the same for all profiles, and that they are compatible with the defined cuts. It is necessary to view the figure below:

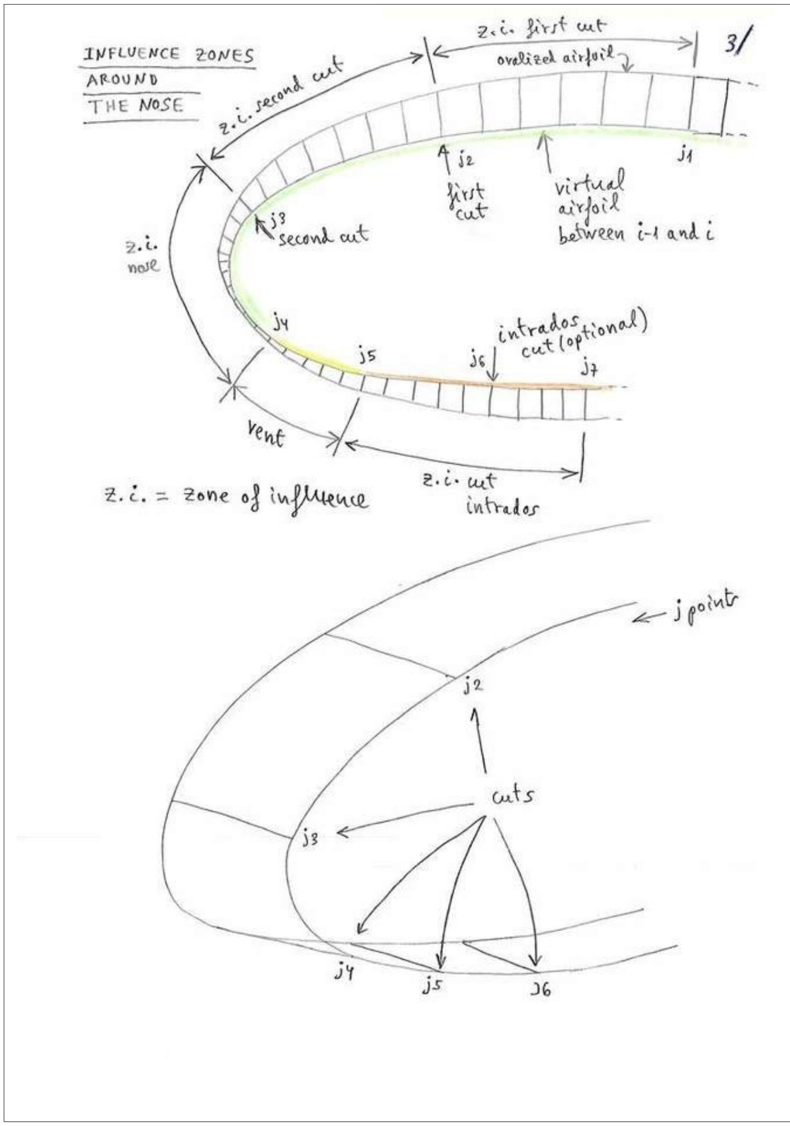

Figure 2. Cuts and zones of influence. J1,j2,j3,j4,j5,j6,j7 indicate numeric values of the selected points in the profile, starting to count from the trailing edge. J4 and j5 are the vent points.

For notation purposes, we will call the different parts in which we divide the profile as:
zone 1 (between j1 and j2), extrados part 1
zone 2 (between j2 and j3), extrados part 2
zone 3 (between j3 and j4), extrados part 3 or nose
zone 4 (between j4 and j5), or vents
zone 5 (between j5 and j6), intrados part 1
zone 6 (between j6 and j7), intrados part 2

It should be noted, that the parameters applied in this section, will be usually "invariant values" applied to the majority of the designs. We just have to think about all this, a single time for each type of profile. And the Laboratory will provide soon the recommended values in next designs. Of course, finding the good parameters is a real art. The program LEparagliding now provides the tools to make numerical and graphical experiments (lep-out.txt section 9, and leparagliding.dxf in box (1,8)).

5. Explanation of the parameters in SECTION 29

Line 1: *integer*

if integer = 0 then no not use 3D-shaping, and finish writing the section.

if integer = 1 then use 3D-shaping, and continue writing:

Line 2: *integer*

integer = type of 3D-shaping theory used, now we use only model "type 1" using transverse cuts, set parameter to 1.

Line 3: *character integer*

character = groups

integer1 = number of groups used

Line 4: *character integer1 integer2 integer3*

character = group

integer1 = number of the group

integer2 = initial rib in group

integer3 = final rib in group

Line 5: *character integer1 integer2*

character = upper , word meaning upper surface (extrados)

integer1 = number of cuts in upper surface (possible values 1 or 2).

integer2 = subtype of cuts, set to 1, only value accepted

Line 6: *integer1 integer2 real*

integer1 = initial point in the first zone of influence (j1)

integer2 = point where the first cut is set (j2)

real = "depth" of 3D-shaping in the cut, possible values 0.0, 0.1,....,1.0,1.2,... (multiplier coefficient arount 1.0)

Line 7: *integer1 integer2 real (only if we use two extrados cuts)*

integer1 = initial point in the second zone of influence (j2)

integer2 = point where the second cut is set (j3)

real = "depth" of 3D-shaping in the cut, possible values 0.0, 0.1,....,1.0,1.2,... (multiplier coefficient arount 1.0)

Line 8: *character integer1 integer2*

character = lower , word meaning lower surface (intrados)

integer1 = number of cuts in lower surface (possible values 0 or 1).

integer2 = subtype of cuts, set to 1, only value accepted

If the number of cuts in intrados is 0, stop writing, else

Line 9: *integer1 integer2 real (only if we use two extrados cuts)*
integer1 = point where the intrados cut is set (j6)
integer2 = final point in the intrados zone of influence (j7)
real = "depth" of 3D-shaping in the cut, possible values 0.0, 0.1,....,1.0,1.2,... (multiplier coefficient arount 1.0)

(...Repeat lines 5,6,7,8,9 for next groups...)

Line 10: *character*
character = `"* print parameters:"` (comment line, it is mandatory to write something)

Line 11: *character integer1 integer2 integer3 integer4*
character = Inter3D, word to indicate representation of the intermediate airfoils in 3D lep-3d.dxf
integer1 = 0 indicates do not draw, and 1 draw
integer2 = index of first airfoil to draw
integer3 = index of last airfoil to draw
integer4 = 0 it indicates to draw with symmetry, 1 only one side

Line 12: *character integer1 integer2 integer3 integer4*
character = Ovali3D, word to indicate representation of the intermediate ovalized airfoils in 3D lep-3d.dxf
integer1 = 0 indicates do not draw, and 1 draw
integer2 = index of first airfoil to draw
integer3 = index of last airfoil to draw
integer4 = 0 it indicates to draw with symmetry, 1 only one side

Line 13: *character integer1 integer2 integer3 integer4*
character = tesse3D, word to indicate representation of panel tessellation in 3D lep-3d.dxf
integer1 = 0 indicates do not draw, and 1 draw
integer2 = index of first panel to draw
integer3 = index of last panel to draw
integer4 = 0 it indicates to draw with symmetry, 1 only one side

Line 14: *character integer1 integer2 integer3 integer4*
character = exteDXF, word to indicate representation of panels tessellation in 3D in a new external DXF file (possible use in CFD analysis)
integer1 = 0 indicates do not draw, and 1 draw
integer2 = index of first panel to draw

integer3 = index of last panel to draw
integer4 = 0 it indicates to draw with symmetry, 1 only one side

Line 15: *character integer1 integer2 integer3 integer4*
character = exteSTL, word to indicate representation of panels tessellation in 3D in a new external STL file (used with programs of 3D modelling as OpenSCAD gold FreeCAD)
integer1 = 0 indicates do not draw, and 1 draw
integer2 = index of first panel to draw
integer3 = index of last panel to draw
integer4 = 0 it indicates to draw with symmetry, 1 only one side

Lines 12, 13, 14, 15 are mandatory to write, but the actions are not yet functional. We are working on the programming. These parameters will generate independent dxf files with the ovalized surfaces, and even a .stl model to view with FreeCAD or OpenSCAD, or even analyze with CFD programs.

All this may seem complicated, but it is much easier to understand section structure watching a few examples.

6. Some examples

Consider a paraglider using 14 ribs per side. Rib 1 is the closest to the center. Consider a gnuA Laboratori profile with the following number of points (header section of gnua.txt):
111 = total number of points
66 = extrados points
9 = vent points
38 = intrados points

Example 1: Do not use 3D-shaping. Set one line with "0" parameter. It is the simplest solution to avoid the "complicated" 3D-shaping module! :)

```
*******************************************************
*       29. 3D SHAPING
*******************************************************
0
```

Example 2: Active 3D-shaping module but without any cut. The utility of defining this, is that the representation of plan 1-8 is activated automatically, with the drawing of the intermediate and ovalized airfoils in 2D. You can also activate the 3D representations in 3D, changing the settings "0" to "1" in the "Print parameters" subsection. In general, preferable to use example 1, that use the example 0 (the two are invariant sections).

```
************************************************************
*       29. 3D SHAPING
*******************************************************
```

```
1
1
groups  1
group   1    1    1
upper   0    1
lower   0    1
* Print parameters
Inter3D 0    1    1    0
Ovali3D 0    1    1    0
tesse3D 0    1    1    0
exteDXF 0    1    1    0
exteSTL 0    1    1    0
```

Example 3. Easy case, only one group and one cut in extrados.

First group from rib 1 to 14 using one cut type 1 in upper surface and zero cuts in lower surface.

Zone of influence of first cut started in point 30 and cut located in point 40, depth of the effect 1.0.

Zero cuts in lower surface, type 1.

Prints 3D intermediate (Inter3D) and ovalized (Ovali3D) airfoils at the left of ribs 1 to 14

```
*******************************************************
*       29. 3D SHAPING
*******************************************************
1
1
groups   1
group    1    1   14
upper    1    1
1       30   40   1.0
lower    0    1
* Print parameters
Inter3D 1    1    14    0
Ovali3D 1    1    14    0
tesse3D 0    1    1     0
exteDXF 0    1    1     0
exteSTL 0    1    1     0
```

Example 4: Usual case, two cuts extrados and zero cut intrados.

One group from rib 1 to 14 using two cuts in upper surface and zero in lower surface.

Zone of influence of first cut started in point 25 and cut located in point 33, depth of the effect 0.95

Zone of influence of the second cut in point 33 and cut located in point 44, depth of the effect 0.80

Lower surface with 0 cuts type 1.

```
******************************************************
*       29. 3D SHAPING
*******************************************************
1
1
groups   2
```

```
group    1    1   10
upper    2    1
1       25   33   0.95
2       33   44   0.80
lower    0    1
* Print parameters
Inter3D 1    1    14    0
Ovali3D 1    1    14    0
tesse3D 0    1    1     0
exteDXF 0    1    1     0
exteSTL 0    1    1     0
```

Example 5: General case, using two groups. Two cuts extrados and one cut intrados.

First group from rib 1 to 10 using two cuts in upper surface and one in lower surface.
Zone of influence of first cut started in point 25 and cut located in point 33, depth of the effect 1.0.
Zone of influence of the second cut in point 33 and cut located in point 44, depth of the effect 1.0.
Cut in lower surface in point 79 and zone of influence up to point 84, depth of effect 1.0.

Second group from rib 11 to 14 using two cuts in upper surface and one in lower surface.
Zone of influence of first cut started in point 35 and cut located in point 33, depth of the effect 1.0.
Zone of influence of the second cut in point 33 and cut located in point 44, depth of the effect 1.0.
Cut in lower surface in point 79 and zone of influence up to point 83, depth of effect 1.0.

```
*******************************************************
*       29. 3D SHAPING
*******************************************************
1
1
groups   2
group    1    1   10
upper    2    1
1       25   33   1.0
2       33   44   1.0
lower    1    1
1       79   84   1.0
group    2   11   14
upper    2    1
1       25   33   1.0
2       33   44   1.0
lower    1    1
1       79   83   1.0
* Print parameters
Inter3D 1    1    14    0
Ovali3D 1    1    14    0
tesse3D 0    1    1     0
exteDXF 0    1    1     0
exteSTL 0    1    1     0
```

As some have suggested, the 3D module can also be used as a simple alternative to separate colored panels in the nose area, or panels with more durable fabric. Remember that the 3D effect is adjustable in depth, and you can even use the amplification parameter 0.0 so that the cut between the parts of the panels is completely straight line. The subroutines developed in this section will be adapted to complete the separation in parts of colors.

7. How decide the perfect parameters for each airfoil and wing

A - Use recommended values set by Laboratori d'envol as default in examples (with LE airfoils). I have not yet decided what the best values are. It is necessary to perform some graphical and numerical experiments, observing the result in the box (1,8). The results of all lengths calculated according to the theoretical foundations are shown in section 9 of the lep-out.txt file. This can be useful. I will soon apply the values to the gnuA, BHL4 and BHL5 paragliders.

B - "Hack" or reverse engineering 3D cuts locations in some real paragliders. Analyze photos, or measure on available wings. Reverse engineering is fun, is necessary, and it is no different from studying.

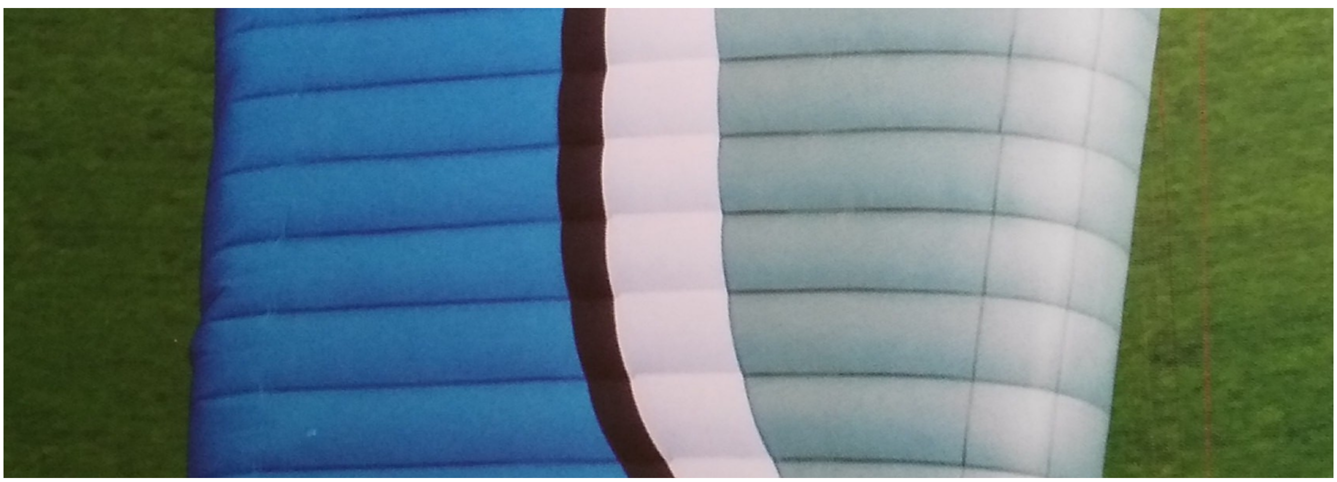

Figure 3. Look at that beautiful wing. It appears to have the cuts located at the 5.5% and 13.5% of the chord measured from the leading edge. You can analyze other wings.

C - Analize 3D representations of the surface (DXF and STL, soon)

D - Do some protos of cells (construct one or two single prototype cells), try to inflate and look closely the results in surfaces.

E - Build entire paraglider or parachute, and fly!

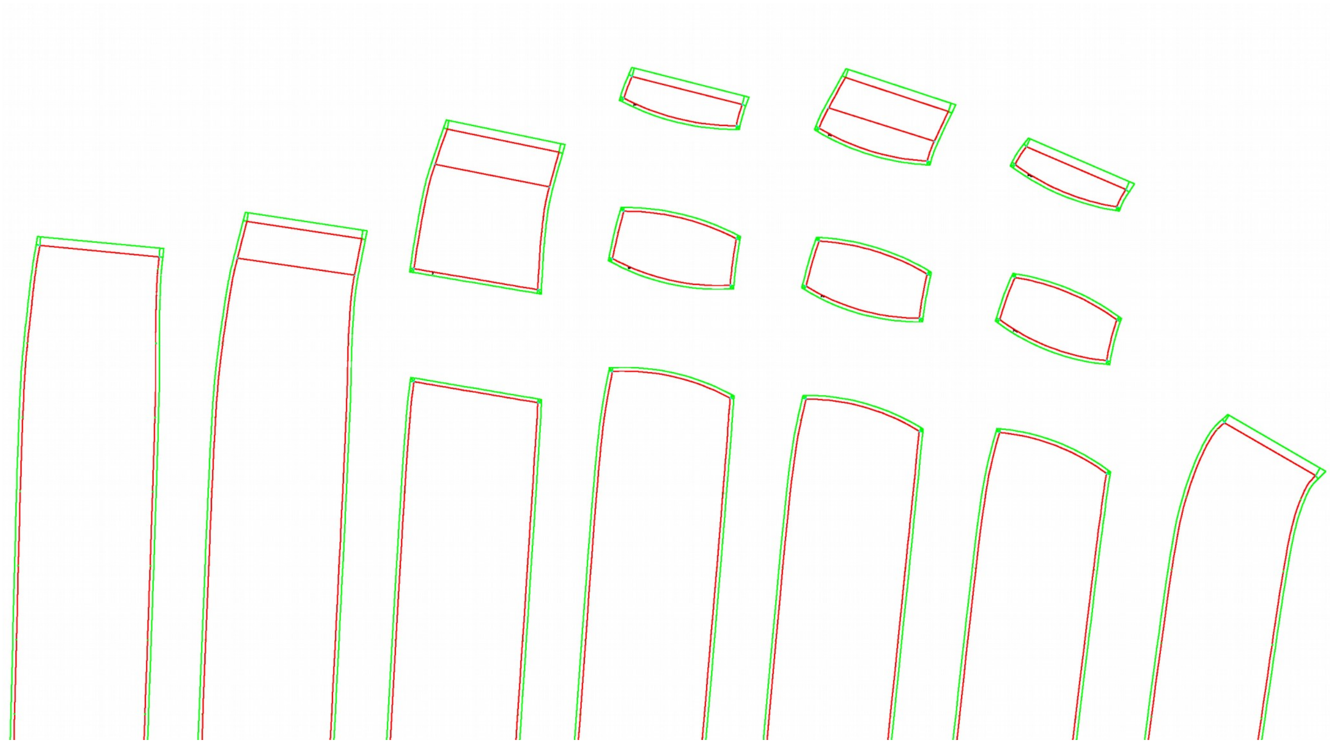

Figure 4. View of some options provided using the 3D-shaping. Individual 3D-shaping control for each panel, setting the necessary number of groups. Make one or two cuts. Optional control of the depth of the curve of the cut, which is calculated automatically according to the theory. Add or not, the panels of the vents, for cells closed or partially closed. And each part is numbered in "roman" style.

8. Notes about the "roman numbers"

The division of the panels into several parts requires the numbering of each of them. The Laboratory uses numbering with "roman" numerals which is very practical (table of the roman numbers show in box (4,7). The numbers, formed by a series of dots are marked on the sewing band. The new printing subroutine allows the user precise control over the position and size of the roman numerals.
This is possible by changing some parameters in section 20. Marks types. If we look at the line that starts with "type8".

```
type8       1  0.2   4.0     2  0.2  4.0
```

After the word "type8" there are 6 numbers in a row.
- *First number*: 1 integer, still not used
- *Second number*: 0.2 real, spanning from 0.0 to 1.0 means the position of the roman number (0.0 totally to the left and 1.0 totally to the right, normal values 0.2 or 0.5
- *Third number*: 4.0 real, means the vertical offset in mm with respect to the baseline. May be positive or negative number.
- *Fourth number*: 2, integer still not used

- *Fifth number*: 0.2, real not used
- *Sixth number*: 4.0, real means the offset in mm between dots of the roman numeral (global size of the roman numerals).

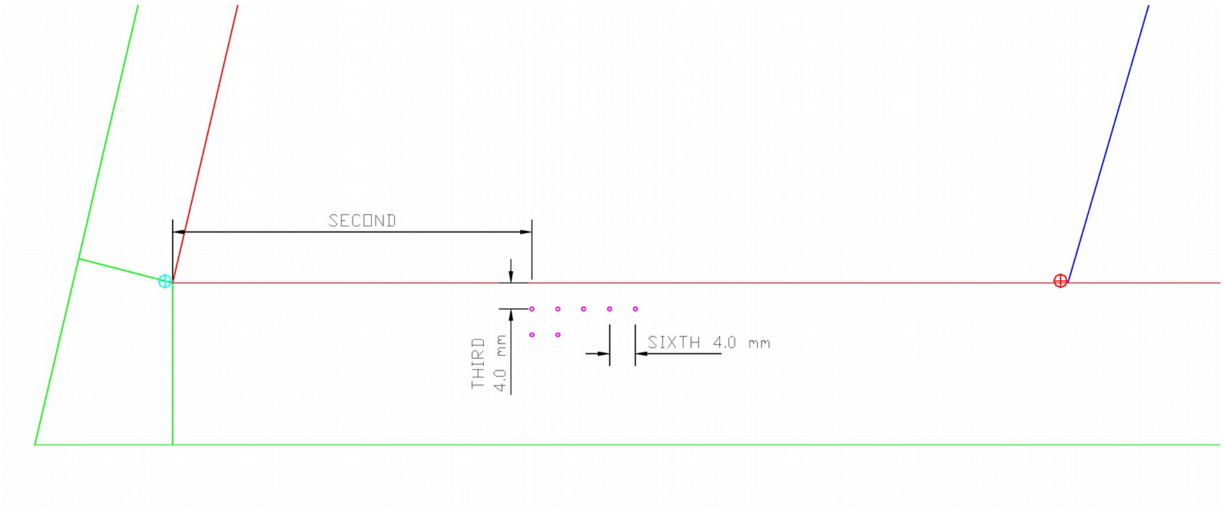

Figure 4. Position and size of roman numerals controlled by "type8" mark.

On panels with curved edges, the numbers are automatically aligned with the curvature. This "type8" mark is experimental, and very useful! For now, only affects the numbering of the panels using section 29. The numbering of the other pieces (V-ribs, diagonals, profiles, continues as before). Thinking about how to add control different from automatic when numbering these pieces.

9. Some known "bugs"

Yes, Leparagliding has some bugs! But fortunately none of them are critical! :-)
A - The intrados mark of the "A" attachment in the panel it is not correctly positioned when the anchor is in the vent zone (unusual), but we will soon correct this error.
B - Some corners of the panels may present some strange shapes, when the corner angle is very different from 90 degrees, or when using very narrow seam edges. This is controlled and we know how to fix it, soon. If a drawing has this problem (it does not always happen) it can be easily corrected in CAD.
C - Erratic polyline representation at mm or fractions of mm in some internal curves of the panels. This is a puzzling problem, which I have verified many times. It only happens at the concave edges of some of the smaller panels near the wing tip. The polylines may present a "chaotic shape" when observed with a microscope. There is no problem when printing, but some laser cutting machines can detect the error. We are talking about a geometry of the order of mm and only at a very specific edges. It has no practical effects except that it is recommended to detect (it is not easy to see) and correct with CAD. I am studying the reason for this problem and its solution.

There are others. Please communicate the observed. But don't confuse a "bug" with an incorrect parameter entry. As is well known, LEparagliding requires you to enter the parameters very strictly.

One of the most valuable rules in programming says: "prototype before polishing". And now with lep-3.10 we have a fully functional program, who allows for a very precise paraglider and parachute design!

10. Next

- Improve manual redaction, text and figures, because it is the only guide to understanding what parameters need to be written and how. Unify manual versions 2.6 / 3.10.

- New vents types (actually only vents types 1,0,-1,-2,-3 are allowed in section 26). I am thinking of a type of vent, type 4, and -4, which allow the vents to be closed and adjustable between 0 and 100% of the defined vent opening, to the right and left. This allows for generic polygonal vents along leading edge. Of course, it can be done now with CAD, but if it is automated easier.

- DXF and STL surfaces, representing a model of the skin tensioned and 3D-shaped surface. Probably will be used to CFD analysis.

- Automatically panel colors division.

- Integrate "3D" panel plans in boxes (-1,3),(0,3) and (-1,5) (0,5) to classical panel locations (1,3) (2,3) and (1,5),(2,5). Yes, the plans in rows -1 and 0 will be removed soon and brought back to their usual positions.

- Use standard .dat files for airfoils? This would be possible, and not very complicated, but the program would have to reformat and internally interpolate all profiles. The current system, forcing the designer to study the profile points and define the profile .txt header, allows for stronger control over the results. The maximum number of points allowed per profile is 500.

Pere Casellas
Teià-Barcelona, Catalonia.
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http://www.laboratoridenvol.com

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