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Purpose

Purpose: To investigate the impact of Rear Fairing on open type paraglider harness.
Modeller: 3D studio MAX
CFD done in Simscale
The harnesses that was modelled was types similar to;
- Kortel Karma 2 (airbag, big rear back pocket of standard type, no real fairing), not shown further on.
- Woody Valley Wani (airbag, small back pocket)
- Prototype, similar to an Airwave harness that was marketed many years ago. Rear fairing behind shoulders and head. Sky Country has a similar harness, too, see Illustration 11: Sky Country X-cool.

Modelled and written by Johan Eklund.

Set up

The dimensions is not exactly as on Karma 2 and Wani, but similar to those in shape and size. The pilot is using stir up in all simulations (pilot, airbag and front part of harnesses is the same in all simulations).

Meshing, modelling and environment

I am full aware that Cz usually is up, and Cx is forward speed. The thing is that 3D Studio Max and 'Simscales mesh generator' really don't like each other and therefore does not agree what is X, Y and Z directions. So Z direction is the airflow in these simulations. I have tried to fix this in simscale, re-orient and re-import the geometry from 3DS Max etc., without success.
Also, the harnesses does not get placed in the middle of the wind tunnel either. I thought it was wide enough but it turned out it is not. The misplacement is fully visible in the force measurements.
The prototype harness mesh with the rear fairing has a mesh that is a bit more dense than the Wani-style mesh. Simscale refused to calculate the proto-mesh when it was less dense for unknown reasons. Inflation layers are set to simscales default values.
The airspeed is 10m/s. The wind tunnel is 10 meters fore and aft of the pilot, 6 meters wide and 6 meters high. The air in the simulation is what Simscale has as default, with a small amount of turbulence in it (also Simscale default value).

Results

General

The first two runs was to see the difference between the Karma 2 and Wani, as I suspected there might be a significant difference in drag between those two. According to the simulation, the difference is quite small, about 4-5% differences in drag, making almost no difference at all for the system (glider, lines and pilot/harness), the Wani-style harness being the worst of the two.
The evaluation is made by studying the energy level (k) of the turbulence and the reaction-forces in the hook up point. The higher the energy in the turbulence, the more sink you will get, because the hight of the aircraft is the only energy source we have around and the energy in the turbulence must come from somewhere.
The simulation runs a 20 seconds analysis, and watching the forces graph, it seems to be enough for the system to stabilize and is sufficient for the (not so scientific) purpose here.

Wani-style

Lets take a look at the simulation of the Wani-style harness. The mesh is shown in Illustration 9: Force/momentum chart for Wani style

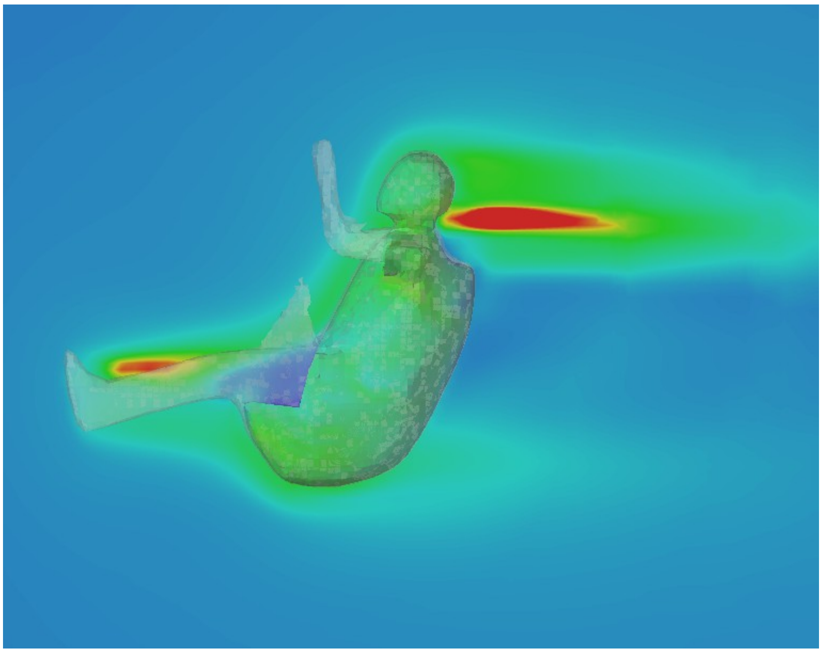

Illustration 1: k-values (0,1-1) for Wani-style harness

Above: Turbulence energy (k) for Wani-style harness. Blue is low amount of energy, red is a lot. Note the huge amount of energetic turbulence behind the head and shoulders.

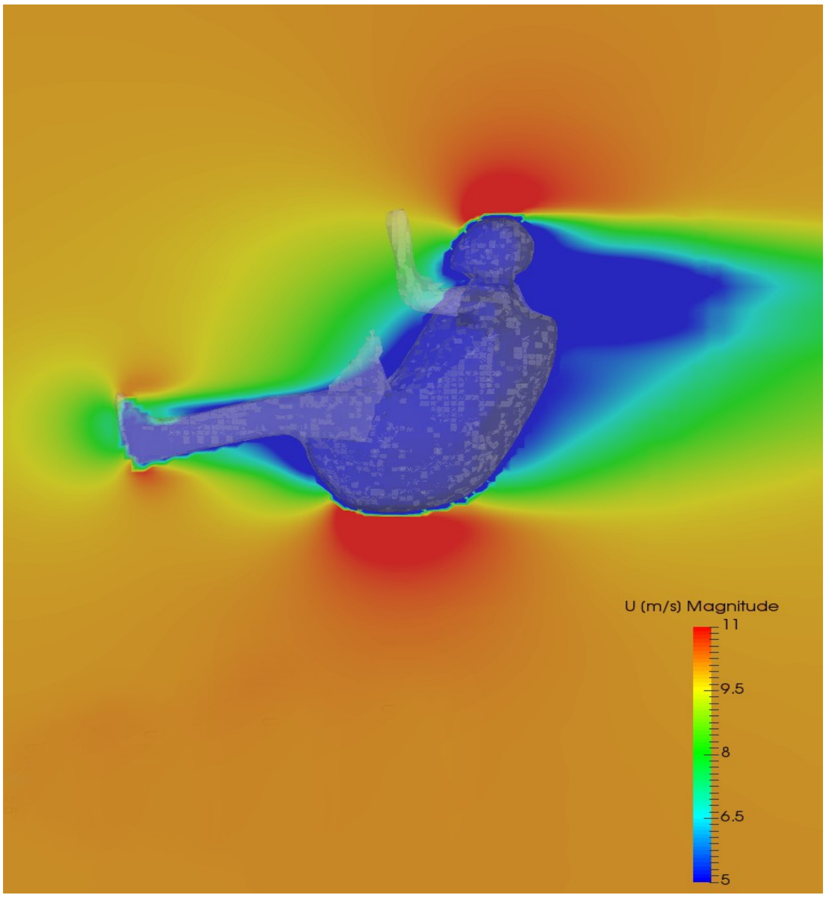

Illustration 2: Wani-Style Air Speed 5-11m/s

Above we can see the air speed around the pilot and harness. This is the magnitude of the air speed, so the speed is shown without regard of direction. Though the air speed is rather low behind the shoulders and head of the pilot, the energy of the turbulence in this area is obviously high.

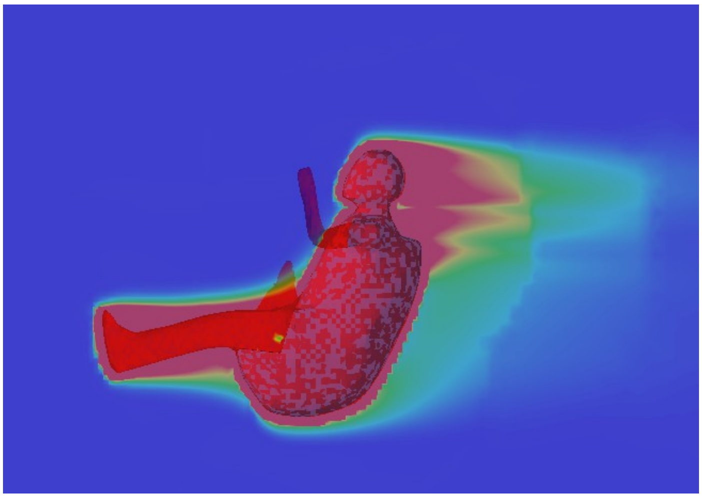
Illustration 3: Vorticity, wani style

Above, an illustration of vorticity. Blue is flow in a straight line, red is more vortices (the steam of air twists as we also can see on the trace line illustration later on...). Close to the surface of the harness and pilot, the airstream twists around a lot. This has an influences on the drag and can be reduced by having a smooth surface, though he vorticity will always be there. A harness made up of a lot of patches, with seams going traverse the airflow will not help... And again; we see clearly that the area behind the head and shoulders are areas of "major problems".

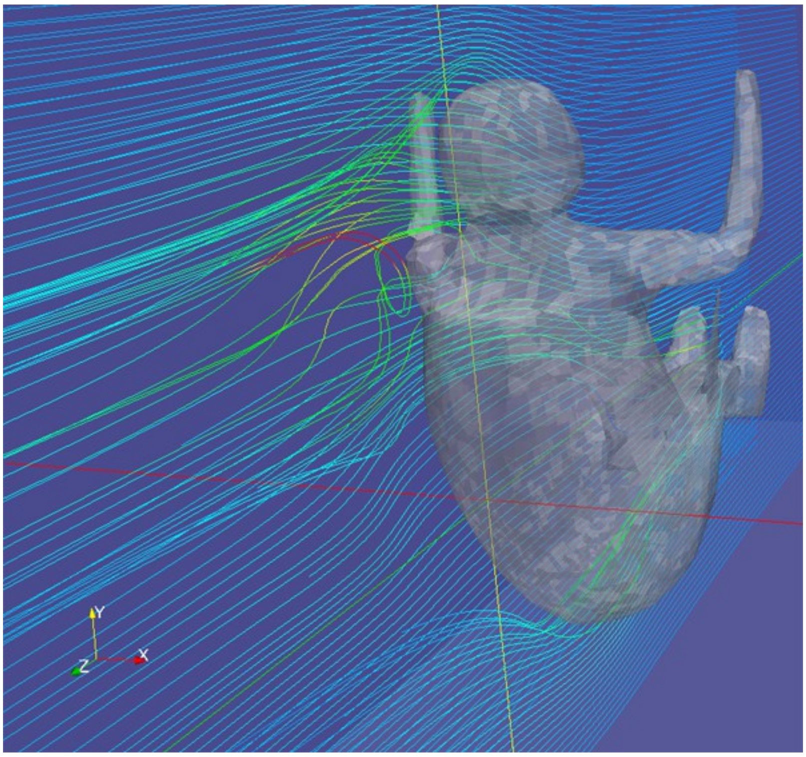

Illustration 4: Tracer of Wani-style harness

We take a look from behind (see Illustration 4: Tracer of Wani-style harness) to get a better view of what is happening. On the trace-view, it is clear that the air swirls around behind the shoulder and head. The upper chest is a relatively large flat area, and the shoulder make a sharp geometrical change (so the air changes direction). Also, by the way the pilots holds the brakes, air gets a bit "trapped" in front of the pilot as well, and slips over the shoulder. As the whole concept is to have an open harness, we can not do anything about the initiation of the problem(s). But we can do something about that happens next, behind the pilot. By filling up the space behind the shoulders and head with a fairing, it is simply no place for these kind of swirling to occur. Instead, the air is guided to follow a much more linear path with no or little swirls and the drag is reduced.

Extended rear faring

This section shows results from the simulation of a harness using a rear fairing (XT, as in eXTension).

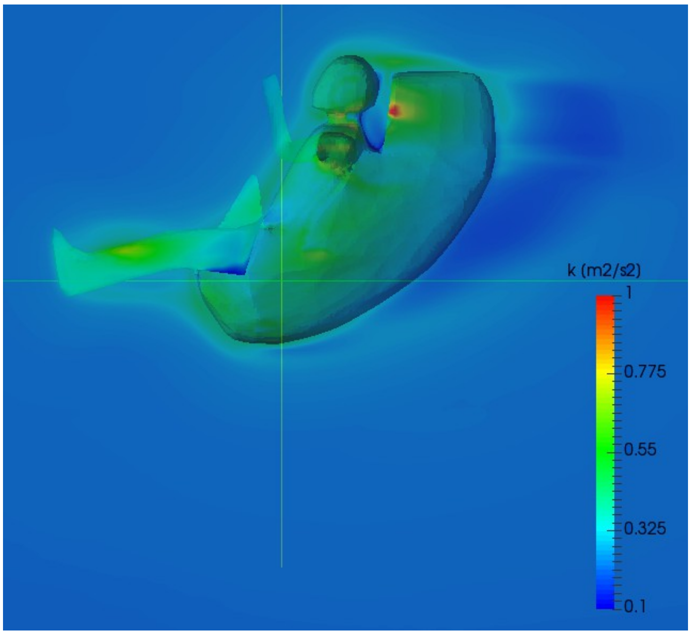

Illustration 5: XT style, k.value

Illustration showing k-value for turbulence. Same scale as for the Wani-style. As we can there is a big difference.

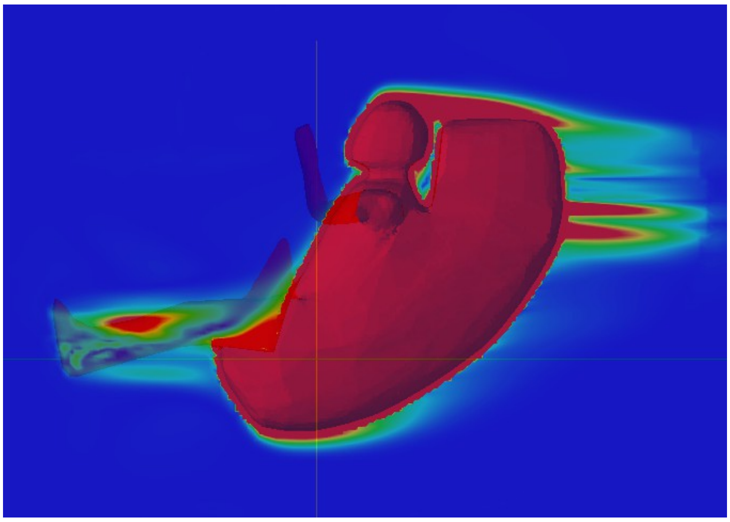

Illustration 6: XT, vorticity

The same apply to vorticity. We also see here that the rear fairing should have been made a little bit longer and higher. There are some vortex behind the harness, though with little energy. There is more energy in the turbulence behind the helmet.

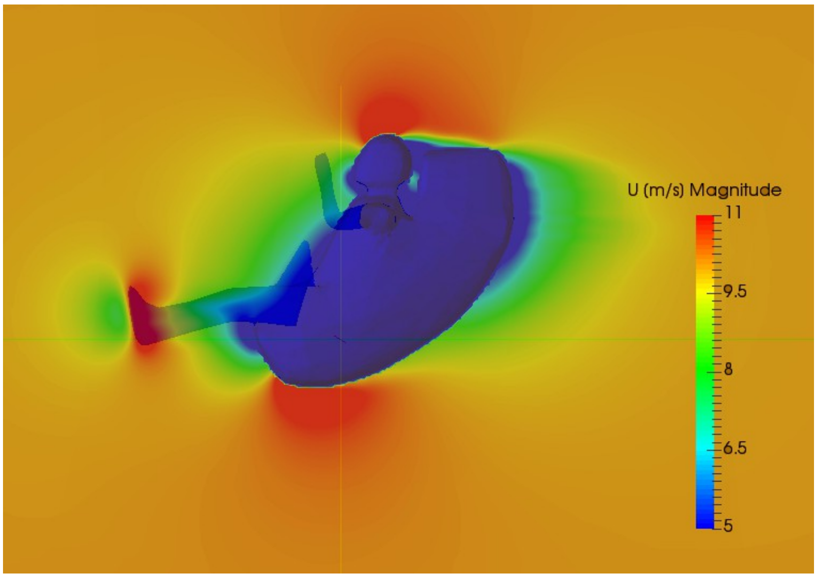

Illustration 7: XT, Air Speed

For good measures, I put in an air speed illustration as well. Again, we get the hint that the faring should have been made a little longer.

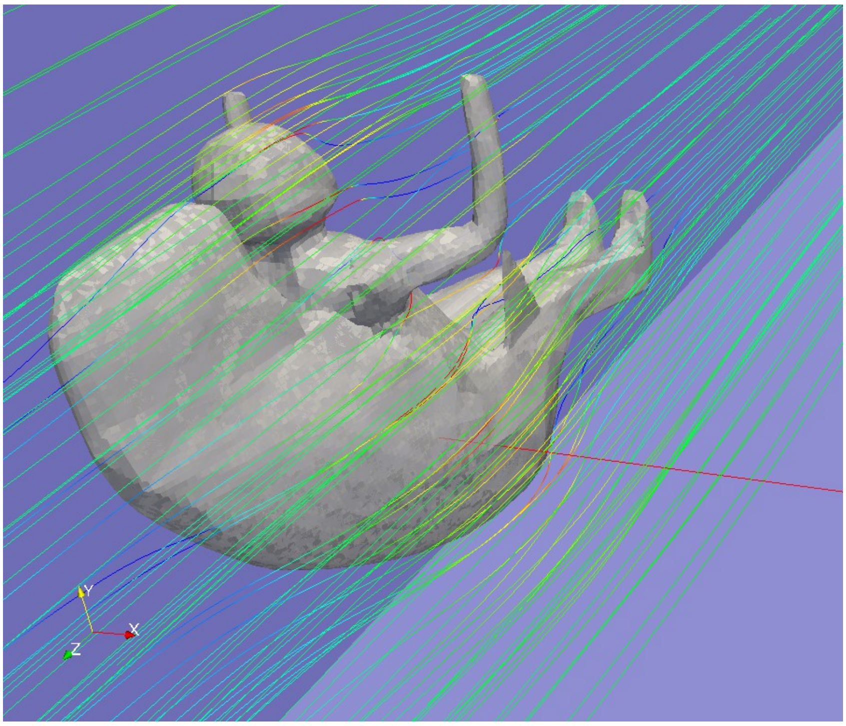

Illustration 8: XT, stream lines

Also, on this illustration, we see a part of the cause for the reduced turbulence; The twisting and swirling of the air stream has simply no space to take place! There is an object in the way, so the air is forces to different positions, and gets aligned around this object.

The numbers

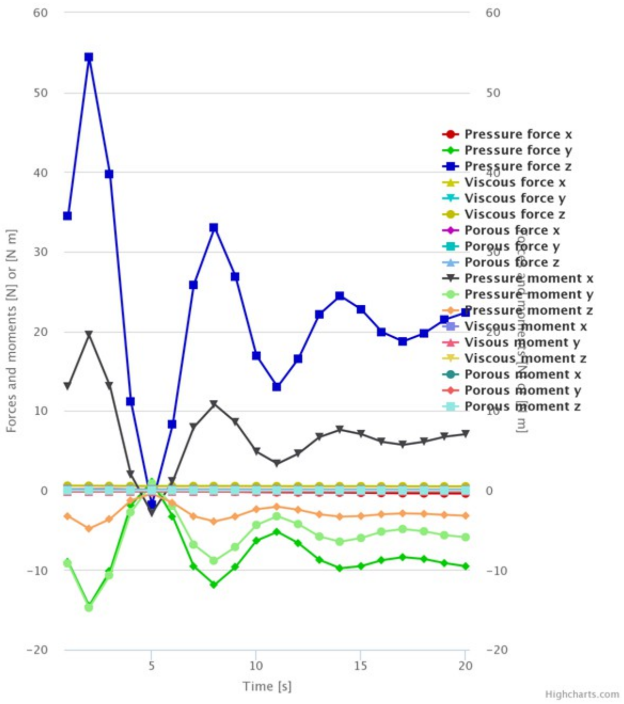

Illustration 9: Force/momentum chart for Wani style

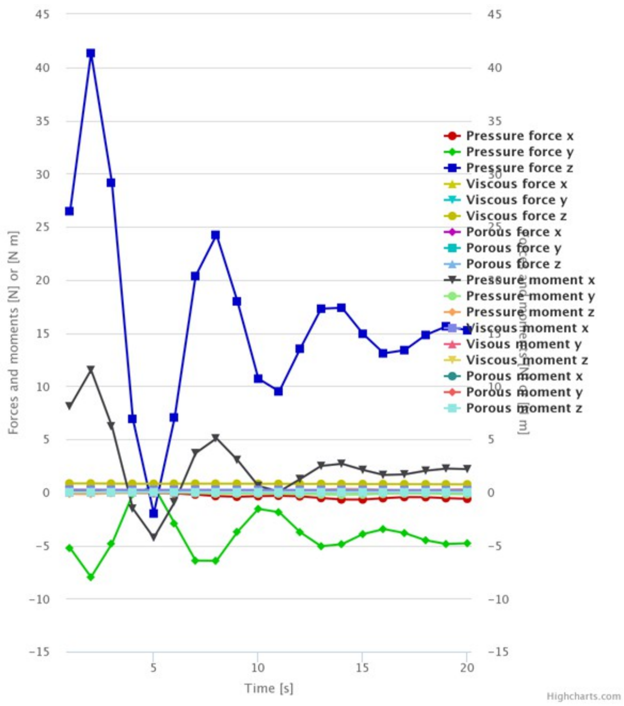

Illustration 10: Force/momentum chart for XT-style

The drag for the Wani-style harness seems to stabilize around some 21-22ish [N].
The XT harness around 14 N. So using the rear fairing, we get appr. 2/3 of the drag we have not using it.

Glide ratio improvement

Table showing glide improvement. Wing is supposed to have 50% of the total drag, lines 20% and harness/pilot 30%. This will of course differ depending on glider and harness used, but it is roughly like this. Lift is supposed to the the same (same wing, same angle of attack). So, about 10-12% improvement in glide ratio (L/D). That is about on pair with the results others (Airwave, Skywalk) have claimed for similar investigations (and marketing).

	Wing	Lines	Harness	Total Drag
Ref Harness (no fairing)	0,5	0,2	0,3	1
Harness with fairing	0,5	0,2	0,19	0,89

Additional illustrations

Illustration 11: Sky Country X-cool

Illustration 12: Airwave Ram-C

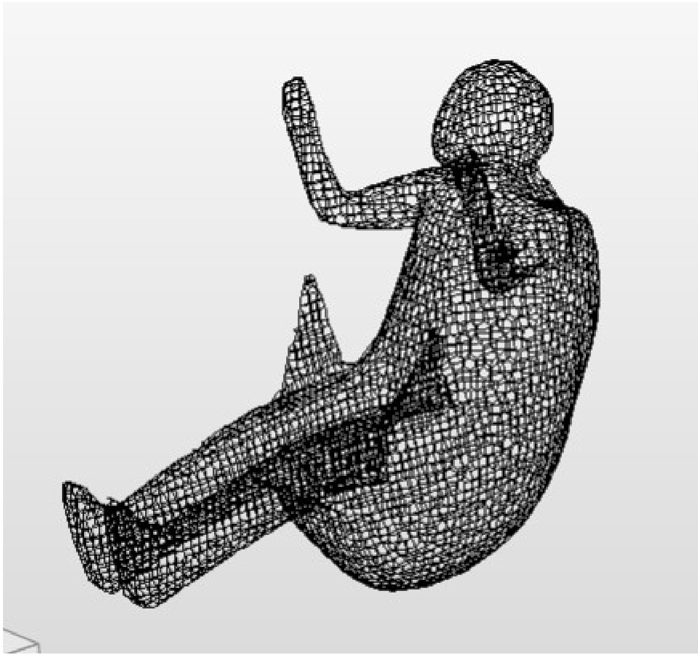

Illustration 13: Wani-style simscale mesh

Illustration 14: XT-style simscale mesh