701 Elevator Cable Mod

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(pictures on following page)

If you're an engineer, the CH 701 is one of the most beautiful planes ever conceived. It performs its primary task of landing and taking off from short (VERY short) strips, better than almost any other aircraft. The design is also a monument to the KISS principal (Keep It Simple, Stupid!).

Like any good STOL aircraft, the 701 is safely flyable even at very low speeds. Flying with the doors off at 60mph, 100 feet above the orange groves or mangroves of Florida is a thing everyone should experience at least once.

The main reason for the slow speed controllability is the design of the control surfaces. The stab and elevator, as most reading this will know, together form an inverted airfoil which enables "high-alpha" operations. I have installed vortex generators which help also. The rudder is all-flying and is effective right down to very low speeds.

Equally, the flaperons allow full roll control with only light inputs, even down to the stall (not that it's easy to make this aircraft stall – I'm not sure I have succeeded yet, despite numerous attempts). One of the reasons is that, unlike a typical aileron design, a significant proportion of the flaperon is situated in the prop wash. So, as long as you keep a bit of power on to ensure adequate airflow through the prop disk, you can maintain full control authority in all three axes even at speeds at which the ASI stops registering.

During the construction of N2701D (also known as "George"), I did notice one aspect of the control system that I felt could have been slightly better. Nonetheless, I flew the aircraft perfectly happily for about two years before doing anything about it.

Specifically, the elevator control was noticeably stiffer when full right flaperon was applied. This is due to an asymmetry in the design of the elevator control system. The elevator control horn is pivoted on the right side of the flaperon torque tube.

I found that this detracted somewhat from the experience of flying the aircraft, so I set about seeking a solution.

Let me use an analogy to illustrate: imagine a bicycle wheel with the axle held stationary in space. Now imagine a rope tied to the rim of the wheel. Hold the other end of the rope anywhere in space. Now, rotate the wheel. Does the rope get tighter or looser, or remain unchanged?

The answer is that it will always get tighter or looser, ***unless*** you hold the free end of the rope in a position on the axis of the wheel's axle. In this case, the rope does not get any tighter or looser as the wheel rotates; the rope actually describes the surface of a cone.

Now, let's apply this to the elevator control system in the 701. There are two cables running from the elevator control horn back to the elevator horns, to form a typical "closed-loop" cable control system. One cable, which connects from the bottom of the control horn to the top elevator horn, is not an issue – it is connected to the elevator horn so close to the axis of rotation of the flaperon torque tube that there is little change to the path length when left-right flaperon is applied.

However the cable that connects the top of the control horn to the bottom elevator horn ***is*** a problem; as left-right flaperon is applied, the path length of this cable changes dramatically, because the top of the elevator control horn is located about 12" off the axis of rotation of the flaperon torque tube (axis shown in red dotted line).

With the cable tension set to 20lbs at neutral stick, I was seeing tensions of 10-15lbs at full left stick (very slack) and more than 35lbs at full right stick. This was tight enough to cause the control horn to bend!

The solution is to route the cable in such a way that it does not go directly from the control horn to the elevator, but instead goes from the control horn to a pulley as close as possible to a point on the axis of rotation of the torque tube (i.e. holding the end of the rope on the axis of the wheel's axle).

In fact, because of the design of the 701 with the steeply rising tail-cone (which of course is necessary to enable those high alphas just

mentioned), it is not possible to situate the pulley exactly on the axis. However, by mounting it just behind the access hatch, the variation in path length for this cable decreases dramatically.

So, I have added a pulley here, pivoted so it can swing left and right, and about 3" right of center (because the horn is on the right of the torque tube). The pulley is anchored with a swiveling, castellated AN3 bolt to two pieces of 6061 angle, riveted back to back, and then riveted to the bottom of the fuselage just aft of the belly hatch. They pick up the bottom longerons left and right.

The tensioning bungee now attaches to the cable coming off the bottom of the control horn, and tensions this cable to the left (right looking aft). This serves to keep the turnbuckles separated for all possible control inputs.

This results in almost no change in cable tension with full right or full left flaperon. I have tension set at 20lbs with the stick neutral, and I am seeing less than +/- 3lbs through full left-right-up-down stick. The elevator now does not feel stiff with full right flaperon applied, as it used to.

I discussed my idea with the folks at Zenith, and they ran the calculations on the structural component of this design. I was initially going to use 0.5" angle, with a thickness of 1/16". However, the calculations showed that, with the design load of 150lbs (ultimate) at the grip on the stick, the potential tension in the cable required a stronger design.

So, I used 1.25" x 1.25" x t=1/16" 6061 angle - the weight is negligible and it's about double the strength of what's needed. As for riveting, I used A4 pitch 40 on the vertical flanges to keep the flanges together and A4 pitch 40 on the bottom flange to install the inverted 'T' to the skin. As always, I followed minimum edge distance rules for riveting and the AN3 bolt holding the pulley on.

This emphasizes how important it is to check your modifications with the factory.

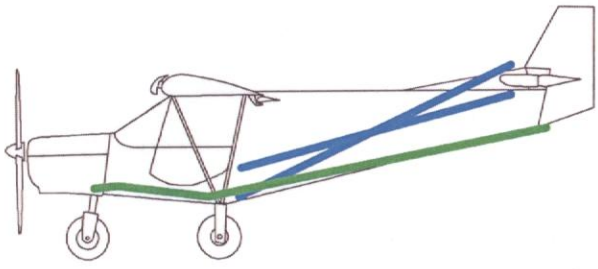
Interestingly this modification allowed me to overcome another small gripe; I had noticed that with full elevator deflections (for example when the aircraft is sitting on the ground and the elevator drops to its full down position), the elevator cable was contacting the elevator horn at the point where it loops around the cable eye. I had been intending to do something about this, while in the meantime checking the cable for any fraying on every pre-flight.

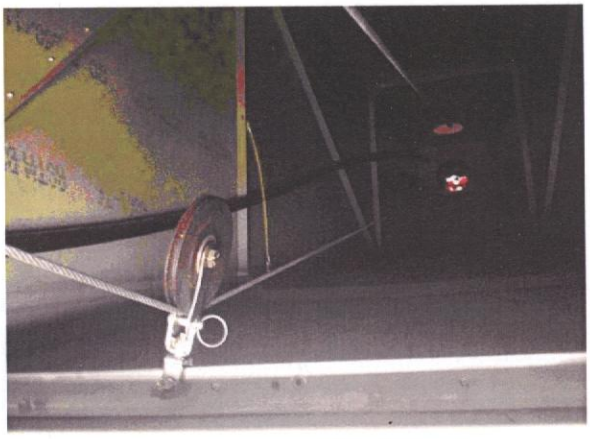
When making the changes described above, naturally enough, the total length of the cable system needed to be increased. Also, I wanted to avoid making completely new cables, if possible. As it happens, the required increase in cable length was neatly taken care of by adding stainless steel links at the four terminating connections of the cables, as seen in the photographs.

So what is the result? The aircraft now feels even more responsive on the controls, especially at slower speeds when you're more likely to use full control inputs. It is definitely made the flying of my 701 even more delightful.

You may have seen Seb's aircraft at Zenith's Sun n Fun displays over the past few years.

Before





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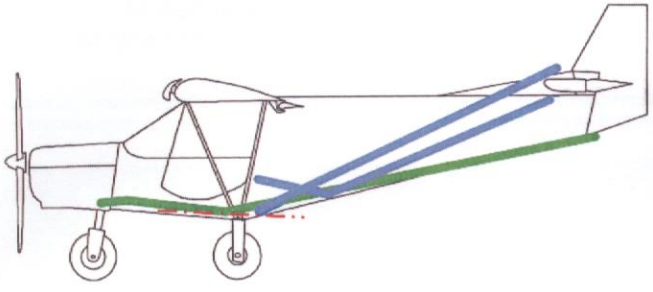

First flight Aug 6 Milan Patrick Jr Shinnston, WV

Zenith display at Sun n Fun 2010