3- REDUCED AIRFRAME DRAG FOR ALREADY FLYING AIRCRAFT

Gap Seals

The ailerons, flaps, and elevators are subject to different pressures from one side to the other. (Not true for the rudder while it is aimed straight back in cruise.) High pressure air on one side will try to go through any gap to escape to the low pressure side. In doing so, the leakage flow must be slowed virtually to zero creating momentum drag, flow through the gap, and then exit back into the free stream at low velocity where a small local flow separation can result. Answer: close the gaps.

For the flaps, I found that I could slide thin cardboard between flap and wing when the flaps are fully retracted. To close this leakage path, I bonded on a rubber seal as illustrated below. This seal and some others started life as window or door gap seals and came from the local Bunnings/Home Depot store. They are held on with adhesive. Control surface seals shown further on were purchased from a sail plane supply house and are normally used to close gaps on competition sail planes.

There have been problems with sail plane gap seals coming off of powered aircraft, sometimes with exciting results. They consist of double sided adhesive tape that holds on a curved Mylar seal. The leading edge of this joint is then covered with PVC tape to provide some resistance to wind peeling. I suggest the following practices when using these seals:

1) Break up the gap seals into shorter lengths, generally going from one hinge point to the next. This way if a section of seal comes loose, only a portion of the full seal length will flop around in the breeze until it falls off.

2) Be meticulous in your bonding procedures:
   a. Clean the paint surface well using a dry clean rag. If you use solvent, give it time to evaporate and use a heat gun to make sure it is all gone.
   b. Tape off the area just in front of where the PVC tape will be located to protect the paint in the next step and to act as a guide when sticking on the adhesive and PVC tape.
   c. Sand the paint with 1200/1500 paper to roughen the surface slightly, clean the surface, and increase the surface area for the adhesive to bond to. Wipe off all dust with a very clean rag. Sanding also yields what is called a “high energy surface” with lots of electrostatic electrical charges that remain for a few minutes until water vapour molecules are attracted. This improves the bond.
   d. Apply the double sided adhesive tape, the Mylar seal, and the covering PVC tape. Then (and this is important) press down hard with your thumb for a few seconds onto the tape sandwich. Pressure sensitive tape needs time and pressure to bond. You need to supply both. Push, hold, then move your thumb along the tape and repeat. It is boring but essential.
   e. Remove the guard tape you applied initially. Go flying.

Here is the gap seal I used for the flaps, genuine hardware store quality. Note cross sectional shape visible on the right end.
Here is a brush seal closing the gap between the flap and fuselage. This is also hardware store supplied and intended to close the gap beneath the doors in your house.

Below is a section of elevator gap seal using sail plane materials.
I used two widths of the curved Mylar tape. The wide stuff covers the region around the hinge where clearance is greater, and the narrow stuff is used elsewhere as illustrated.

I did not want to use a brush seal on the ailerons because of possible increased friction, so I focussed on keeping the gap between the wing tips and ailerons as small as possible.
Unfortunately because the complex rolling motion of the flaps when deployed (they move along the surface of a big cone), one can not use a tight gap between ailerons and flaps as it leads to interference when flap and aileron are both fully deployed. The best you can do is the tapered gap shown above.

Foam seal closing gap between cowl flap and fuselage, cowl flap on bottom, engine cowl to left. The goal is to have all the pressurized air exit backward, not leak out perpendicular to the free stream flow.

**Main Landing Gear Door Seals**

To prevent deflection under loads that might lead to increased gaps and leakage, I made the main landing gear doors particularly stiff by the addition of a foam and carbon fiber box section construction as illustrated in the figures below. I modified the front of the doors to make a forward door extension that would close the hole normally left by the landing gear leg, and then put seals around the door and across the long piano hinge to prevent air from entering or exiting. My goal was to have all the cabin air vent down the length of the fuselage and out the gap where the elevator torque tube exits the side of the fuselage at the tail.
Photo of rear edge of one of the main landing gear door openings. The finger points to a thin neoprene rubber seal with some grey adhesive smeared after being squeezed out during seal application. Use an industrial adhesive designed for rubber when bonding neoprene. Silicone rubber adhesive eventually lets go for some reason.

Main landing gear door showing raised area/box section for torsional stiffening and neoprene seal along piano hinge to prevent air flow in or out.
Baggage Door Seals

My non-pressurized fuselage has the baggage compartment as a rearward extension of the cabin so it is at cabin pressure. The fuselage is convex curved along flow streamlines in this region so the pressure is likely below ambient and below cabin pressure, particularly when there is ventilation air coming into the cabin. So it follows that eliminating leakage through the baggage door gap should reduce drag.

Here is a photo of the baggage door. Note that there are no external locks sticking out into the free stream, and also note that the gaps are around 0.060 in., as narrow as I dared make them. The door is hinged with a carbon piano hinge located so it is not exposed to internal cabin pressure so it can not leak. The baggage door has also been substantially stiffened to minimize any deflections that could create larger gaps around the perimeter while carrying internal pressure loads.

The baggage door is kept closed with spring-loaded shear pins that engage the bottom of the door, and opened by an air spring and lever in the roof of the baggage compartment. The pins are retracted by pushing a button on the cabin door sill so that it is impossible to pop open the baggage door when the
cabin door is shut. The baggage door is sealed with hardware store window seals, a double lip seal around most of the door, and a single lip seal on the bottom as illustrated below.

![Double lip seal used on top and sides of baggage door](image1.jpg)

![Double lip seal on top of baggage door, carbon piano hinge, and opening lever pushed by air spring](image2.jpg)
Lip seal on lower edge of baggage door. Also shown is one of the spring-loaded latching pins engaged when the door is pushed shut.

**Fairings**

Some fairings can be added after the aircraft has been completed. Here are some examples.

The cabin door hinges must be installed flat and parallel in a roof line that is curved. As a consequence steps are created at both hinge locations. These can be smoothed out with the addition of wedge shaped fairings.

Fairing to smooth forward-facing step at front cabin door hinge.

Fairing to smooth aft-facing step at rear cabin door hinge.
The spherical joint that controls the aileron position sticks below the lower wing surface. The front portion of the fairing above (right) is permanently formed into the lower wing skin. The aft portion of the fairing was made in a mold using model airplane fibreglass for lightness, and is held with a bit of silicone rubber adhesive and then covered with PVC tape so that it can be removed if necessary.

There is always room for improvement. Once you have addressed the higher drag items, you can focus on the little details which become more important as the airplane gets cleaner and cleaner. Here are some items on my “to do” list – they will get some streamline fairings someday.

There are only two exposed antennas, the comm one belly antenna above and the transponder antenna. I am sure some improvements are possible.

I have four fuel drains, two in each wing, one in front of the spar, one behind. These also need some cleanup.