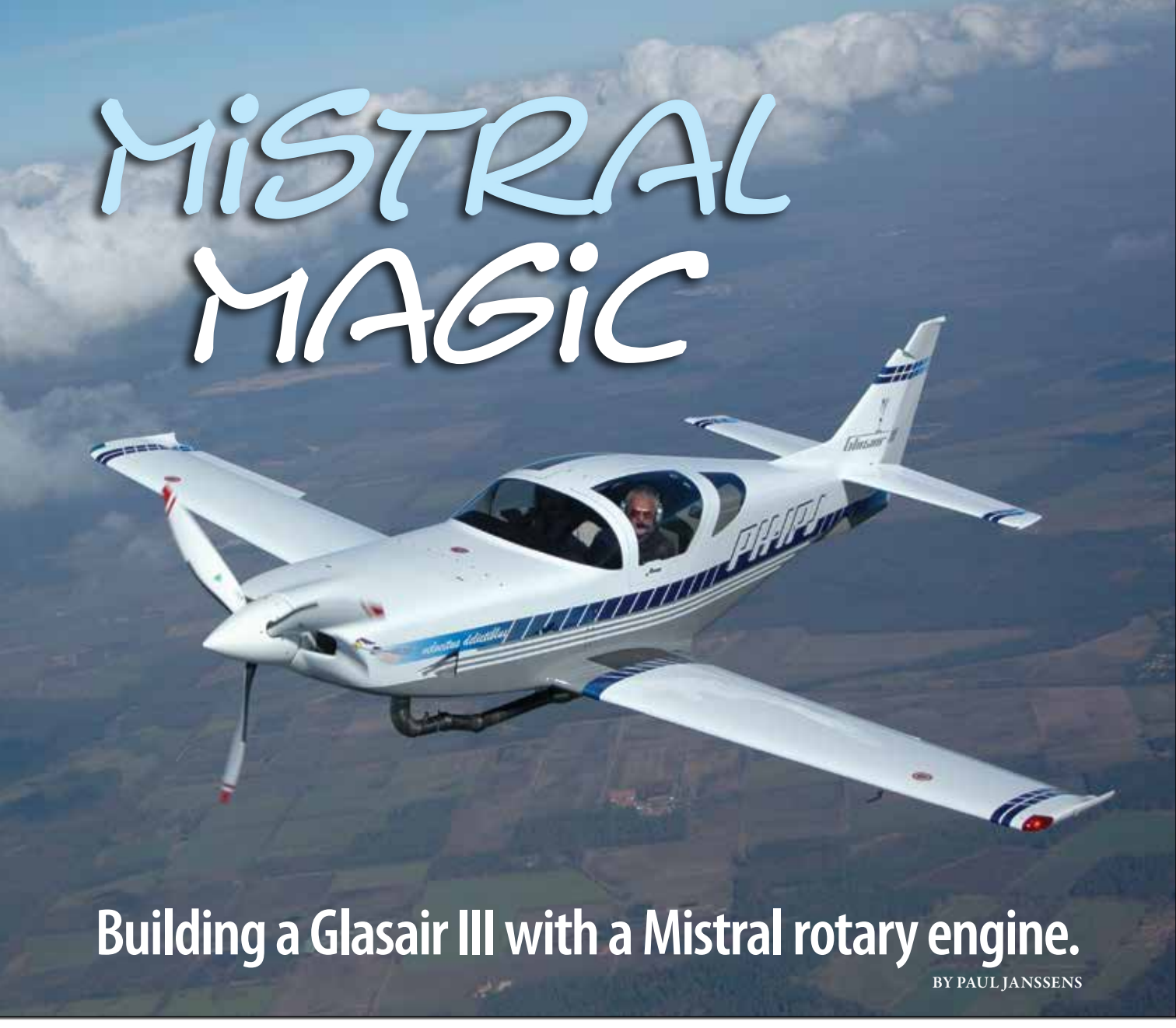
MISTRAL MAGIC



Building a Glasair III with a Mistral rotary engine.

BY PAUL JANSSENS

With the FAA finally evaluating unleaded avgas proposals, 100 low lead might actually be one step closer to its demise. That's hardly news in Belgium where I live. Higher prices and severe environmental regulations have caused 100LL to be on the way out for years.

Because of the fuel situation, I decided to look at alternatives to the 300-hp IO-540 Lycoming my Glasair III kit was designed for. For me, the trusted Lycosaurus wasn't a viable option. I wanted something to point my Glasair into the future.

Starting the Build

The project began in 20__, when I purchased a partially completed Glasair III kit. The horizontal stab was finished and the ribs were installed in the wing, but that's all that had been done. I started on the wing and slowly transitioned from a scared beginner to at least having a good hunch of what I was doing.

Although the manuals were reasonably good, they did have problems. They had been developed for the first Glasair, and for that, they were super. However, as the kits evolved, and when the Glasair III came along, the manuals were quickly modified only where it was essential. This was very clear when installing the slotted flaps. They were an option that first appeared on the Glasair II. In the documents that came with the kit, there were only very short, mostly handwritten references on what the flaps needed to look like on the Glasair III. It was almost an afterthought: "Oh yes, if you're building a III..." Luckily, builder support was good and I successfully completed the flaps.

Perhaps the most impressive day of the build came with the closure of the wings. Gluing the top skins requires mixing and applying a lot of resin, and it sets in 40 minutes, so the work needs to be done quickly, precisely, and completely. I selected five friends, we watched the video, did a couple of dry runs where each of us chose a task we felt happy with, and I started the clock.

Ribs attached to the lower skins of the one-piece wing.

Thirty-two minutes later, the first wing was closed. We took a break, I mixed up a new batch of resin, and this time we did it in 28 minutes without feeling like we had hurried. That was a great success. But when I measured the wing after the resin had cured, my hopes sank because the wing was warped by 0.4°. In pure panic, I called builder support, and they laughed and re-assured me: "Go out to your flying club and measure a Cessna 150 or anything built commercially. You'll see." I did, and measured two 150's...my 0.4° was a joke!

By 2005, the wing was finished. Flying freight at night, I worked one week *on*, and one week *off*. During my week on, I studied building techniques, the manuals, ordered parts, etc. That allowed me to spend all my time building during my time off, and that was usually seven days a week, at least 12 hrs per day. I did that from mid-September to the beginning of May, and then I took a building hiatus to move to the South of France to fly gliders in the Alps. This rhythm proved to be a very good one. By March, I usually felt the workshop walls closing in on me, and by early September, I was very eager to start building again. Throughout the build, my all-important motto was, "Make it perfect, or learn from it and throw it away." The build took 8.5 years, working mostly by myself.

In 2006, I had the airframe just about ready. One winter Saturday, I asked six friends to help lift the fuselage onto the one-piece wing. About an hour later, the fuselage was sitting roughly in place, and I thanked my friends. Because it had started snowing heavily, they all decided to stay a bit longer, and it seemed like the perfect opportunity to measure carefully and try to position the fuselage properly.

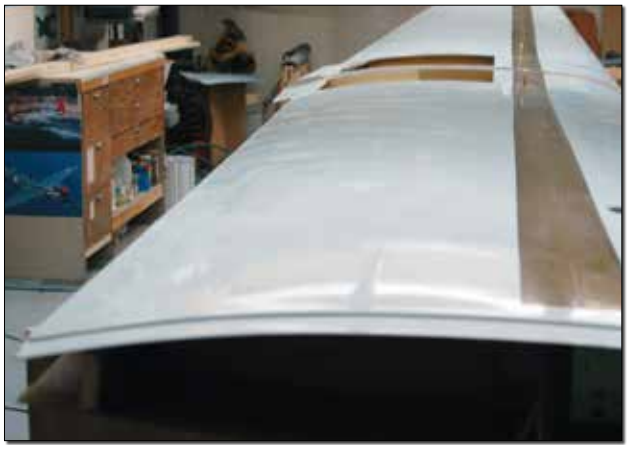
I thought this would be a tough feat to accomplish in one afternoon because it is fairly complicated to adjust a fuselage onto a wing in pitch, roll, and yaw. However, our first measurement showed that it was all set just the way it said in the manual. I measured four times, and then went away in shock to allow my friends to see where I was making a mistake. Surely you can't get it right just by eyeballing it! Four hours after the fuselage had been lifted onto the wing, the holes were drilled and the wing attach hardware was successfully installed.

Choosing an Engine

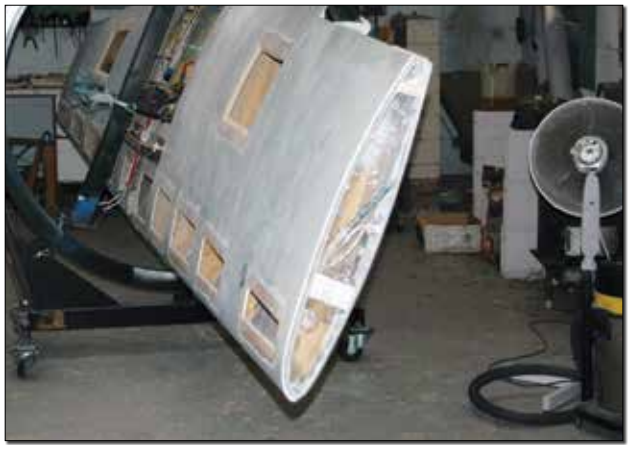
My experience at work flying a Convair 580 with Allisons made me a firm believer in turboprops. But where would I find a 300-hp turboprop for a Glasair III? I did end up with the knowledge that in this horsepower range, turboprops are either horrendously expensive, or they have serious trouble with stability of the flame in the combustion chamber.

I contacted Innodyn and over the phone, they promised me that all was sunshine and roses. I decided to meet up with them at AirVenture, so it was off to Oshkosh in the wonderful USA. When I arrived, Innodyn was nowhere to be seen, and soon enough, I found that it had all been a bunch of...let's just call it fantasies.

So, there I was in the market for an engine, but cast adrift. In Textron's impressive tent was a mockup of a 300-hp diesel, but not a soul could tell me anything about it. The Continental people looked at me as if I was joking around—why fly on jet fuel or car gas? There was also Subaru, but I heard mixed reactions about that one. Rolls-Royce had the perfect solution in the shape of a 300-hp

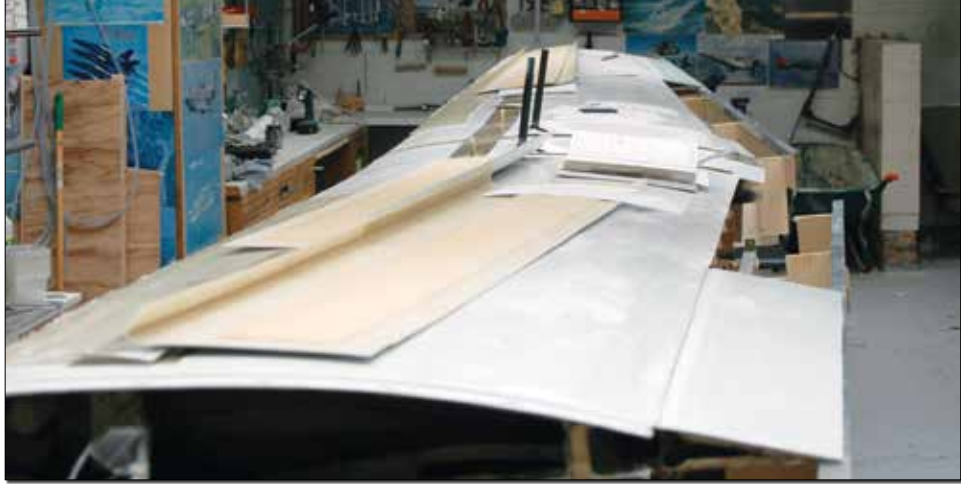


The completed one-piece-wing.



Holes for applying an ethanol-proof coating to the tanks.

Photos: Paul Janssens



With the ailerons complete, it was time to work on to the flaps.

turboprop, but a P-51 would have been less expensive to buy—and to run.

And so I sought solace in the warbird area. At least these old ladies gave me some moral support. On the way back to the commercial exhibits, I'd passed a tent of what seemed to be an engine maker. The logo on the flag showed a Wankel engine rotor, but I walked on. I remembered what I'd heard about these engines as a young kid; they guzzled fuel, ran very smoothly, and produced good power, but once the seals went (and they went quickly), it was all over.

On day three, I was really depressed. I finally decided to look into the tent I had skipped earlier, mostly out of boredom and despair. Inside were Wankels, all right. Then I heard something familiar. One of the salesmen was speaking English heavily laced with French. When he turned to me, I asked him where he was from in French. That cut the ice in a second. A bit later, I told him about my troubles *and* about my mistrust of the Wankel engine.

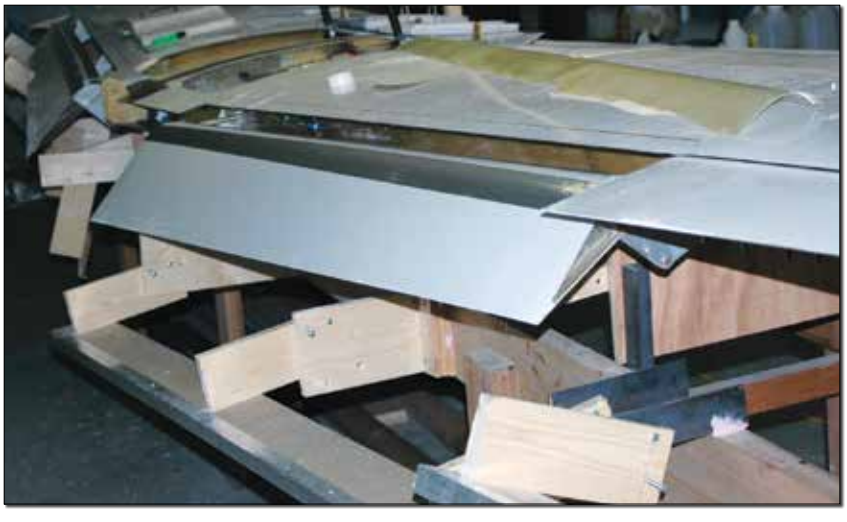
François was the CEO of Mistral engines, and they were based in Geneva, Switzerland. He then started his sale pitch, or that is what I thought at that time. Five minutes later, I realized that he was being very honest about the engine. Yes, they had problems, but they were trying this and that, and a solution would be found soon. It was the honesty that drew me in, and that evening I spent most of my time researching the Wankel engine on the Internet.

The next day, I reappeared in the Mistral engines tent with two full pages of questions. François smiled and presented me to Gordon, their research and development expert. Gordon again surprised me with direct and honest answers. The next day I was back with another load of questions, and François said, "You have to come and see us in Geneva."

Doing My Homework

I researched the engine further, and made contact with people who drag-raced the Mazda RX-7 engine, on which the Mistral engine was based. Then I talked to boat racers who used the same engine. Conclusions were:

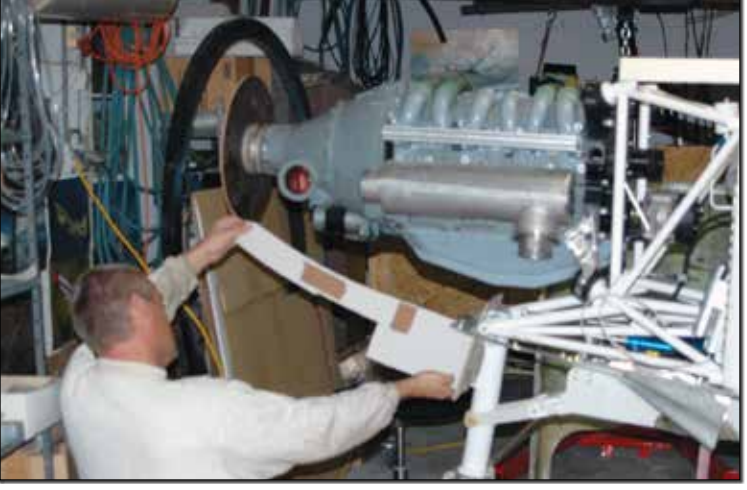
- The engine is very good as long as it has ceramic seals. The old Wankel engine had metal seals that wore out near the center. After that engine had cooled down, the seals warped, leaving a large opening. Because of the loss of compression, starting an engine with worn seals was very frustrating.
- The RX-7 engine could provide up to 600 hp per rotor, but that would destroy it. In drag racing that was fine. The boat racers claimed that 400 hp per rotor was about the best you could get from that engine without reducing its life. Mistral was proposing engines with 100 hp per rotor, very comfortably on the safe side.
- It is true that the Wankel engine is remarkably smooth in operation, and it has no parts that go banging back and forth. Only three parts move, and they all rotate. If a part fails, the engine will keep running at a reduced power output. *All* of the racers mentioned that, and they all had experience with engines blowing up.



The dreaded flaps, not quite finished, but getting there.

And so I went to Geneva and was drawn in further in by the enthusiasm and honesty of the Mistral team. I ended up placing an order for a G-300. *Why?*

- I was (and still am) impressed by this team. They were honest and very keen to make the engine into a success.
- The engine was already in a stage where it was suited for aviation. Sure, there would still be teething problems, but they would be in the software, such as presentation of data, etc.
- Mogas is the big word in general aviation in Europe. Avgas was already 40% more expensive, and



The engine mockup allowed me to design the new engine cowling.

This is what I could use of the original lower cowling.

though diesel engines were on the market, they kept having problems. In addition, the taxman had found out about jet fuel being used in general aviation, and for this use, started being taxed at a special (i.e., more expensive) rate.

- Safety. It may sound strange from a man about to install a virtually unflown engine in a high wing-loading, fast airplane, but everything pointed to the conclusion that I'd feel a lot safer behind this Mistral engine.
- Expected TBO at 3000 hours. Not bad, *and* I expect it to be a true time, not "You will probably reach TBO if you exchange 30% of your engine's parts somewhere along the way."

Why didn't I go for a diesel engine? In my research I came across an engineer that had worked on the integration of aero-diesel engines in European aircraft. He had quit his job because he felt that the continuing engine troubles could not continue. (In fact, the company later went bankrupt.) He said something that made sense: "A diesel is the perfect engine for boats, trucks, and trains. Make 'em heavy and they will do the job, but try to make them light enough for aviation, and the materials will end up failing."

So now I was in knee deep, looking at installing an Experimental, water-cooled engine in an equally Experimental homebuilt airplane. I just hoped my research had been sound, along with my building, *and* the work of the Mistral team. I also decided to be *very* thorough as the testing began.

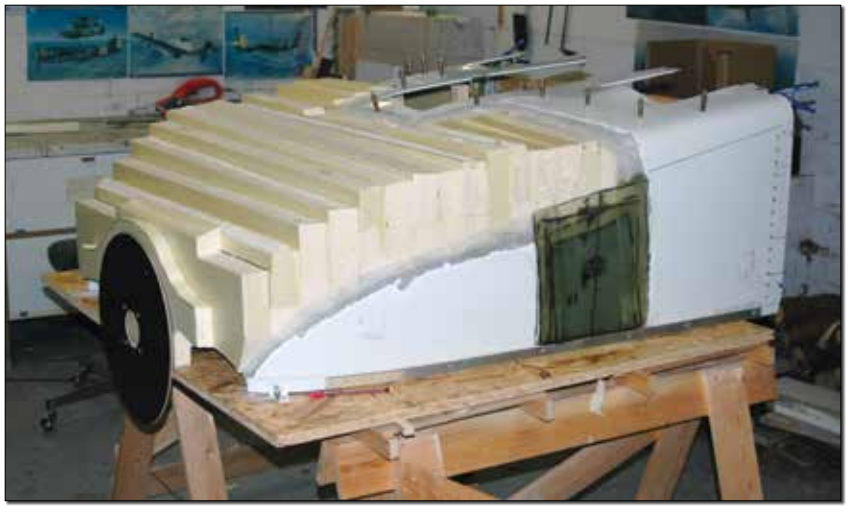
Preparing the Airframe for the Engine

The build progressed nicely, and the fuselage had been de-mated from the wing for engine installation, while Mistral had kindly lent me an engine mockup. The original Dynafocal engine mount could be used, and the mockup was simply bolted in place 10 minutes after it arrived. The engine is five inches longer than the IO-540 for which the cowling was designed, so I cut the cowling into pieces and ended up throwing 70% of them away. The bits I could use were molded into the new, lengthened cowling.

Cooling the engine was a big question. What size radiators should I use? Mistral could only give me a rough idea, as it also depends on the speeds one flies. How to calculate all of that? Everywhere I asked, I only got evasive answers, leading to the conclusion that trial and error seemed to be the system mostly used. I forged ahead, but started by getting radiator dimensions for just about every 300-hp Wankel engine I could find—cars, boats, you name it. At least it gave me a starting point, and I still had time to think and play with ideas until the engine was delivered.

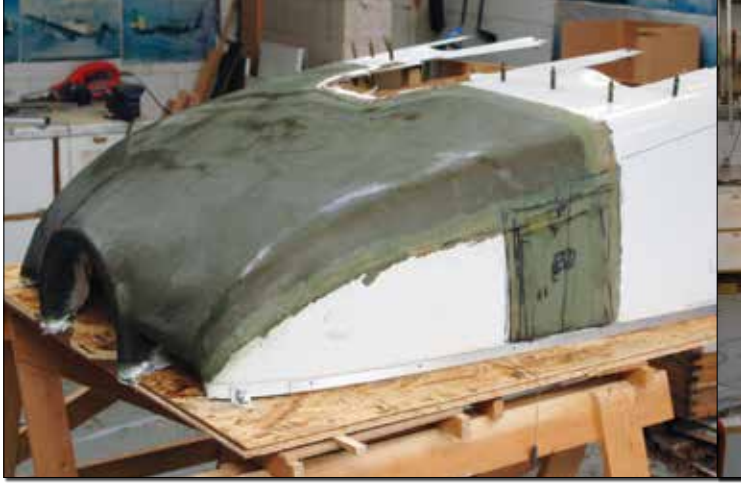
The Ethanol Dilemma

Then came a bombshell! Automotive fuel has ethanol added, and the resin used in the Glasair's wing (and fuel tanks) did not provide adequate protection against degradation from ethanol. Briefly, ethanol would make the wingskins swell up, and slush would form in the fuel. By this stage, the wing was ready for paint, with not a pinhole or wave on its surface, the result of many hours of work and a couple of layers of skin off my fingers. I was proud of that wing, but now I faced a choice—open it up and apply an ethanol-proof coating, or use avgas



I used the lost-mold technique to produce the new lower cowling.

Here the lower cowl is ready for fiberglass.



The lower cowling after adding a four-inch extension.

and throw away the main advantage of the Mistral engine.

With the help of a specialist, I found a very good epoxy coating. I must admit I had tears in my eyes when I cut those 12 holes in my virgin wing. The work was long and hard. After prepping, the coating needed to be applied in four layers, with seven hours between layers. To my surprise, it took almost six hours to apply one coat, so you can imagine what the next two days were like.

After the wing was closed back up and had been prepped for paint again, I felt a huge load sliding off my shoulders.

Planning for Cooling Issues

Now that everything was installed, cooling needed to be addressed with answers and actions. I settled on an oil cooler that would sit in the left-hand air scoop, and a large coolant radiator that would sit at an angle, almost parallel to the engine, and would be fed by air from the right-hand scoop.

Now, here's a thought that came to me in my sleep: ram air going into both scoops, blowing the cowling up, venturi effect sucking the air out via the cowl flap openings, Vne 295 kts...Would the venturi effect suck all the air out, or would I blow my cowling off in flight?

I woke up, bathing in sweat. I'm a pilot, not a mathematician, so I had to either get the help of a pro, or...

I built a wooden scoop that had the same surface as the inlet scoops to my cowling, and placed that on the car roof—ram air. I opened the aft passenger window so that the opening had the same surface of those cowl flap openings—venturi. I put my altimeter on the dashboard, and did a couple of possibly illegal passes on the highway at night, but the altimeter stayed at zero. This indicated that all the air being pushed in was also being sucked back out. To confirm that my method was sound, I slowly closed the aft window until the altimeter started showing below zero. I had about a 30 % margin in surface with those cowl flap openings.

Time for Paint

Over the previous five years, I'd been thinking of a paint scheme, and looking at thousands of pictures of aircraft. I came to the conclusion that there are a lot of ordinary paint schemes that make an aircraft look...well...ordinary. I wanted my Glasair to look amazing!

When looking at pictures didn't bring a solution I could "borrow," I built a model of the Glasair, and did a showdown of paint schemes. I'd paint one side of it differently from the other side, and the loser would be painted over with the next candidate. I just couldn't find that one perfect solution, and I was near panic when my girlfriend started drawing some schemes. One of the first grabbed my attention, and I added some changes. We saved it as a good safety net, but ended up using that design and

Beginnings

I guess it all started when I began flying in the Belgian Air Force, way back in 1985. I grew up on an airfield and had passed through the stages of plastic model aircraft, then control line, then radio control. I soloed in a glider at age 15. The first powered aircraft I flew was the SF-260 M Marchetti that the Air Force used for primary training. This was the first of a few rare aircraft that made me feel like it was an old friend only seconds after taking control. I flew 135 hours in the Marchetti and got hooked on aerobatics and formation flying, for which the aircraft was perfectly suited.

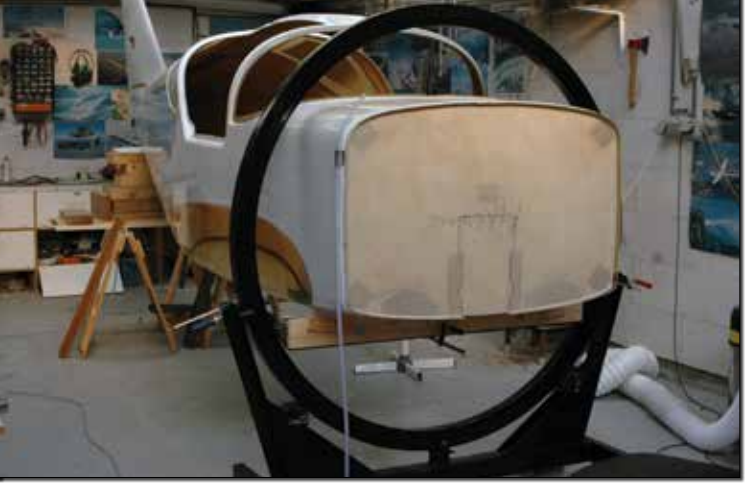
Fast forward to the early '90s, when I got hold of a brochure about the Glasairs that people were talking about. I got all fired up, but everybody told me it was extremely hard to build one. My youthful 26 years probably made some people actively discourage me from launching myself into such a project. I'm not sure if they were right, but the advice was well intended.

Another zap forward into time and by 2003 the spark had grown into a plan. I'd bought a house that had room to add a large workshop. With that choice made, nature took its course.

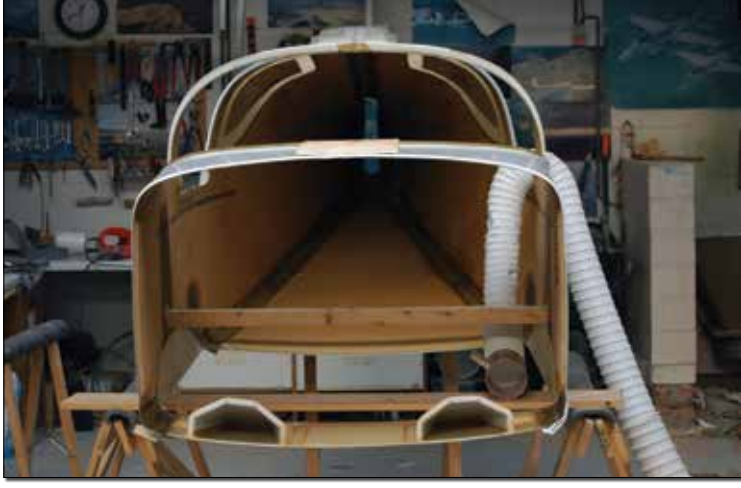
I started gathering information about all the stuff that airplane builders have to deal with: authorities and regulations, building techniques, materials, and deciding on what I should build. Being a very active glider pilot, I considered (and still do) powered aircraft as rather boring—unless you livened things up with an additional challenge like aerobatics. I love taildragger flying, but building a taildragger just for the fun of takeoffs and landings seemed like the wrong choice for me.

In the end, I came to the conclusion that no powered aircraft was ever going to provide the pure flying fun of a cross-country flight in a glider. However, I selected a Glasair III mostly because I simply did not have the funds for a P-51. (Know the feeling?)

—P.J.



I made the ring that allowed me to fully rotate the fuselage.



Gluing the fuselage shells together.

I'm very pleased with the result. A good paint job is equally important with good building quality.

The next 3 weeks were spent polishing the varnish, I wanted that deep gloss, but it comes at the cost of long tedious hours; They're worth it.

Final Assembly

You know what they say: "95% done, 95% to go." Is that ever the truth! The hydraulics leaked like a sieve and I spent a week in sticky, stinking fluid. Then there was the phantom of the undercarriage. Briefly, when the gear reaches the down-and-locked position, the hydraulic pump is allowed to put 800 psi on the down side of the system, and a pressure switch then shuts it off. Well, sometimes it did, and sometimes it didn't. I spent three weeks rechecking all the wiring, the pressure switch, and diagnosing the system, but I couldn't find anything that pointed me to the cause. In the end, and purely by accident, I found it.

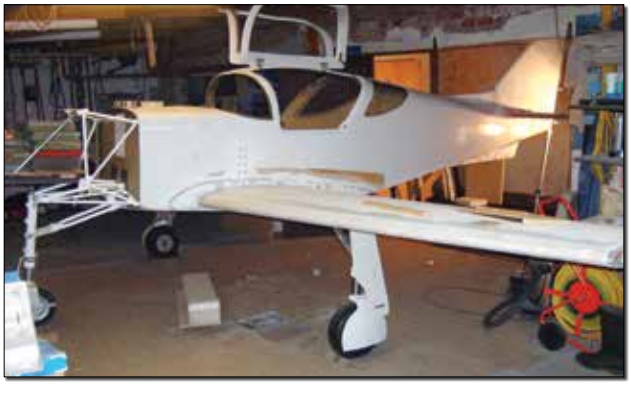
Over the pressure switch wiring, a bridge was made with a push-button type switch. In case the pump shut down prematurely, the pilot would simply press that switch and add down-pressure on the system. In that five-cent, brand-new, push-button, there was a tiny piece of metal that occasionally shorted the switch out, causing the pump to keep running.

Finally, the day arrived that Mistral engineers came to check my installation and start the engine. They were happy with my work, and the engine ran beautifully. I could start doing static runs. I quickly got into trouble doing the static runs. The Glasair III sits on long gear legs and at 40% power, the leverage of the pull of the engine completely compressed the nose gear strut, causing the nose to dip down—even with full-up elevator. Thank you, Stoddard-Hamilton for enough prop clearance! The taxi runs started early, and that was a good thing, because the Glasair is quite a handful during the takeoff run.

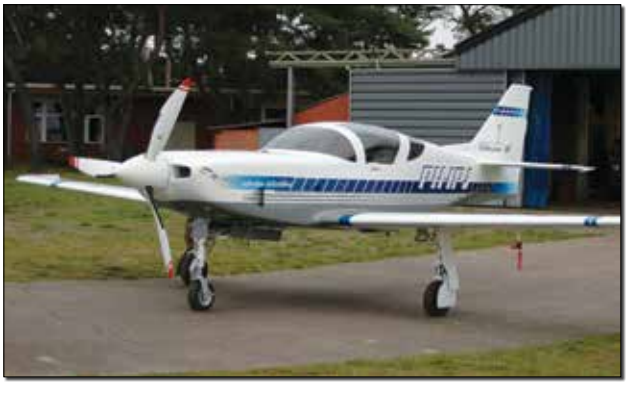
The first flight was on December 6, 2012, and all went smoothly. In fact, the airplane never gave me any trouble. Even my cooling system worked fine, although I suspect it contributes to drag. I'll go into more details about the engine and its installation in the next part of this series. ✠

PAUL JANSSENS

Paul Janssens was born in Belgium in 1964 and made his first solo flight in a glider at age 15. He has since accumulated over 7800 hours in 45 types of gliders and has won the Belgian Gliding Championship and World Mountain Gliding Championship several times. He specializes in flying long distance in the Alps, and trains and instructs competitive, long-distance glider pilots. He flew in the Belgian Air Force for two years, flew private jets for seven years, and freight for 15 years. He has 5500 hours of powered flight time in 34 types. A designer of model aircraft, his website is www.pjmodelclassics.be.



First time standing on its own legs.



With the paint complete, it was time to begin testing.