

Grassroots manufacturing

The evolution of 'homebuilts' into factory-builts - à la Zenair



Stars of Zenair's fleet: The ZODIAC CH 601 and the STOL CH 701

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CANADA'S AVIATION industry - particularly the homebuilt sector - is fortunate that 18-year-old, French-born [Chris Heintz](#) decided to enter aeronautical engineering, and that a series of events led him to emigrate from Switzerland to Canadian shores a decade later.

Heintz's late-Fifties education - at the world-renowned ETH in Switzerland - was computerless. Says Heintz: Computer-driven calculations do not allow sufficient leeway for unusual situations, and most are developed for large, heavy jet transports. Computer predictions too often are invalidated by prototype performance.

His first job involved flutter analysis for the Aerospatiale Concorde. At that time, Avions Robin was building the popular all-wood Jodel series under license. A row with the designers left Mr. Robin looking for an aeronautical engineer to create a design. He found Heintz, whom he appointed Chief of Engineering. Chris quickly learned two things: how to work with people, and how difficult it was to design a whole new aircraft. In the yearly Race of Sicily, where competitors flew for six hours at wave-top heights with Lycoming O-320s turning at 3600 rpm, Heintz's design won the prize for three consecutive years, and was disqualified from running again in fairness to other entries.

A decade later, Avions Robin was building an aircraft per day; Chris took on civic responsibility by accepting the post of town mayor. But he had to leave the company - the day before it was to become unionized and staffed essentially by surplus army personnel. But he had signed a contract with Avions Robin promising not to work as an engineer in Europe if he left the company.

This stipulation unwittingly engineered his departure from Europe. With his wife and five children, he pinned a world map with Waldorf school locations, and chose Brazil, only to discover that its climate was too hot for serious productivity. Canada was the alternative, and DeHavilland in Toronto was the employer.

HOMEBUILT ROOTS

Heintz's homebuilt penchant began one day back at Avions Robin in France, where he started designing his own two-seat, all-metal Zenith during his spare time. He finished the airframe in six months and it was flown two years later. It was an immediate success, and Chris used the Zenith for commuting to work.

The plane was flown later at the Oshkosh Fly-in, where it sparked considerable interest. Although hassles with DoT [Canadian Department of Transportation] were ripe, Heintz was eventually allowed to bring the Zenith to Canada. Says he: DoT in those days was staffed by British personnel who had moved to Canada after crushing general aviation in Great Britain.

After some time with DeHavilland working on the Dash 7, he despaired of the whole concept of government employment and decided to strike out on his own to help fill the need for well-designed recreational aircraft. With his friend Gerry Boudreau in charge of production, and working out of their double-car garages, Zenair began production. Gerry in Bolton specialized in welded structures and inventory control, while Chris fabricated the sheet-metal structures in Richmond Hill. This little outfit grew, and eventually produced 700 flying aircraft (plus many more in varying stages of construction or storage).

Heintz's aim in building kitplanes, in his own words, is "to help in the cure of ills plaguing modern-day society." If one doesn't have a goal to help others, in time one will become emotionally ill. Most individuals have a job that's boring to them – nothing more than a money-motivated endeavor. When they go home, they want to be involved in something creative.

"By providing safe, well-designed aircraft," says Heintz, "I can contribute to the achievements and fulfillment of kitbuilders and pilots around the world. Many builders claim their project was the best experience of their life. This, and wives who are gushy about their mutual accomplishments, are my rewards."

The Experimental Aircraft Association estimates an average completion rate of 8 - 10% for first-time kit-builders. The Zenair kits are apparently completed by 98% of the buyers! The most important factor here is the quality of the kit, says Heintz. Companies often claim their kits are 49% complete, when in actual fact they could be much less. Finishing details, reading the plans, and shopping for materials not provided in the kit, are major time consumers. On the other hand, professionally written construction manuals with supportive photos can save builders a great deal of time. A project that gets interrupted due to lack of materials or information tends to be abandoned.

Builders should therefore look for factory support and quality when it comes to choosing a homebuilt.

Design criteria are also important, says Heintz: To avoid serious injury or fatalities during crash landings, the flaps up stall speed must be below 50 mph. "Many think my central control system between pilots was created to reduce weight and complexity. In fact, it was to move the sticks away from a potentially hazardous location. Similarly,

throttles are mounted in upper outboard portions of the instrument panel where they can't impale pilots."

Since maintaining high proficiency is difficult for sport aviators, their aircraft must be simple and efficient. Generally, this means avoiding retractable gear, variable-pitch props and complex high-lift devices. Zenair's CH 701 STOL wing achieves a lift coefficient of 3.1 with a simple fixed slat! "My visits to major flying shows has taught me that few people really know what kind of plane is best for them. My aircraft are designed to be useful to the largest segment of sport pilots."

"Because I'm six-feet-two, cockpit access and comfort can be less than ideal. It is important to consider creature comforts, especially for cross-country flights."

In the case of kit production, the package should be produced so that all difficult tasks such as welding, and heat treatment are completed by the factory. The builder should be able to put the aircraft together with basic hand tools.

There is a trend toward higher prices for amateur-builts. One reason, says Heintz, is that more of them now are supplied as ready-to-assemble kits rather than as sets of plans. Also, the quality of design has been improving - more aircraft are built to FAR 23 and European JAR standards, adding further to developmental costs. Professional engineering will always cost more than the creations of relatively unqualified designers. Also, many companies do not conduct sufficient testing of their prototypes before offering kits to the public. Not only the wings but the tail, engine mounts and landing gear should all be load-tested. Wings should also have torsional and twisting loads applied - similarly to those encountered during flight. An aircraft that has not been flutter-tested or spin-tested should not be released for public use. This testing all costs money.

Prebuilt kits begin with high-cost tooling. At Zenair, for example, a CNC computer-controlled drilling machine produces perfectly aligned pre-drilled skins, and a very large bending brake prepares full-size aluminum alloy sheets. Manufacturers must tool up properly; otherwise the designs are labor-intensive and at risk of financial failure, leaving builders high and dry.

Redesigned cowlings (for engine options) are expensive to develop. Many kitplane manufacturers provide only one design, leaving it to the builder to make all the necessary modifications to accommodate a different engine.

Quite a few manufacturers produce newsletters for their builders, keeping them informed on design and construction developments.

Zenair designs have been said to be slightly more expensive than competitive ones. But, says Heintz, "In order to remain in business for the past 17 years, we could not allow ourselves to lose money - and we came very close to that situation when we moved from the Toronto area to Midland. Setup time and before-sales costs really drained our resources."

But there's a good side to all of this: None of the 700 flying Zenair aircraft has ever suffered a structural failure. Few companies can claim such a record. "Because my

designs meet or exceed factory aircraft standards in Europe and North America, owners can relax with the knowledge that the aircraft is adequate for their specific purpose," says Heintz.

Additionally, more and more options have been converted to standard equipment, reflecting market preferences. Zenair kit prices generally include more standard equipment than competitors have, and part of the reason for this is bulk buying discounts. In other words, builders must include all factors when comparing prices: equipment, engine, instrumentation, and safety features.

Also, about one-third of the kit price received by Zenair is used to finance R&D, without which no new aircraft would be forthcoming and improvements to existing models would cease. So, probably, would the company, in time.

When it comes to modifications proposed by owner-builders, Heintz reviews the plans and approves them if they're safe and suitable.

Heintz no longer creates aircraft that he personally feels should be designed. He prefers the market-research approach, visiting the major aviation shows and talking with the public about their "wish lists". He carries a list of all Zenair builders with him when he travels soliciting their opinions and keeping tabs on their preferences.

"Once I decide to build a new aircraft type, it takes three years to reach the marketplace. Two years are involved in the building process and one in flight testing, to get the 'bugs' out. Sales are initially slow because many builders will not get involved in something new. Only after the first few aircraft have flown do the sales really begin. This is a tough time for new aircraft sales - and the point when most new companies fail."

Incidentally, it takes Zenair about 2000 man-hours to accomplish all of the engineering calculations involved in a new design before any metal is cut.

Zenair aircraft are essentially all-metal, because "sheet-metal aircraft are more durable and last longer". Although aluminum alloys are initially more expensive to buy, the maintenance costs are much lower than with fabric-and-tube or wooden aircraft. Because metal aircraft can be stored outside without significant deterioration, the cost of hangaring can also be avoided. "Strange as it may seem," says Heintz, "metal construction and 'working' rivets give obvious warning signs of imminent structural problems. Wood and composite structures behave very differently: the structure generally holds together up to the point of complete failure."

Fatigue, less likely in composite structures, is well known in metal aircraft but a qualified designer can account for it by "overdesigning" critical parts. Zenair guarantees a 10,000-hour service life.

"Since most accidents are survivable at impact speeds below 50 mph and few are survivable at speeds above 60 mph, designers should strive to keep stall speeds to a maximum of 44 knots, says Heintz. "And because many recreational pilots are unable to maintain currency on only 30-50 hours per year, their planes must be easy to fly and forgiving. Recreational aircraft should be built for the human being's pleasure, not

for record-breaking attempts. Visibility is also very important to provide pilot cues and, of course, avoid the risk of mid-air collision. Too many aircraft have major blind spots.

And why not composite aircraft with their sleek compound curves? "The major design problem with composite kits is the need for costly molds. If the aircraft design is flawed, it is generally too expensive to make a second or third mold, with the result that the problems are often reproduced in each of the production aircraft."

"Some of the composite ingredients are toxic, and I know of one man who became blind two years after he completed his aircraft. Composite materials are like artificial wood - essentially a man-made product that is affected by humidity and temperature changes. The composite sandwich has a problem wherein differential heating and cooling causes the materials to creep against each other, creating a gap that can allow water ingestion. Freezing, cracking, and delamination can then occur, drastically reducing the structural strength. Continued quality control has resulted in similarly produced composite sandwiches having widely differing properties. Even the testing can be a problem for most kit producers, due to a lack of suitable equipment,

"Looking at an accident, I see fiberglass and wooden structures tending to splinter, creating a war zone in the cockpit. While steel-tube cockpit structures are much better, be sure they are heat-treated to remove brittle areas and restore structural integrity. Nothing protects occupants like the progressive crunching of a well-designed sheet-metal structure. One of our CH-701s crashed directly into a vertical cliff just short of a runway. Moments later, the pilot climbed out of the cockpit remains and walked away, uninjured."

Some pilots think Chris Heintz designs his aircraft with an axe. Says Heintz: "My major goals are safety, strength of structure and pleasurable flight characteristics; the aircraft are optimized for aerodynamic efficiency rather than visual beauty.

It was Chris Heintz (among others) who proposed the recently adopted Aircraft Recreational Vehicle (primary) category in 1982, and the concept was adopted very quickly by EAA. His proposal is based on the original Zenith - which was France's first all-metal sport aircraft. The prototype ARV was built in 1987 and, as of January 1990, qualified under the new JAR-VLA category in Europe. The Zodiac-like craft features side-by-side seating, tricycle gear, a low wing and dual-yoke controls. Suitable powerplants in the 80-120-hp range include the Rotax 912, Continental O-200 and perhaps the Norton Rotary.

TIPS FOR BUILDERS

If readers are thinking of building a kit, here is a crash course on correct attitudes, compliments of Chris Heintz:

"Follow the builder's manual all the way. Some builders feel competent early in the game, with the result that they tend to forge ahead without consulting the manual. Then I get a phone call asking, "How do I get this aileron bellcrank in the closed wing?" Don't laugh, it's happened.

"Also, if your project has a newsletter, subscribe! They tend to be filled with very useful

building tips, sources for equipment and support for the builder."

Chris talked briefly about progress: "People used to laugh when I introduced 15%-thick airfoils on the Zeniths. Now, everybody is using them. My use of 18%-thick airfoils on the Zodiac is likely to spread to other light aircraft in five to ten years."

About the two-stroke-versus-four-stroke engine controversy: "The Wright brothers flew with a two-stroke engine. Years ago, two strokes were easy to build but difficult to adjust; however, the popularity of snowmobile and boat engines has advanced the art so much that they have become suitable as aircraft engines. The problems stem from the fact that the engines were not designed for aircraft use and consequently were often installed poorly.

"After three years of trial and error, Rotax is producing dependable engines for aircraft use - but they must be maintained correctly to be reliable (just like four-strokers). Several of our customers have more than 1500 hours on their two-strokes. When you consider that an overhaul on the new two-stroke Rotax 582 is about \$300, you can see why I believe it's a good compromise between cost and performance. The fourstroke 912 Rotax is 80 lbs. lighter than a similar Continental and just as reliable. We have 400 hours on our first 912 and it has cost us nothing for maintenance, thanks in part to its modern metallurgy. Although our purchasers chose evenly between the 912 and the 582, the fourstroke 912 is 40 lbs. heavier and costs \$8500.

"Although one has to be cautious with test-stand claims, I and many others think the rotary is an engine of the future. The 90-hp rotary from Norton is very smooth and reliable, but it is also expensive and very noisy.

While his sons Matthew and Sebastien are running the production and sales portions of the company, Heintz is busy trying to promote general aviation. "Every year students from universities in Europe visit us to study our engineering and production methods at Zenair. While we offer the same opportunities to Canadian universities, no one seems particularly interested in our offer. Maybe I'll write a book."

My visit to Zenair's facilities was a revelation on the matter of high quality design, production and customer support. Canadians tend to feel that we compare unfavorably with our neighbors to the south. However, lest we forget, the Avro Jetliner and Arrow were well ahead of their time in many ways. And while the country may not have been ready to capture major markets for political reasons at that time, it seems that our private-aircraft industry has potential to capture a significant market share. In the case of Chris Heintz's factory, the world is turning to Canada for guidance in the complex technology.