May - June 2005

RECREATIONAL FLYER

Recreational Aircraft Association Canada www.raa.ca
The Voice of Canadian Amateur Aircraft Builders $6.95

STOL for the People:
Zenith's Amazing
CH 701

RAA
RECREATIONAL AIRCRAFT ASSOCIATION
RÉSEAU AÉRONEFS AMATEUR CANADA

The Specialist:

Gary Wolf tries on the Zenith CH 701

Text and Photos by Gary Wolf and Mary Mills

No one looking at a Zenith 701 sitting on the tarmac has ever accused this plane of being excessively beautiful. However in flight, the charm of this STOL aircraft becomes immediately apparent. Chris Heintz designed the CH701 some twenty years ago and it has proven itself all around the world. When the only runway is a cleared patch in the jungle, and the alternative is a week of hiking through snake-infected swamps, the 701 starts to look pretty good. This is a plane that can use almost any clearing as a runway, and its high angle of climb means that you won't hit the trees at the end of the strip. A football field is plenty enough airstrip for a 701. With performance like this, the boxiness of the fuselage can be forgiven.

When Chris Heintz drew the 701 it was a complete departure from his earlier designs. He had earlier designed for Avions Robin, and the influence of those wooden French aircraft can be seen in his earlier 200 and 300 series of low-winged aircraft. Chris pioneered the use of 6061 aluminum and Avex pulled rivets for aircraft, and the 701 continues this successful combination. The original 701 was designed around the Rotax 532/582 2 stroke engines, and in this configuration could be built light enough to qualify for the then-new AULA category. The original gross weight of the plane was 960 pounds, and lately there have been spar and other detail mods to increase the gross to 1100 pounds. A light airframe weight is achieved by careful selection of materials, and to that end most of this plane is made from .016" aluminum sheet. Artful and subtle design create a strong and light structure that can take a beating, even when loaded up with a 100 hp 912S and a set of amphib floats.

The leading edge slats are the secret of the STOL characteristics of the Zenith 701, and they drive the entire design. Because of these, the wing can be much smaller than that of a conventional STOL, which relies on large area and low wing loading to achieve a slow takeoff and landing speed. Unfortunately, low wing loading also means a plane that is sensitive to turbulence. Many conventional ultralights can match the takeoff and landing of the 701, but these usually fly only in the morning and evening when the air is calm. The Zenith 701 has a short span wing with a very high coefficient of lift and a higher wing loading, so it is not unusual to see one flying in 25 knot winds, in the mechanical turbulence that usually accompanies that sort of weather. The slats and full length flaperons result in a coefficient of lift of as high as 3.3, and this means a short wingspan of 27 ft for efficient hangaring, and nimbleness in the air. The short wing is also much stiffer and lighter,

Artful and subtle design create a strong and light structure that can take a beating, even when loaded up with a 100 hp 912S and a set of amphib floats.

increasing the payload of the 701. The Junkers flaperons are used to provide excellent control right down to stall. There is no washout in the wing itself – all washout is by the difference in the angle of attack of the inner and outer flaperons.

The slats develop their amazing lift at a high angle of attack, and this requires a fuselage tailcone with a steep rise, to keep the tail from banging the ground on takeoff. The horizontal stabilizer has an inverted airfoil to provide maximum downforce with minimum drag, and it is mounted on top of the fuselage for ground clearance. The bottom of the all-flying rudder is cut at an angle too, again for ground clearance during high angle takeoffs.

The wing of the 701 is all aluminum, with a built-up main spar from ¾" aluminum angle .090" thick and a shear web from .025" with stiffening holes down its length. At the outer end where the loads are light, the spar becomes a .025" channel, bevelled on its bottom surface for the Hoerner wingtip. The forward spar is stressed to the usual Zenith standard of +6, -3 ultimate. Chris began his career by doing stress analysis for the Concorde, so his numbers are credible. The spar is hard-riveted, and everything else on the plane uses Avex pulled rivets. The D-cell has four slots along its length for the standoffs that support the slats from the nose ribs. The rear spar for the 701 is a series of short aluminum sheet channel sections, fitted between the rear ribs. The wing skins continue past the rear spar and are squeeze riveted together right at the trailing edge. The result is a rigid and light torque box. Lift struts are usually round steel tubes, but airfoil section aluminum lift struts are used by some. Round steel tubes are very draggy, so some builders have made .016 aluminum streamline fairings from material left over from building the rest of the plane. Members Jay Davis and Gerry Poulton have both done this and have reported an increase of 5 mph, very worthwhile for an afternoon of work.

At high angles of attack the slats funnel high speed air over the top of the wing, and keep the flow attached

The slats have even determined the type of landing gear on this plane. A tricycle gear can be rotated to a higher angle of attack, so this was chosen for the 701. Because this plane can get in and out of anywhere, the landing gear must be strong and compliant to handle the rough ground that the plane will encounter. Early models had a flat spring aluminum main gear with 3/16" aluminum forks. These forks were later reinforced by top doublers to give better lateral stiffness. The latest gear, completely retrofittable, is the four-bend aluminum "jeep" gear, which is usually fitted with wide flotation tires. The earliest 701's used plastic nosewheels and aluminum spiderweb Azusa main wheels, some with drums and some with discs. The latest planes use wide Matco wheels mounted on cantilevered axles bolted to the sides of the jeep spring. The Matco and jeep gear combination is the preferred combination, but check the inside flanges for cracks after a hard landing.

The steerable nose gear is a simple tubular plunger suspended on bungee. There is an aluminum fork bolted to the bottom of this plunger, and the latest model's fork has been widened for tundra tires, and now carries a top doubler. Mid-series models used the same spiderweb aluminum wheels as on the main gear. Whether the tundra tire is necessary for the nose depends on where and how the plane is landed. Some owners use a $19.95 wheelbarrow wheel and tire on the nose, and even it seems to work well enough for normal use.

The fuselage of the 701 is constructed primarily of 6010T6 aluminum sheet that is .016" thick. A 4 x 12 sheet weighs under 12 pounds. The tailcone of the 701 is made from four flat panels that are reinforced with .025" aluminum ¾" angle stock, to minimize oilcanning. The four flat sides are connected by .040" aluminum angle stock, riveted with corner gussets. Two bulkheads at the rear give torsional stiffness to resist rudder loads, and the rearmost car-

Right: Nose gear is suspended by bungee
Below, Left to Right:
1. Rigged at 8 degrees, Gerry Poulton's 80 hp 701 gets off the water within a few hundred feet
2. Heintz's trademark all-flying rudder, and inverted airfoil stabilizer
3. late style main gear with tundra tire
4. early main gear with Azusa wheel

ries the rudder hinges. Even with the .025 angle stiffeners, the sides of the tail cone will rattle like distant thunder if the engine is a 912 that is reluctant to start. Some builders have lagged the insides with foam, but this adds weight. Others have used their fluting pliers to crimp the .025 stiffeners, bowing them out slightly to dampen the resonance. Once the 912 engine is up to its 2200 rpm idle speed, none of this matters because there is no more sympathetic vibration.

The forward section of the fuselage uses aluminum sheet in thicknesses up to .040, depending on the particular part. There is a .040 channel under the seat to accept the flat spring landing gear, and it is tied into the forward seat bulkhead that carries the centre stick controls. Seats are married into the fuselage sides to give lateral stiffness to the structure. The forward fuselage sides are stiffened by a series of .025" angles, and by 4130 tubes that descend from the forward wing carry-through. The doorframes are the cabanes for the wings, and the rear one is supported by the monocoque seats and the package shelf. There is a bulkhead at the cabin rear, at the vertical station where the tail cone attaches. Every part does double duty in this design, another reason for the lightness of this plane. The forward wing carrythrough is welded from 4130 tube and has "seaplane braces" that mate to the upper motor mount bracket, sandwiching the steel firewall and providing a straight load path to the engine. Doors are usually made from .016 sheet with framing from 3/8" aluminum tube, and .040 lexan for windows. Some builders make slider windows, others make them completely removable for summer flying. Some even leave the doors back in the hangar on nice summer days. Zenith now sells clear lexan bubble doors that increase the elbow room from 40" to 44". Some builders have added lexan windows behind the doors to improve rearward visibility. The drawings show clear lexan for the cabin top, and this provides good sightlines in the circuit. The forward fuselage section and the tailcone are built as separate subassemblies, so the standard 4 x 12 building table will suffice for construction. Before building a table your own, check with your chapter or on the RAA National e-mail forum to see who has one sitting in his garage. Members will frequently loan a table or even give it away.

The vertical tail of the 701 is unusual. The rudder is all-flying, hinged near the bottom from the rear bulkhead. The tapered spar is .025 aluminum reinforced at the flanges with .040 angles. The nose is a D-cell with only top and bottom ribs. There is a

series of ribs to support the flat sides of the rear .016 skin. Zenith sponsors rudder workshops several times a year, and many who attend never go any further. If you are plans building, rudders are a dime a dozen. Watch out though for skewed ones though. This part must be built carefully to end up with a straight part. The rudder hinges are made from 1/8" wall, ¾" aluminum angle, and the pivot points are bushed with short ¼" steel tubes. The load on these hinge points is high, and cleanliness and lubrication is essential to prevent wear. Member Tom Mills recommends Castrol motorcycle chain lube, because its vehicle evaporates to leave a clear lubricant in the pivot. Tom uses this at all pivots for the control surfaces, and also for the nose gear plunger.

The horizontal tail has an inverted airfoil to minimize drag while providing the downforce to achieve a maximum climb angle. The stab has two channel spars, and the elevator has one. Hinge points are at the ends and also at the centre, and the cable-operated horn is tucked under the nose of the rudder. The stab is mounted to the fuselage upper longerons by aluminum angles and doubler plates, to carry the loads to the fuselage side skins.

Flying It

OK- what does it fly like? Here is a typical circuit with two 200 pound pilots and a full 40 litre cowl tank. We used Tom Mills' plane, fitted with an 80 hp Rotax and an Ivo 72" three blade Patriot prop. Give the 912 full throttle and pull back slightly on the centre stick. Within a hundred feet the airspeed is 40 mph and the wheels pop free of the ground. Immediately pull back to hold 60 mph for climb. This results in a surprisingly high angle, and anyone accustomed to a Cessna will want to climb at 70 mph, or pull back a bit on the throttle until he becomes accustomed to the angle. Because of the high climb angle, the forward speed will be something like 45 mph at this stage. Circuit height can be reached before the end of a 4000 ft runway with only a 5 mph headwind. Pull back to 5000 rpms, turn crosswind, then downwind and check the gauges. The 80 hp 701 will be clipping along at 75 mph at this power setting and weight. Tom's test plane is used for ultralight training so its prop setting is biased towards climb. With this setting this plane will hit 85 mph fully loaded at 5600 rpms. It will actually go faster but the throttle must be pulled back to prevent overspeeding of the engine. A slightly coarser setting would probably better suit most pilots, and provide another 5 mph. Hold circuit altitude until the base to final turn, one-half mile out from the numbers and pull back to idle. Lift the nose to maintain 55 mph in descent and hit the numbers, feeding in a bit of power to slow the slow the rate of descent during flare. The landing will take fewer than 200 ft, and this is without the flaperons. There is none of that Cessna

Ultralight instructor Tom Mills in his plansbuilt 701

This is a plane for flying a couple of hours to a fly-in, for landing on a riverbank to fish, or on a farm driveway to visit friends

glide in a 701, nor is there much chance of ballooning. If there is any fault with the plane it is that the pilot must fly it right to the ground, and then flare. With the nose high, the flying stops at just under 40 mph. Flare ten feet high and the landing will be a hard one. Pilots report that the power-off stall is a gentle mush with an automatic recovery, almost a non-event. Power-on stalls require a determined pull on the stick, and if top rudder is applied to correct a wing drop, it might just be possible to enter a spin. It would take a determined effort to get enter a spin, and most have never been able to approach it.

Seventy-five mph for cruise uses less than 15 litres of 87 octane auto fuel per hour, so the 40 litre cowl tank provides almost 200 miles of useful travel with a half hour reserve. Wing tanks hold 40 litres each, and more than triple the range of operation. Seventy-five mph might not be impressive to some but it compares well to a J-3 Cub. When the 701 is fitted with the 100hp 912S engine and a Woodcomp prop it becomes a much livelier plane. Tom Mills recently test flew a newly-completed 701 at Brampton and it would actually hit the Vne of 110 mph, verified by his GPS. The cruise on this plane is 100 mph, and Tom gives much of the credit to the Woodcomp. This is a plane for flying a couple of hours to a fly-in, for landing on a riverbank to fish, or on a farm driveway to visit friends, in short for any sort of sport flying that doesn't involve long cross country distances. Even with the plane's moderate speed, Jay Davis and David Chesterman have flown their 701's from London Ontario to Oshkosh, by the Northern Michigan route.

Don and Beate Kingsley used their original 80 hp amphib 701 as the grocery-getter when they lived on an island. When they moved back to the mainland, they sold it to get a bigger plane so that their dog Jack could accompany them on trips. Don is now building another amphib 701 because he misses the fun of the 701. Gerry Poulton fitted his 912-powered 701 with a set of Puddlejumper amphib

Rigged at 8 degrees, Gerry Poulton's 80 hp 701 gets off the water within a few hundred feet

floats and loves it. At first he had the floats rigged at a 4 degree angle to the wing and found that the tails of the floats were dragging when he tried to rotate. He had to attain an excessive speed to gain enough lift for takeoff. Rerigged at 8 degrees, the plane pops off at 40 mph because the wing is at a high enough angle of attack to develop good lift. The downside is that there is more drag from the floats while in flight, but the tradeoff is worth it. Zenith recommends as high as 12 degrees for some applications. Amateur-built and U/L registered 701's may be fitted with any floats that the owner prefers. Planes registered AULA must use Zenith floats only, because Zenith's DS10141 statement to Transport states that the combination has been tested and will meet the requirements of the category.

Many builders, especially those building from scratch, frequently want to fit engines other than the 912 series Rotax. Here are some cautions: do not fit any direct drive VW conversions that use a prop in the 52-60" range or the low prop efficiency will kill the STOL performance of this plane. Even 2 strokes with 64" three blade props will not deliver the goods. Choose an engine that will develop 80 hp and can turn a 68-72" prop, while weighing less than 200 pounds. This rules out Subarus too because they generally come in at 230 or more pounds, and will require a lot of tail ballast to balance. Tom Mills tried a 200 pound Geo Metro 1300 and used it for three years of flight training, but it felt like about 70 hp. Right now the only engine that will make the 701 perform is the Rotax 912 or 912S. Fortunately there are a lot of 80 hp half time engines, and even some rebuilds on the market. When Rotax came out with the 912S, owners of all types of planes began selling their 80 hp engines. It is still not a buyer's market

Anyone interested in a 701 should spend an evening reading the Zenith design college section on the factory site, and cruise the links for building tips

but the prices are low enough to compete with a converted auto engine and redrive. Gerry Poulton's 701 was originally powered by a so-so Subaru EA81 and it was a disappointment. For $10,000 CDN he bought a zero timed 912 from Tri-City Aero and has been flying happily ever since. On the used market, a 701 with any 912 is usually offered for $30-45000, depending on whether it includes floats or skis. 912 701's get sold quickly. Any other engine attracts only the tire kickers.

There are a lot of copies of the 701 being built all over the world, and they all claim to have made improvements. Some have rounder fuselages, some have conventional wings and tail, some have longer wingspan, and all claim to be better than the 701. The www.zenithair.com website even devotes space to these imitators. Anyone interested in a 701 should spend an evening reading the Zenith design college section on the factory site, and cruise the links for building tips. Member Mark Townsend has his own website, www.701.com devoted to this plane. There is so much information available on the 701 that no one has to worry about getting stymied during construction. The plans are well drawn, and a builder can choose any route from complete scratch built to a full kit. All subkits are available separately, and the newsgroups can often lead a builder to a partially completed project at a bargain price.

With the new Light Sport category arriving in the US, Chris Heintz is now building the prototype of a larger version, called the CH 750. The plane will have two feet more wingspan with the same chord and airfoil. The fuselage will be a couple feet longer with larger tail area, still using the inverted airfoil for the stab. The landing gear will be stronger to handle the higher gross weight, and the fuselage will be widened a couple of inches and will use the CH601 firewall and nose gear. This plane will use two different 100 hp engines, the 912S, and the O-200. Chris Heintz feels that the new US Sport Pilot license will attract the older crowd who are afraid of losing their medicals. These pilots will feel more comfortable with a Continental, so Chris has convinced Continental to go back into production with the O-200. This CH 750 will be an excellent STOL aircraft.

From fifty feet away the new CH 750 will look just as beautiful as the current CH 701. RAA