



FLIGHT TEST | Airglow HPA

Pilot Powered!

Flying an aircraft that's powered just through the efforts of furious pedalling by the pilot is tougher than you might think, and you need a whole team of helpers to get to the point you rotate for flight...

WORDS JOHN BOYCE PHOTOGRAPHY ED HICKS



“Airglow has the same wingspan as a Boeing 737, but weighs in much less than half the weight of paint on the Boeing!”



Opposite Team mates John Boyce, Sam Morley and Darren Arkright unload and assemble the fuselage
Top and above The wing is made of seven separate sections, and a pre-bend load must be added to the centre three sections to attach the upper flying wires
Left Each HPA is registered with the BHPFC
Below The wing is attached to the top of the fuselage structure with two pins



Social media has a lot to answer for, but in my case it was the reason I found myself involved in this most bizarre branch of aviation. Sheltering from horizontal rain in the outer Hebrides whilst on a cycling trip, a few minutes browsing Facebook found me reading a post asking for cyclist/pilots to take part in a competition. Intrigued, I responded. There were texts, emails and broken phone calls full of static, but once I heard all the information I was hooked. My journey into the esoteric world of human-powered flying would start whilst cowering in a gale behind a wall with two Highland sheep.

Less than one week later I arrived at Sywell for the Icarus Cup, a Human Powered Aircraft (HPA) competition run by the British Human Powered Flying Club (BHPFC). This is an annual event, where teams take part in a series of tasks, earning points towards a grand total and a chance of winning the coveted Icarus Cup.

The alarm goes off and it's still dark. Stepping outside into the dawn of a very early July morning, I have my first glimpse of the delicate machine that is known as Airglow as the first rays of sun settle on her carbon tubes. As each section is carefully withdrawn from the coffin-like trailer my first impressions are that of a well-worn, decades-old model aircraft on steroids.

Well, that's not too surprising because she basically is a gargantuan model aircraft built with modelling materials and modelling techniques.

Oh, and she is decades old. Three decades next year to be precise. And she has survived multiple crashes and rebuilds. All HPAs are experimental aircraft, with enormous wingspans, very much at the mercy of any unwelcome gusts or wind shear, and Airglow sports many battle-scars.

As the aircraft is gingerly assembled I can't help but marvel at the intricate construction of the wings – scores of foam ribs interconnected with balsa wood and Kevlar string, all covered in ultra-light heat shrunk Mylar. Airglow was designed and built by John Macintyre, his brother Mark and Nick Weston in the late 1980s and had her maiden flight at Duxford almost 30 years ago. She has the same wingspan as a Boeing 737, but weighs in much less than half the weight of paint on the Boeing!

I cannot begin to comprehend the thousands of hours of painstaking and delicate work that went into the construction. Almost all components, including the complex gearbox, were designed and hand-built by John and his team. John still attends every Icarus Cup and is hugely supportive of the team, and happy to keep sharing a wealth of aeronautical knowledge. It's clear he loves to see his brainchild fly, but must wince with her pain each time a novice pilot unceremoniously dumps her on to the deck.

The total wingspan is about 30m with the supertips ▶

fitted. There are two sets of wingtips, which can be swapped out in moments.

The extra long ‘supertips’ are for unassisted take-offs and endurance tasks, and shorter ones for speed trials. The aircraft behaves completely differently in these two configurations and this presents further challenges to the already overworked pilot. We also use different lengths of flying wires for different weight pilots, as the length of these determines how much wing bend, and thus dihedral, is developed in flight. Long wires, supertips and a heavy pilot produce an almost ghostly spectacle of flight. Gossamer wings reaching skyward, defying the Earth its bonds.

Pre-flight begins with a ground-run and power check of the engine, in other words blasting up and down the runway on your bike to try and wake up sleeping legs and lungs.

You need to be fit to fly an HPA. I’m a regular cyclist, but I’ve been training hard for six months for this event. It is difficult however to fully prepare for the sudden burst of flat-out power required for take-off in the very early morning after just a few hours sleep.

Climbing in is a feat in itself. The aircraft is very fragile and you have to feed your rear end in first, then bend double to get your head in the small gap in the thin Mylar cockpit cover without damaging it. A finger carelessly placed will easily puncture the covering which will then require a hasty repair with a strip of Sellotape. The seat is a thin aluminium frame covered with stretched canvas.

Weight is everything in the HPA world. I even take off my watch and belt before each flight, that’s another 200 grams, or about one watt saved. Likewise, a pee behind a tree before flight can save you around two watts. Take-off power required at my weight is around 400 watts. To put these power figures in perspective Chris Froome, (four-time Tour de France winner) puts out around 400 watts in a long climb, but this is for an hour or more, we only have to manage a few seconds! Chris’ breakaway power can exceed 700 watts. At 75kg I’m one of the heaviest pilots in the competition. The absolute maximum weight in Airglow is 80, but most of the competitors are sub-70. Any pilot over that soon discovers that any extra weight comes with a price.

If the exterior appearance hadn’t already convinced you this was a highly unconventional aircraft, once you’re in the cockpit, the complete lack of any panel or instruments will soon convince you that this is far from normal. Airglow once had a small LCD display with airspeed and other data, but this no longer works, so it has to be flown purely by feel, and there’s precious little of that due to the fly-by wire control system. This sounds wonderfully sophisticated but in reality it’s a joystick harvested from a model aircraft remote control transmitter linked to model aircraft servo motors.

Fore and aft is conventional in controlling pitch, but left to right on the stick controls the rudder, your legs being very much otherwise engaged.

The cockpit space itself is claustrophobic, and

extremely hot when the sun shines. Imagine doing a gym workout inside a very small polytunnel!

Pre-flight preparation includes moving the seat to each pilot’s individual position as the distance to the pedals is critical, and then adjusting the pitch trim to compensate for the change in CofG.

In an aircraft weighing in at under 50kg, a seat change of just centimetres fore and aft has a dramatic effect. Trim is not possible in flight and is achieved by moving a split pin on the elevator actuator. This sets the neutral position of the elevator but also affects the ratio of up/down elevator available so this must be done with great care, though it is initially an educated guess for each new pilot. A piece of masking tape on the tailboom tube records individual settings against the initials of every pilot.

The seven wing sections are assembled and attached to the fuselage at the beginning of every flight session and dismantled afterwards, so a good pilot will check all the retaining pins before flight.

From the cockpit the pilot then calls for a control check to ensure correct sense, and I always ask the boom man to bend down and check the bicycle brake blocks are free as they have a habit of sticking. The last thing you want is any hint of drag, and to have every bit of power available going into the prop, not producing heat.

The 2.9m diameter prop is a pusher, driven by a gearbox at the pedals, through a drive shaft which in turn drives a sprocket and a very thin, very long bicycle type chain up to the prop itself, which ingeniously rotates on a tube around the main fuselage tube. The blades are thin carbon fibre, and each one weighing little more than 400 grams.

Preparing for ‘that’ take-off

Every flight requires a team of dedicated helpers, often at very unsociable hours. The kindest weather conditions are found in the earliest part of the morning as the sun is rising, and the rigging process will have started much earlier.

You need five ground handlers for each launch, one pushing on the fuselage tube and one on each flying wire to support the wings during the initial take-off run, during which time the pilot has absolutely zero roll control. You also need two chase bikes to follow along and grab the wings after you land, to prevent them from touching the ground.

During the daytime there’s usually too much wind and thermal activity, so those hours are spent making repairs or trying to catch up on sleep before the evening session when the winds die down. It’s not unusual to rise at 0415 and hit the sack after 2300 during the competition and tempers become very fraught as the week progresses.

Once all checks are complete, you have to begin focusing on the task ahead. ‘Clear prop’ is the shout to signal that the pilot now has control of the propeller, i.e., feet clipped into pedals.



Top The wingspan with supertips is almost 30m, almost the same as a Boeing 737

Above left Masking tape note records trim, pitch and seat positions against pilots’ initials

Above right Attaching the flying wires is a fiddly job

Left Airglow is turned using just rudder, which is mounted on the side of the tailboom

Below left Fly-by-wire at its simplest... the flying controls are operated by model aircraft servos

Below Mounted on the very front of the fuselage tube structure, the pedals and gearbox were hand made by Airglow’s designer John McIntyre

Right The hand made carbon fibre propeller blades weigh just over 400g each



Slowly winding the prop up gets the blood flowing in your legs. I am now rehearsing the flight in my mind. The burst of power needed for take-off, the level-off at cruise, assessing drift and concentrating on the gate ahead. The gate is usually two flags, 10m apart. If you miss the gate you score no points. Where's the second gate? What's the wind doing? The nerves are jangling at this point, there's so much to pull together, an improbable mix of piloting skills, split second judgements and raw athleticism.

When you're ready you make the calls to the runners in sequence, 'walking', then 'running', whilst speeding up the pedalling to full power when you yell, 'ALL OUT, ALL OUT'. At this point the runners drop off, the 'fuse man' gives his last push of assistance (hoping he gets out of the way, or else he will get clobbered by the fragile tailplane) and you are on your own...

Unassisted take-offs are possible, and are one of the competition tasks. You are allowed just one wing handler to keep the wings level but all forward propulsion must come from the pilot's legs. This is a tough task. As with any aircraft the prop is initially stalled, just churning air, and it takes a lot of energy to get the aeroplane moving at all.

You know when you're approaching rotation speed because the loud noise from the solid plastic nosewheel reverberating around the hollow cockpit becomes intermittent. Time for a gentle squeeze of back stick, a bit more power and when it all goes quiet you know you are airborne! You now have to keep the power going in the climb to the dizzy cruising height of around three metres.

Once levelled off, the power requirement drops by

about 30 per cent but as soon as you begin any manoeuvre you need to wind it back up to full chat.

The 500m slalom is particularly demanding, you are constantly turning so it's a full-power-all-the-way task. Points are scored each time the fuselage fully crosses the centre line.

Control harmony in the two axis you have is very like the instruments – zero. Roll is achieved by secondary effect of rudder and the large dihedral adopted by the wings under load. Roll response is, at best, laboured. In performing the slalom, you apply rudder and power (legs), then wait. As soon as you feel the turn beginning to develop you need to start the counter-turn or you will overshoot. In a crosswind this effect is hugely magnified due to wind gradient.

With a 30m wingspan the upward wing in a turn is in much faster moving air than the downward wing so you have to anticipate this impact and make the counter-turn input even earlier. If careless, you can easily reach a point where you lose the authority to reverse a turn. This happened to me last year, resulting in a nasty groundloop.

Crosswind gusts

Turning is very slow in Airglow with a turn radius of around 100 metres. If you bank too hard you will never recover, the inboard wing will stall and dump you on the ground. Crosswind gusts can easily put you in this situation too. Airglow suffered major damage once due to a cross-gust, the pilot narrowly escaping injury.

In pitch the response is painfully sensitive, always seeming that if you do any more than think about



Images: Airglow team



Above John Boyce reattaches the pod following some mid-competition maintenance. Note the long thin chain drive that runs behind the pilot's seat

Above inset Airglow is controlled using the joystick from a model aircraft controller. The stick is mounted at eye-level to the upright carbon tube in front of the pilot

Left Propeller hub rotates around the main fuselage tube. The blades have three pitch settings, which are set using cotter pins

Right Fragile wings sag under their own weight prior to flight



Below The wings take on an insect-like shape in flight



“Flights in HPAs are short. My first one was less than one minute, but it's a unique experience, and I'm told more people have been into space than have flown an HPA”



Airglow settled comfortably into cruise flight

Lucas Arkwright

Other HPAs

“For once you have tasted flight you will walk the Earth with your eyes turned skywards, for there you have been and there you will long to return.” Leonardo da Vinci first dreamed of human flight in the 15th century. He drew fantastic designs of bat-like flying machines before realising his folly and coming up with a design for a single monoplane wing, which is the basic principle behind most aircraft of today.

SUMPAC (Southampton University Man Powered Aircraft). The first genuine flight of a human-powered aircraft was that of SUMPAC in 1961 when Derek Piggott took off and landed under his own power. SUMPAC was designed and built by students, and managed 64 metres on its maiden flight. It clocked up 40 successful flights and recorded nearly 600m on one flight, before being retired in 1963 after a crash. This was the birth of real human-powered flight and rekindled a worldwide interest in the endeavour.

Another notable UK HPA was Phoenix – wingspan 32m, weight 47kg. This was an innovative all-inflatable wing with a huge wing area. First flown in 1982 at London Docklands, piloted by Ian Parker. Phoenix went on to make numerous successful flights.

Probably the most famous HPA of them all is Gossamer Albatross – wingspan 30m, weight 32kg. Designed by Dr Paul B MacCready, she flew the English Channel in 1979, winning the £100,000 prize money which had been put up by industrialist Henry Kremer in 1959.

Currently in the UK, besides Airglow, there is Aerocycle. Designed by John Edgley and with a wingspan of 24m and weighing 39.9kg, Aerocycle is similar in design to Airglow but with a fully braced wing – so no flying wires. She has proved a successful type, winning this year’s Icarus Cup and setting several new records, including Niall Paterson’s triangular flight and new Icarus Cup distance record of 2.6km.

There’s also Betterfly. Designed and built by David Barford, Betterfly, wingspan 23m and weighing 40kg, has a large wing area and a low flying speed making her a great aeroplane on which new pilots can cut their teeth. She was third in the Icarus Cup this year and set a new UK distance record for a female pilot.

More information can be found on the British Human Powered Flying Club website www.bhpf.org.uk



Above
Aerocycle



Left
Betterfly

pitching up, the nose rises sharply and with cruise, VNE and stall speed so perilously close together, this is to be avoided. I know all about the stall in Airglow. Last year I took off from grass and due to a mixture of factors, poor trim, gusty conditions, etc I went up at 45° straight into a full aerodynamic stall. There are no warning signs, no buffet or stall warner, she just stops flying. At about 10ft off the deck this posed a significant problem! As a GA pilot in this situation the brain calls for two things: stick forward and power.

Stick is easy, now for power – ah yes, pedal like your life depends on it. Well it does actually because all you have between you and the tarmac is a strip of seat canvas and a carbon fibre spar which, when shattered, becomes 10,000 stilettos pointing directly at your posterior! I posted a record power output on the Garmin cycling computer of just under 700 watts in those few seconds of frenetic activity, and incredibly, Airglow skimmed the ground whilst just recovering flight. However, the next gust put me in to the aforementioned groundloop.

Keep pedalling...

Landing is fairly straightforward, with the landing sequence usually being initiated once your lungs and legs deciding enough is enough! However you can’t just stop pedalling as she will descend too quickly, and you also lose authority over the tail surfaces near the flare due to the loss of propwash. So it’s a gradual reduction in power, then add a little burst of pedal as she settles as this softens the landing especially on hard surfaces.

Watching bad landings, including some of my own, reveals astonishing wing and airframe deflections on impact, and there is video footage of my terrible groundloop where the wing bends to horrifying angles yet remains intact.

Someone recently asked me if I’d had much opportunity to practise for competitions. My questioner was amazed when I said I’d never flown a single flight in Airglow outside of the competition.

Practice flying is a problem, you need a lot of help and you need perfect weather, so it rarely happens. My first-ever flight in an HPA was on day one of last year’s competition at Sywell.

I quickly discovered that day what real PIO is, and as a 700 hours pilot I was disappointed to find myself porpoising my way down the runway in Airglow like the Loch Ness monster chasing a tourist. The problem



TECH SPECS

is trying to produce constant power. Every time you back off, or power up it affects the pitch of the aircraft, and the effectiveness of the tail surfaces. Just imagine trying to do a smooth take-off and climb with somebody pumping the throttle in and out of the instrument panel.

The Icarus Cup is awarded to the pilot who scores the most points, and this leads to some serious competition within teams, each pilot vying for a chance at every flight.

Team Airglow only had two pilots this year, myself and the young, light and hugely enthusiastic Reuben Arkwright, so this was not a problem for us. However, over the other side of the airfield, Team Aerocycle fielded a team of eight, so there was some serious competition going on. There's also the team challenge and the team that amasses the most points wins.

Personal accomplishment

I was lucky enough to be able to complete the 1km flight, a milestone for any HPA pilot. I will never forget the sight of the yellow 1km flag finally disappearing under the cockpit as my energy sapped and the light faded. At 59 this was a huge personal accomplishment and I am still buzzing from the experience a month later. My team mate Reuben was thwarted by rain on his attempt, but he is young and will certainly do it next time.

We learned that day that it is pretty much impossible to fly an HPA with wings covered in water droplets. Apart from extra weight, the raindrops disturb the airflow too much and once airborne it felt like trying to fly a canal barge! Needless to say, it was a very short flight.


It takes a while in any new aircraft to get a proper feel for it, but flights in HPAs are short. My first one was less than one minute, so the learning curve is very steep. But it's a unique experience, and I'm told more people have been into space than have flown an HPA.

To simply fly Airglow in a short hop is actually not that difficult and the HPA movement is keen to bring new pilots into the sport.

But to fly her well, and in a competition environment, is a very different thing. You have to employ surgical control inputs on the tiny joystick while your whole body thrashes with the Olympian task going on below the waist, and be able to make instant piloting decisions while under extreme stress.

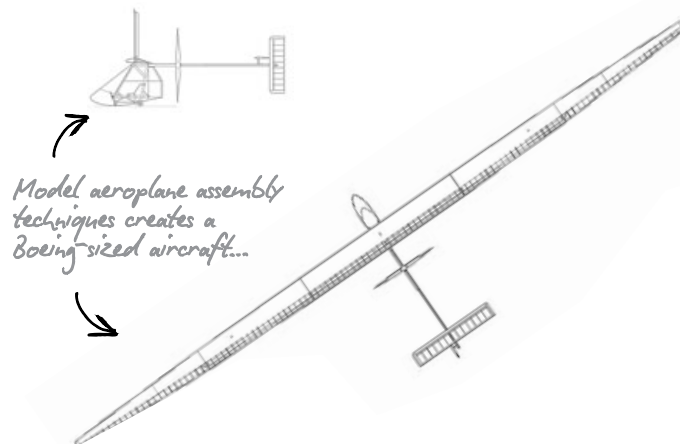
However, flying an HPA is a truly magical experience, and I will not forget my first flight, the sublime feeling of being aloft and controlling an aircraft solely powered by your own body is really quite moving.

The Icarus Cup is an annual competition, but the odds are stacked against the teams and pilots from the start. There are winners and runners up each year, but for me, every flight in a human-powered aircraft is a minor miracle of aviation.

Team Airglow is currently seeking a new sponsor in order to continue competing in 2020. Any interested parties should email sponsorship@teamairglow.co.uk. 

Airglow HPA

Where the pilot is the powerplant...



Performance

VNE unknown
Cruise speed 18-19kt
Stall speed 15kt
Rate of climb @ 500w (.65hp) & 75kg pilot - 38fpm
Service ceiling not tested
Range not yet fully tested

Weights & loading

Seats One
Max take-off 120kg
Empty 41kg
Payload 79kg
Fuel capacity Zero
Baggage capacity Zero

Dimensions

Wingspan 29m
Wing area 26m²
Length 8m
Height 3m

Spec

Airframe Carbon fibre cockpit and spar, balsa wood, foam, Kevlar string, all covered with 16 micron Mylar
Engine Legs
Cruise power around 300w (0.39hp)
Propellor 2.9m dia carbon fibre, ground adjustable
Avionics None
Undercarriage Twin, inline

Manufacturer

John and Mark McIntyre, Cambridge, England

Price

Priceless!

Web

www.facebook.com/TeamAirglow



Above Flight completed, the pilot can rest his legs. Then it's just a case of waiting for the crew to come and carry Airglow back to the take-off point