
HATCHED
BRANDS

THE DR107 ONE DESIGN

A CAPABLE AND AFFORDABLE MONOPLANE AEROBAT

By Phil Burgess

Aerobatics as a sport is constantly evolving. As new aircraft types become available with ever increasing performance, the rule book has had to develop to include ever more demanding aerobatic figures to challenge the pilots. Gone are the days when you could compete at unlimited level in a Stampe! Of course, it's not just unlimited level that has changed, there are five levels of aerobatic competition in the UK and each has grown to include tougher figures to keep them demanding enough to be meaningful.

This arms-race has seen a proliferation of high performance monoplanes in recent years, all utilising state-of-the-art construction techniques in various ways. They all have one thing in common though – they come with an eye-watering price tag and huge running costs, putting them out of reach to the average pilot. However, as new designs emerge, it becomes possible to buy the older ones second-hand with the result that we see them filter down into the more junior levels of the sport, often helped by pilots' belief that they need to spend more in order to improve their scores.

At the Advanced National Aerobatics Championship this year there was an impressive array of such machines supporting this trend, with one notable exception. Unlike its rivals, the aircraft that won the National Championship title didn't have a six-cylinder engine, wasn't built in some sterile factory and didn't require a second mortgage to operate. It was a homebuilt DR107 One Design!

I've owned G-RIHN since 2009 and have campaigned her to great effect at intermediate and advanced level competitions, amassing around 50 medals ›

G-IIID has a 180hp Lycoming and is the only one of the trio to use a fixed-pitch prop – a compromise solution for weight and C of G

The author's G-RIHN in which he has had significant success against more complex – and more expensive – aerobatic monoplanes

and many trophies. I even won the Queen's Cup Air Race Challenge Trophy in 2011, flying a timed aerobatic sequence against faster and more powerful machines. Sure, there's a measure of pilot skill involved (that's what the game is all about), but the key to my success has, without doubt, been this incredibly capable yet affordable aeroplane. Thank you Dan Rihn for bringing the One Design into the world!

Back in the early 1990s there was much discussion in the USA and the International Aerobatics Club regarding the direction that the sport was heading, and a strategy was developed to try and make it accessible to a wider community of pilots. Of key concern was the ever-increasing cost of competitive aeroplanes and the dwindling numbers of competitors. The concept of a new class of competition was drawn up with the aim that all the aircraft would be the same, therefore removing any advantage a pilot might have by being able to spend more money on his machine. In order to make the concept appeal to a wider range of pilots, a relatively low-cost but high-performance aeroplane was needed, and Dan Rihn stepped forward to draw up a machine that would meet this specification.

Coupling his expertise as a Northrop Grumman design engineer to his considerable experience in building and modifying aerobatic aircraft, Dan expertly crafted the prototype, which first flew in 1993. A large number of experienced aerobatic pilots were allowed to fly it and after incorporating a few minor changes, the drawings were made available for homebuilders. The original concept specified a stock Lycoming O-320 engine driving a fixed-pitch propeller, and in this configuration the aircraft is very light and well balanced, but perhaps most importantly, also eminently affordable. A standard colour scheme was also agreed to offer the pilots a degree of anonymity in the interests of making the judges work a little harder for their lunches. The three aircraft in this article each have a variation on this scheme as in the UK we had the additional limitation that the area directly above the main-spar could only be painted white. This was to allay fears that localised solar heating of the glue joints might weaken the structure if painted a dark colour.

WEIGHTY ISSUES

Many builders opted for larger engines and constant speed propellers which, whilst adding some performance, also increased the overall weight, complexity and operating costs of the machine. The extra weight is all forward of the centre of gravity, therefore it becomes necessary to operate in the forward end of the envelope, which is less than ideal for the aerobatic purist in pursuit of such things as perfect spin entries, flick-rolls and dynamic freestyle handling.

All aeroplanes are born of compromise and sacrificing an ideal centre of gravity for increased vertical penetration and acceleration from slow flight are the main benefits for fitting larger engines and constant speed props. What is perhaps somewhat more debatable is whether the average pilot could put these benefits to any tangible advantage during a competition flight and whether it is worth the extra cost.

I have been very fortunate to have flown the three examples pictured here, each of which has a different engine and prop combination. The red aeroplane has a 180hp engine driving a fixed-pitch prop; the green machine (my personal mount) has 160hp and a constant-speed prop; and the blue example has 200hp and a constant-speed prop. We were also able

G-RIHN PHIL BURGESS

The majority of the build took place in Canada, and with about 90% done and 90% still to do the airframe was imported to the UK and completed by James Brown. After around 50 flying hours, the original engine and fixed-pitch prop were replaced with a brand new Lycoming/Titan ECI AEIO-320 and MTV-11C prop, a lightweight starter and alternator, Sky-dynamics cross-over exhaust and Airflow Performance fuel injection system delivering around 160hp. This results in a climb rate of 2,150fpm at max all up weight.

Phil purchased the machine at the end of 2009 and began stripping it to prepare for the coming aerobatics season. New cowlings and various fairings and fuselage panels were built to reduce weight and drag, and the new colour scheme and sponsors' logos were applied. All of this was achieved with just hours to spare, meeting the deadline of the first intermediate contest of 2010 – which he promptly won!

This aircraft has an analogue instrument fit with separate engine gauges used for ease of maintenance. As with most serious aerobatic aircraft, the sequence card holder dominates the panel, which also doubles as a mount for an easily-upgradable tablet PC running GPS nav software. USB charging is incorporated into the electrical system as is a stereo audio feed to spice up the transit flying to comps and displays. G-RIHN also has an awesome smoke system for extra visual impact at displays.

Neil Bigrigg's G-CVII is the most powerful of the trio with a high-spec'd 200hp Superior XP IO-360 and a constant-speed propeller

to carry out some rudimentary performance comparisons in flight to try and settle this debate. To gauge vertical penetration, we flew line abreast at the max level speed of the slowest aircraft. We then all pulled smoothly to the vertical and applied full power and waited to see who would go the highest before doing a stall turn and recovering. Interestingly, the red and green aircraft went up to about the same height, with minor differences probably being attributable to having slightly different weights at the time. The blue aircraft went up further, as you might expect, and probably topped out a hundred feet or so higher.

With constant speed props, the blue and green aircraft can accelerate quicker from low speed, which is useful when fiendish sequence designers put a high start speed figure after a low exit speed one. With a fixed-pitch prop, it takes more time and distance to achieve this without descending, which can compromise positioning when flying for a panel of judges. It's also easy to over-speed the fixed-pitch prop in a dive so your throttle hand is constantly on the move throughout an aerobatic sequence. Every time you move the throttle, an additional rudder input is required and all of these extra inputs reduce the available brain power for planning the perfect execution of the next figure.

While this was hardly a scientific test, the irrefutable evidence is that the 160hp green machine used less fuel to carry out this mission, which I take as a clear victory for my aeroplane – sorry guys! As it doesn't have a fuel flow gauge, it is difficult to give accurate figures but I reckon that I use about 40lt per hour flat out for aerobatics and somewhat less than 30lt per hour in a 130kt, 2,250rpm, 22.5in manifold pressure cruise. The fuel system is contained in the forward fuselage and has a 50lt tank that gravity feeds a 30lt 'acro' tank. This provides a good measure of utility – I recently flew 100 miles, then spent eight minutes displaying at full power followed by another 100 mile return transit before landing with a 25lt reserve on board. Many other types are limited in this regard as aerobatics aren't permitted with fuel in their wing tanks and their small acro tanks dictate that they must land soon after a display.

Other differences between the three examples featured here are a little more subtle. Builders have the option of fitting a one-piece, side-hinged canopy, which may be a little less draggy than the sliding canopy detailed on the plans. The side-hinged canopies would be damaged if opened in flight and the lack of a fixed windscreen may be a hindrance should you feel the sudden urge to try a spot of parachuting. Again, builders have to choose between performance and utility. The fuselage and tail surfaces are built from welded steel tubes and incorporate stainless steel bracing wires. Spruce stringers, an aluminium turtle-deck and fabric covering complete the rear fuselage, with aluminium panels covering the fuselage from the seat-back to the firewall. Two-piece carbon/glass fibre cowls envelop the engine and feature a variety of inlet configurations to suit the particular engine installation.

G-CVII NEIL BIGRIGG

"Keep the weight down and the performance up" was our mission goal for this award-winning aircraft build, says Neil. G-CVII (107 in roman numerals) was designed around a Superior XPIO-360 engine with lightweight oil sump, starter and alternator, dual E-mag electronic ignition, a balanced four-into-one exhaust system and an Airflow Performance fuel system. A huge MTV-15 constant speed propeller is used and all parameters are monitored by a Dynon FlightDEK D-180.

We obsessively tried to keep the weight off the airframe with the incorporation of simple control systems and extensive use of carbon fibre in all of the fairings to smooth the airflow and help make her fast. A good deal of future proofing was also incorporated into the build by the fitment of a Trig TT21 mode S transponder and a Becker AR6201 with 8.33kHz channel spacing.

Built over a six year period by Neil Bigrigg, Mark Davies and Ian Tunstall at a cost of £62,000 (but who's counting…), performance surpassed all expectations with horsepower pushing 200 and achieving a full-power, fully-fine climb rate of 2,500fpm at max all up weight. It was obvious from the very first flight that we had an aeroplane more than capable of what it was built for, which ultimately was to replace our beloved Pitts S2A and to take us on to win advanced aerobatic competitions.

At 55% power, the straight-and-level cruise of 2,100rpm and 21in of manifold pressure gives 144kt, with a fuel consumption of just 26.5lph, compared to a straight-and-level aerobatic full power setting of 2,500rpm and 25in of manifold pressure which gives 157kt and a fuel consumption of 60lph.

Now with almost 100 hours under her wings, she never fails to put a silly grin on our faces, either with her sheer aerobatic performance, including an unbelievable vertical penetration, or just as a time machine for going cross country.

(Above) **The panel of G-CVII features Dynon FlightDEK-D180 'glass', Trig Mode-S and a Becker 8.33 radio**

(Left) **David Kean's G-IIID uses a relatively basic Grand Rapids Technologies EIS 4000 for engine monitoring as part of a simple, budget panel**

There are several different styles of wing root and undercarriage fairings in use which have been incorporated into the design to counter reports of buffeting when pulling high g. Although much has been written on this subject in the USA, I haven't experienced this phenomenon in any of these three machines. I often wonder if this is a problem of piloting technique rather than a genuine issue and I'd be keen to see some hard evidence, perhaps from wind tunnel testing, as to which is the best type of fairing.

The wing features a tapering, solid spruce or Douglas fir main spar, ply ribs and ply skins, with optional glass fibre moulded tips. The wing is finished in lightweight glass cloth which can support a durable paint finish. The ailerons are push rod actuated with all hinges and bearing points assembled with adjustable rod end bearings and ball races. This results in a very strong and reliable control system which has a minimum of backlash and friction. The ailerons themselves are built up from spruce and ply and are fabric covered. They are mass balanced and as a result are surprisingly heavy for their size. Some examples have opted for aluminium ailerons which are much lighter resulting in lower mass balance weights being required, resulting lower inertia in the control circuit.

Standard features for serious aerobatic machines are the aileron spades. These small devices protrude forward of the aileron hinge line to provide an aerodynamic assistance to lighten the stick forces. By adding various shims and altering their size and position, the spades are adjusted to trim the aeroplane in roll and alter the stick force gradient over the range of deflection. Competition pilots spend many hours perfecting this set-up, tailoring the handling to their own preference. My own set-up produces a genuine roll rate of 360° per second at VA and although some claim to have achieved 420° per second, I find that to achieve such a roll rate, some control centring, break-out force and general feel has to be sacrificed. I'm more concerned with accuracy for competition flying and having the aircraft offer as much assistance as possible to free up my limited brain power.

The elevators have a similar aerodynamic assistance in the form of servo/trim tabs. The rigging geometry is designed to give much more assistance when pushing negative g than when pulling positive g. This keeps stick forces roughly symmetrical when pushing and pulling, and well matched to the aileron stick forces. In flight the controls are very light in pitch and roll while only the smallest movements of the stick are required to guide the aircraft around the circuit or to transit from A to B. Pitch stability is affected a great deal by the centre of gravity, and when loaded with overnight bags and other junk in the turtle-deck, the aircraft becomes even lighter to the touch. Care must be taken as only the smallest control inputs are needed and can produce a rapid pitch change at any airspeed.

G-IIID DAVID KEAN

G-IIID had several owners whilst being constructed, including me, before being expertly finished by Vernon Millard in 2005. I have had the fortune to own the aircraft for almost 10 years and I think that speaks for itself. I find the performance is significantly better than the Pitts S1S that I used to own, with roll rate and visibility from the cockpit being obvious improvements.

The engine is a 180hp Lycoming with an Ellison throttle body and a fixed-pitch MT propeller. It cruises at 125kt at 2,250rpm and 25lph,while 2,500rpm will produce 140kt but fuel flow rises to 38lph. The only analogue instruments are airspeed and altimeter. All engine parameters are monitored by a Grand Rapids EIS4000. A digital g meter records the evidence.

LEAP IN PERFORMANCE

Handling reports in magazines are often very subjective and depend a great deal on the relative experiences of the writer and reader if phrases like 'light controls' are to have any meaning. To try and put it into context, imagine flying the average club trainer and then stepping into something like a two-seat Pitts. This is pretty much how I progressed into aerobatics a few years ago and I'll never forget the highly responsive controls, the excess of power and the overwhelming sense of freedom poling this rocket ship around the sky. A similar magnitude leap in performance awaits those who venture further and try a single-seat Pitts, but the jump from any Pitts to a One Design is of an entirely different scale. It reacts so quickly to control inputs and can change direction so abruptly that it corners like it's in a cartoon. Even in a Pitts there is a barely perceptible delay when moving the stick as the airframe flexes a bit and the flying wires begrudgingly take up the slack under g. Not so in the One Design; if it wasn't for the feeling of the g force through the seat, you might believe you were in a low budget computer game.

Having said that, the One Design is not difficult to fly, you must just be aware of the

Doing what the One Design does best, bringing competitiveness and affordability to the Unlimited Aerobatic category

control inputs you are about to make. There are no twitchy aeroplanes, just twitchy pilots! Thinking in terms of stick position rather than stick force is required and this is especially useful when flying close to the stall. Imagine we are pulling out from a vertical dive; as the stick force doesn't build rapidly as speed increases and you apply more g, it's very easy to keep pulling harder and harder expecting the pressure in the palm of your hand to keep increasing. But once you realise that the aeroplane stalls with the same stick position regardless of speed, it's easy to avoid making this mistake. Although it's happy to fly with an impossibly high angle of attack, the drag increases exponentially as we approach the stall and it's therefore not an efficient use of energy to corner in this manner when we only have a limited amount of height or horsepower to replace it with.

When the high speed stall does occur, all the controls remain effective in their normal sense and the only indication is a very light airframe buffet followed by a sudden divergence from your previous flight path. It's a bit like cornering in a car and instantly developing serious understeer when you hit a patch of black ice. If flying out of balance the aircraft will drop a wing, although with the proper footwork this can be avoided. The 1g stall occurs at about 55kt in upright level flight, resulting in a high rate of descent rather than a pronounced nose-drop. To recover, a large forward stick pitch input is needed to re-attach the airflow to the wing. Trying to regain the pitch attitude from prior to the stall before the airflow re-attaches will result in a further stall and more height loss, despite the ASI winding up through 90kt. It's quite obvious when the airflow re-attaches as it will be accompanied by a small bump through the airframe, as normal service is restored. If attempting a stall in the climb at full power, bringing the nose ever higher will eventually result in a stall, at which point there is so much control authority left that full back stick and some balancing work with the feet can pitch the aircraft all the way round in a kind of micro-loop before diving to recover.

"It's a bit like cornering in a car and instantly developing serious understeer when you hit a patch of black ice"

Approaching to land, 80kt is about the minimum speed, as any slower and a tailwheel first arrival is likely. A gentle sideslip works well on final, although it is necessary to add 10kt as the ASI will over read in the sideslip. The main undercarriage legs are a one piece aluminium spring unit which give a ground angle that is much more nose-down than the stall angle. For this reason, you are definitely still flying even when all three wheels are on the ground, so pulling back on the stick at touchdown will load the tail-spring and launch you right back into the air again. Slight forward stick is needed on touchdown to avoid skipping and bouncing down the runway. Small control inputs are essential after landing as even at 65kt, with full aileron the One Design will roll faster than a Pitts S2A at 165kt!

Taxying is easy, with a gentle weave to clear the blind spot ahead of the nose. There's plenty of weight on the tailwheel so at low speed you can brake really hard without risk of nosing over. This gives a lot of confidence when taxying, but it's best to keep sharp turns down to a low speed as the risk of a ground loop is ever present. The view from the cockpit is better than in a Pitts, there is very little airframe out there to get in the way of your sight lines and the wing tips seem impossibly close. The adjustable seat back accommodates a variety of pilot shapes with your legs over the top of the main spar and feet raised up high. Unlike a Pitts, full aileron control can still be achieved even if you've got generously proportioned thighs like mine and the cockpit is proportioned to easily accommodate pilots of six foot two and over. The instrument panel is fairly small, limiting the amount of redundant gauges that can be fitted, which helps keep things simple and light.

The One Design is often compared to other aerobatic types as people try and work out where it fits into the grand scheme of things. In my estimation, and in overall terms when comparing performance against cost, they are top of the pile of the four-cylinder aerobatic aircraft that are available in the UK. There are a good many others in this group that cost more to own and operate, but at best only offer similar overall performance, such as the Pitts S1, Laser, Extra 230 and Edge 360. For this reason, the One Design certainly offers the best 'bang for buck'. In other countries, One Designs are even competing successfully at unlimited level at the hands of some very talented pilots. We will have to wait and see whether there will ever be a contest purely for aircraft of this type, as they are still a fairly rare beast despite over 600 sets of plans being sold worldwide. Even with this aspect of the design philosophy yet to be realised, the One Design has now earned its place in the aerobatic food chain in its own right, and it's definitely here to stay. ■