contributed by Grant Benns

Aerobatic Aircraft Design Quirks

HAVE YOU ever looked at a dedicated aerobatic aircraft and wondered what those things hanging off the ailerons are all about, or why a particular plane is flown from the back seat?

Over many years (decades... a century perhaps) aircraft designers have been tweaking and fiddling to produce the 'best' aeroplane for the job – it just depends what the job is. In the case of a competition aerobatic aircraft that job description includes high rates of roll/yaw/pitch, generous speed range, high rate-of-climb, good visibility and hot rod looks, because most aerobatic pilots are showmen too!

Of-course many aerobatic aircraft are just a modified version of your local club trainer, but even those planes will have modifications that separates them from their non-aerobatic kin. Quite often this is structural – thicker skins, more wing ribs, and heavy duty hardware, all of which generally add weight and ironically detracts from some of the key performance requirements mentioned above. They can also have other more visible differences – for example the C150 Aerobat has removable seat cushions (for wearing parachutes), a door jettison system and windows in the roof. In NZ all aerobatic aircraft must have a G-meter fitted.

However, the truly dedicated aerobatic aircraft has a whole host of 'goodies', all with the express aim of achieving the job description but as always in life there are compromises…

Aileron spades

I'll start with an obvious and very visual appendage, and one that kids of all ages always ask about. Big flight controls being constantly moved to full deflection - typically the ailerons - can generate large control forces that feed back to the pilot. An aileron 'spade' is sometimes used to reduce these forces by adding an aerodynamic surface ahead of the hinge point, similar to the rudder or elevator horn balance found on many aircraft. In un-deflected mode, there is no effect and little additional drag but as the control deflection increases the additional surface area and lift generated opposite to that of the control surface, lightens the control forces considerably. Much time can be spent 'tuning' these beasties to get the optimum feel – not too heavy, not too light.

Aileron Spades to lighten control forces.

Top and bottom ailerons on the Pitts Special.

Giles G202. The pilot sits behind the passenger.

Turbo Raven: 1400lbs of plane, 2800 lbs of thrust.

DR-107 One Design built from 'nature's composite'.

Aerobatic sights on the Extra's wingtip.

Big Control Surfaces

As you would expect, high rates of roll come from having big ailerons and large deflections. Many monoplaness have 'full-span' ailerons and most bi-planes (such as the Pitts Special) incorporate top-and-bottom ailerons. To further help with roll rate the wingspan is kept compact – this helps structurally too, considering the huge loads the wing must sustain when those big ailerons are pushed all the way over. Bigger control surfaces are also apparent around the tail in order to achieve the high pitch and yaw rates required for some manoeuvres. Once again, varieties of horn balances, balance tabs and or big springs in the control system aid in making the loads felt by the pilot lighter.

Back Seat Pilots

Tiger Moths and J3 Cubs have been doing it for 80 years, but putting the pilot in the back seat of a tandem two seat aerobatic aircraft has many benefits, and a few pitfalls. Sitting behind the trailing edge of the wing is good for visibility, as a great deal of aerobatic flight is devoted to checking out the view of the horizon beyond the wingtip, such as in loops, stall turns, and cubans. When flying with two on-board the passenger sits nearly on top of the centre of gravity, thus barely changing the handling characteristics of the plane. For passenger joy-riding the pilot can see where the passenger is looking (for the best view), and can also witness the colour fading from the cheeks later in the flight... The downside is an instructor sitting in the front can't see anything the student in the back is doing, in particular where they are looking. Some bi-planes have a mirror on the top wing to help in this department. Other downsides to this seating layout include a lack of visibility on the ground, access for the passenger, and increased G felt by the pilots (being further away from the centre of gravity).

Power-to-weight

Ever flown a plane with too much power? No? Neither have I, although the MX2, with 360hp and a take-off weight about the same as a C152, is getting close. The problem with most pilots is that after an hour or two you wonder what it would go like with 400hp!

The first Pitts Special had a mere 55hp

(but it also only weighed 500lbs), however over the years that thirst for more performance has led to so-called 'Muscle Pitts' on the airshow circuit, with up to 400 horsepower. American Wayne Handley topped everybody in 1998 with a 1400 lb aircraft called the Turbo Raven. The 750hp turbine PT6 and monster prop could produce 2800 lbs of thrust, which basically produced a helicopter with wings. Wayne could climb vertically, stop, then accelerate vertically again. Very cool party trick, although sadly it all came to an abrupt end with an engine failure during a steep 'reverse pitch' approach, resulting in the plane being destroyed and the pilot seriously injured.

The other option to more horsepower is less weight and in this regard aerobatic planes tend to be rather spartan. This can translate to noisy, cold/hot, uncomfortable, etc. however most flights are of short duration so the dedicated aerobatic pilot will tolerate this for more performance. The method of construction can help to achieve light weights, and the advent of composite technology has resulted in very strong but light airframes – the Giles G202 has an empty weight under 1000lbs yet has an airframe maximum load factor rating of +/- 10G. Not to be outdone by 'plastic fantastics', traditional rag-and-tube aircraft designs like the DR-107 One Design and Laser series can also be built very light, incorporating 'nature's composite' (wood!) for the spars and wing skins.

Inverted Systems

Aerobatics doesn't have to include inverted manoeuvres, and indeed many famous WWII fighter aircraft had limited-to-none inverted capability. But most military pilots would rather 'pull' than 'push', and from a comfort point-of-view having the G load going through your seat is more natural than being restrained by seatbelts from being ejected out of the canopy! However, competition and display flying can include elements of inverted flight meaning many design features must be incorporated – stronger seat harnesses, inverted fuel pick-ups, inverted engine oil systems and ultimately the aerodynamic arrangement of the airframe such that the aircraft flies just as well and the same upright or inverted.

Aerodynamics

The Zivko Edge 540, most famously used in the Red Bull Air Race series, is a great example of an aerodynamically neutral design. Note from the great picture of Paul Bonhomme's racing Edge – no dihedral, no incidence and the wing and tail surfaces all on the thrust line. As always there are downsides and compromises to this design, such as visibility, stability and access. But perhaps this plane meets one of those other goals mentioned at the beginning more than most – it looks great and sounds even better!

Some pilots wonder why aerobatic aircraft aren't faster given their apparent light weight and high horse power. A good example is the Extra 300, with its mighty 300hp Lycoming but a cruise speed of only 155 kts. A similarly powered Glassair, Rocket or even Cirrus would do 200kts or more. The answer is all in the wing, or more to the point the airfoil. Aerobatic wings are designed to corner well (pull G and thus generate big lift) but also have a sharp, pronounced but predictable stall, in equal parts. Speed is very much a secondary consideration, as too much speed would be a bad thing in the competitive arena due to the tight constraints of space to work in – the 1000m square 'Aerobatic Box'. So the airfoil must produce copious lift up to the critical angle of attack, then dump it all in an instant! This quirk, coupled with light pitch forces, can make for interesting loops when first attempted, where the

difference between flying and shuddering can be measured in millimetres of stick travel, but with no appreciable change in stick force. Nothing that practice can't fix, and once fixed the ability to 'fly' and 'un-fly' the wing is remarkable. Have a look at the wing section of an aerobatic mono next time you get the chance and you would think it was designed by a three year old – big round leading edge with a dead straight line going back to the trailing edge. And it is the same top and bottom, creating the symmetrical aerobatic airfoil. If you are interested in reading more, see: www.eaa1000.av.org/technicl/onedesaf/1desaf

The Aerobatic Sight

Whether taped to the inside of a canopy, attached to a strut or out on the wingtip, the purpose is the same – to present the pilot with a means of quickly referencing the aircraft attitude against the horizon.

Most often this is used for 45 degree and vertical lines, as flown in stall turns and Cuban-8s. From a competition perspective, if you have to adjust your flight path AFTER looking at the sight you have probably blown it – the judges will have seen your adjustment and down-graded you – however the sight is good for practice and does give you a target to aim for (or through). Beware of catching yourself on it during walk-arounds!

Taildraggers

Of course, real airplanes have a 'conventional' undercarriage, or so say some, however most dedicated aerobatic planes have the taildragger configuration for weight savings – two and a quarter wheels weigh less than three, plus it is less complex. Prop clearance is also an issue for the more powerful aircraft, although this could be solved on a trike with long undercarriage. But now we are talking about more weight and drag again - a familiar theme with performance aircraft? Not having the nose wheel hanging off the engine mount allows for the engine mount to be simplified to cope with the +/-10 G loads, whilst also freeing up space for an efficient cross-over exhaust for more power. The obvious downsides with taildraggers are visibility on the ground and relatively more effort and/or skill required for take-off and landing, unless you have learnt to fly in a taildragger and don't know any different – lucky you!

The modern aerobatic monoplane is truly a 'pilot's plane' - not load haulers, strip performers, sky floaters or weapons delivery machines. They slice through the air, have incredible handling and leave you wanting more. Through syndication, some, such as Giles G202 ZK- NUT, are quite accessible too.

Disclosure of interests: President of NZ Aerobatic Club, part owner of G202 ZK-NUT!

Red Bull Air Racer: Zivko Edge 540.

contributed by Bill Beard

Aircraft Liability Insurance Explained

IT IS IMPORTANT for every aircraft owner and pilot to have a basic understanding of the principles of liability and the way it relates to their aviation insurance policy. The most common form of aviation policies are divided into three main sections as follows.
SECTION 1: Loss of or accidental damage to the aircraft hull.
SECTION 2: Legal Liability to third party property and bodily injury or death other than for passengers.
SECTION 3: Legal Liability to passengers when entering, on board or alighting from the aircraft.

In general terms however all incidents resulting in death or injury to persons in New Zealand are covered under the ACC Legislation and as such there is no provision in NZ for anyone including aircraft passengers to issue proceedings in New Zealand courts seeking compensation for death or personal injury. The Law however does not prevent claims for mental shock, distress or trauma so you still need passenger liability cover.

The main liability risk for New Zealand aircraft owners therefore are claims for accidental damage to third party property and the associated legal fees.

The main events likely to result in a third party property claim are as follows.

- Taxiing into another aircraft (biggest risk in the vicinity of fuel pumps or in tight manoeuvring areas).
- Damage to other peoples property as a result of a forced landing.
- Loss of direction on take-off or landing and running into other aircraft, fences, hangars or whatever. There was a close call at Ardmore some time back when a landing aircraft lost directional control and crossed the adjacent taxiway at high speed just missing a highly valued brand new aircraft backtracking on the taxiway (it could have been a corporate jet!).
- Simple ground handling incidents such as pushing your aircraft into another aircraft or worse – a helicopter.
- The worst scenario – a mid-air collision where you may be found at fault.

If you damage another aircraft resulting in the owner of that aircraft having to make an insurance claim, it is the third party insurance company which will look around to see who was responsible for the damage and they'll be on your case in a flash to recover their repair costs. You need to ensure the aircraft liability coverage or limit of liability is adequate to cover you for any negligent acts. Half a million dollars is not nearly enough in today's world. The absolute minimum industry standard would be NZ$1M but with the price of aircraft and associated equipment on today's market, most operators are insuring for at least $2M to $5M.

In aviation circles the amounts awarded can be quite large, therefore it's important to carefully consider purchasing higher limits in order to have an adequate limit of liability to cover all possibilities.

All policies should include the "Pilot Indemnity Clause" which extends the policy to cover the pilot as if they were the insured. This gives the same protection to the pilot as to the policy holder but does not increase the liability of the insurers beyond the declared indemnity.

To discuss this topic or any other questions relating to aviation insurance or to seek quotations, contact Bill Beard at Avsure on 0800 322 206.