THE THREE BIG GHOSTS

Coming back to haunt those involved in the care of an aircraft are cracks, corrosion and wear

BACK again, looking out of the window at a pretty dismal July sky wondering where the last two weeks have disappeared to. Yes, it's already two weeks since my return from my holiday in Turkey, a trip that now seems like a distant memory.

Sadly, nobody is interested enough here to even ask to see the holiday snaps. At the time, that's during my trip, it seemed like I had been away for ages but now... oh well. For the one thousandth of a percent of the readership who are interested in my welfare, I had, if I can still remember it, a fantastic holiday... thanks for asking.

Back to the daily grind. Actually, being midsummer, it's been pretty fraught here, which is, perhaps, the main reason for the apparently rapid passing of time and the general lack of interest in my holiday adventures. I woke this morning thinking it was Wednesday and it's actually Friday; this edition of Safety Spot should be on the Editor's desk by now. Instead, it languishes as a complex mass of disparate facts and figures in the interior of my cranium. Better get on with it then!

I have said before that aircraft engineering is an absolutely fantastic pursuit for those with an enquiring mind. It's almost impossible not to end up as multi-trade. OK, you might start out life as an apprentice airframe fitter, but it won't be long before you have an arm up inside the bowels of an engine, or are doing sums to work out the correct resistance required to achieve a certain voltage. That's one of the main things that I like about the profession.

It has to be said though, that the same old things keep coming back to haunt those involved in the care and maintenance of aircraft regardless of any 'specific' trade. The three big ghosts, in my experience anyway, are cracks, corrosion and wear. It's a pity really that wear begins with a 'W' otherwise we would have been able to call it the three 'C's of aircraft engineering and make a poster or something. WC's of aircraft engineering just doesn't have the same ring to it somehow.

In this Safety Spot, we will be exploring problems that have occurred with members' aircraft in all three of these problem camps.

The first good picture was sent in by Dr John Chapman. Take a close look; it is the inside of a Hunter wing. You are right, of course, we haven't got one of those on our books but hey, aluminium oxide is not picky.

John sent me this picture ages ago and I've been looking for an opportunity to feature it.

I spoke to John, who was actually in France at the time learning about mountain flying, to ask his permission to use the photo and the weather was horrible there too.

PHOTO Dr. John Chapman

What a brilliant picture of exfoliative corrosion; as the material is rolled during its manufacture, the grains are forced into layers. Corrosion products force these layers apart – the results can be easily seen in this example. Notice also that the aluminium plate is held in place by ferrous bolts and nuts so the initiation of corrosion here could have been the electrical current generated by the dissimilar metals. Thanks, John, for taking the trouble to send this picture in.

Blocked fuel outlet

THIS item was sent to me by LAA Inspector Dave Wood who, as an ex Dover Harbour Customs man, knows how to spot the unusual. Dave started his letter, 'A couple of bits for the black museum.' OK Dave, they have a place among the exhibits already, thanks a lot for sending the items in.

For those of you who are familiar with the type, the Ran's S4 is a single-seat homebuilt microlight aircraft. The particular machine featured was constructed in 1992 and has shown good service over the years, giving its owners plenty of air time at a relatively very low cost.

The engine that's used on all of the LAA registered aircraft, and we have about 20 examples on our books, is the Rotax 447.

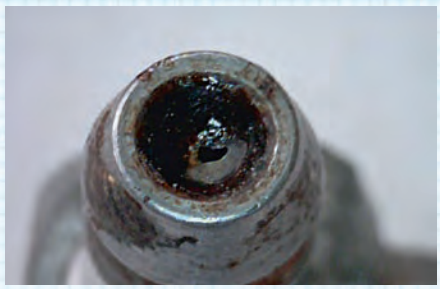
This is an engine that's pretty miserly when it comes to fuel consumption, averaging out somewhere between 15 and 20 litres per hour, if my memory serves me well.

This low-fuel consumption was just as well in this particluar case...

Dave used his new 'Maplins' Stick-Cam to check inside the top fuel tank during the annual inspection and sent me the rubbish he fished out of the tank in a plastic bag... thanks, mate. But that was only the start of the story.

When Dave tried to remove the fuel outlet fittings he noticed that they were both glued in. Eventually, he managed to get them out and, well, you can see the issue for yourself in the accompanying pictures – one of the fittings was virtually completely blocked by some unknown substance of unknown origin. I wonder when the last fuel flow check was done? Dave reckoned that the flow from this tank might just have kept up with the engine's usage!

Here's the inlet for the fuel tank fitting off the Ran's S4 discussed in the text. All fuel system components must be kept in 'tip-top' condition for obvious reasons.



PHOTOS Malcolm McBride

You can see that this outlet is nearly completely blocked by some unknown substance – it looks like the residue from the glue that was used to cement the fitting into the tank.

With Malcolm McBride
Airworthiness Engineer

Pioneer 300 Fuel selector corrosion

THIS is the second fuel system problem I was sent, both found rather by accident, as opposed to the normal route, which is 'as a result of an accident'!

In this issue, the aircraft was undergoing a programmed 'big check' as the aircraft was then five years old. This was something that was agreed between the owner, Michael Langmead and the Inspector, Matt Petit, even though the aircraft hadn't too many hours logged. Michael took the time to bring the fuel valve into HQ for me to have a look at, so many thanks to him for that. I took some pictures and you can see why there was concern; it's our old friend electrolytic corrosion.

The reason why this particular component was disassembled is that it was agreed that it was time to replace the fuel pipes. These are not 'lifed' items on Permit aircraft but, because they were starting to harden up, it was not worth not changing them at the same time as doing a big check.

During this replacement, the fittings, which are made from steel, were removed from the fuel selector assembly, which is made from L168 aluminium. The manufacturers of the fuel valve, Andair, had gone to great trouble to prevent this type of corrosion by anodising the body of their unit but, because the male fittings are not really standard aircraft parts, this problem has arisen.

Naturally, to keep costs down, automotive and other parts are often supplied by kit manufacturers and the builder/owner should be mindful of this when designing their maintenance schedule.

The discovery of this problem highlights the need to take a really close look at all the components on an aircraft from time to time. Because of the very variable usage among the LAA fleet, no single maintenance schedule really fits the bill. I've been talking for a while now about the owner's responsibilities in this regard; in essence, the owner is responsible for designing and implementing a maintenance schedule that accommodates the needs of continuing type airworthiness, manufacturer's and LAA requirements and practical considerations, like the kind of operational environment which the aircraft exists in. In other words, aircraft that operate from rough farm strips may need more 'looking at' than an aircraft that is operating off a billiard table-like airstrip. Counter-intuitively, it may be the case that an aircraft that is only used infrequently may have more problems with, just for example, corrosion, than something that's being flogged a bit. In this latter machine's case, wear might be the issue.

There is absolutely no reason why the planned maintenance of a relatively low-usage machine couldn't involve one big job per year. My personal view is that an aircraft in this class, with an average usage of about 50 hours a year, should be looked at thoroughly every three years. By arranging a planned maintenance schedule it may be, for example, that the wheel bearings could be completely refurbished every three years but start the cycle off at year two. Then, this could be missed at the three-year check (being required again at year five if there's no change to the aircraft's usage or environment), which would give you the opportunity to do another big job, maybe a complete control removal/refurbishment.

This 'bite-size chunk' approach is usual in bigger aircraft, but the annual/annual/star annual approach is more common among smaller machines where the Light Aircraft Maintenance Schedule (LAMS) has been the basis for inspections. The trouble with this rigid approach is that it doesn't take into account the various usage profiles and, in my opinion at least, things are just too easily missed out.

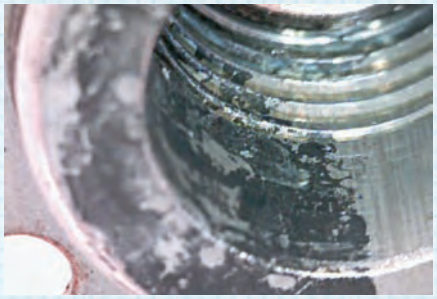
Another problem, highlighted by this fuel selector valve incident, is that it is very difficult to predict where problems might surface on a homebuilt aircraft. In this case, the manufacturer of the selector valve would not have foreseen that a kit manufacturer would have used steel fittings with a ¼in np thread which, as you may know, has a taper on it which is almost designed to 'bust through' anodising.

Anyway, well done to Matt for insisting that this year this aircraft needed a big check and well done to Michael for agreeing.

PHOTOS Malcolm McBride

Here is a picture of the Andair Fuel Selector, and beautifully made it is too. Normally a fuel selector will have a number of selections so that the pilot can manage his/her fuel usage. Normal selections are OFF, where no fuel can pass; LEFT, where only fuel from the left-hand tank is used; RIGHT, where only fuel from the right-hand tank is used; BOTH, where left and right tanks are used together. In this case, the body of the unit is L168 aluminium chromic anodised, ie high spec. The commercial steel fittings look to have been originally designed for use in compressed air applications.

In this picture, the 'Taper' on this NPT can clearly be seen. Out of interest, the taper rate is ¾in per foot, which is a taper angle of about 2° so quite a lot of force can be generated (regular readers will remember the Rotax oil filter incident).



Here's a close-up of the corrosion within the fitting of this fuel valve. It's not a brilliant picture as it doesn't give justice to the internal damage found. There's a huge chunk of material missing roughly in the centre of the shot.

Evektor Eurostar Brake actuator corrosion

AS can be seen from the excellent photographs here (which I think were taken by the owner, Cedric Flood, but sent in by his Inspector Dick Davison), this brake unit is scrap.

This is a case of corrosion whose probable origin lies in the difference in electrical potential created when different metals are brought together in close contact. This so called galvanic effect is primarily the same mechanism used to generate electricity in a battery. The problem is that at least one of the metals involved is sacrificed.

A generated potential difference (voltage) is one thing; what causes the trouble is the electron flow (current, in this case measured in micro amps). Naturally, an electrolyte is required to allow electrons to flow, and this ionic solution is provided in batteries by either the acid or the base that separates the various metals chosen.

In the case of Cedric's brake pack, the electrolyte could either be atmospheric water (which almost invariably, especially in the UK, contain salts) or water held in suspension within the hydraulic fluid itself. As a maintenance aside, one of the reasons for changing hydraulic fluid at regular intervals is that it is hydroscopic (that's the ability to 'suck up' water) and subsequently corrosive by nature.

Cedric (or Dick) sent me a chart of the various electrical potentials of some common metals and I've reproduced it for you. When there are two metals in close proximity separated by an electrolyte, it's the difference between the numbers that matters. In the table provided, the difference is measured in volts – a volt can be considered to be the difference in electrical potential between one point and another, a bit like a pressure difference.

Without checking, I cannot be absolutely sure what materials go into the production of this Eurostar brake pack, but I would imagine that Cedric's guess that the cylinder would be made of brass and the body of the unit aluminium wouldn't be far out. As you can see from the chart, the brasses have an anodic index of between 0.4V and 0.45V and aluminium between 0.75V and 0.95V, so the best difference between brass and aluminium is 0.3V.

The small oxidation paths created are fairly obvious in the pictures. It's a bit worrying that the new component fitted was showing signs of corrosion.

Thanks Cedric and Dick for taking the time to send in your pictures.

METALLURGICAL CATEGORY	ANODIC INDEX (V)
Gold, solid and plated, Gold-platinum alloy	0.00
Rhodium plated on silver-plated copper	0.05
Silver, solid or plated; monel metal. High nickel-copper alloys	0.15
Nickel, solid or plated, titanium an s alloys, Monel	0.30
Copper, solid or plated; low brasses or bronzes; silver solder; German silvery high copper-nickel alloys; nickel-chromium alloys	0.35
Brass and bronzes	0.40
High brasses and bronzes	0.45
18% chromium type corrosion-resistant steels	0.50
Chromium plated; tin plated; 12% chromium type corrosion-resistant steels	0.60
Tin-plate; tin-lead solder	0.65
Lead, solid or plated; high lead alloys	0.70
Aluminum, wrought alloys of the 2000 Series	0.75
Iron, wrought, gray or malleable, plain carbon and low alloy steels	0.85
Aluminum, wrought alloys other than 2000 Series aluminum, cast alloys of the silicon type	0.90
Aluminum, cast alloys other than silicon type, cadmium, plated and chromate	0.95
Hot-dip-zinc plate; galvanized steel	1.20
Zinc, wrought; zinc-base die-casting alloys; zinc plated	1.25
Magnesium & magnesium-base alloys, cast or wrought	1.75
Beryllium	1.85

I'm not sure who to credit this chart to, Cedric never said where he got it from, but it broadly fits the tables we use here and looks nicer! If possible, it's always better to insulate one material from another. Various methods are employed in industry including the use of high resistance scrims and proprietary pastes – like Duralac.

PHOTOS Flood/Dick Davison

A closer look shows this brake unit was only a few applications away from failure.

This is worrying. There were signs of corrosion on this replacement part before it had even been fitted. Several Eurostars operate under an LAA Permit; this is the first time I've seen this.

You can see Cedric's problem: the inner edge of the brake calliper has disintegrated, exposing the 'O' ring surface. This brake unit is only four years old, and may have been missed without complete disassembly. It is essential that calendar life of components is taken into account in your maintenance schedule.

Jabiru J400 Rudder jammed in flight

REGULAR followers of Safety Spot will know that this is not the first time we have seen a control surface jam on this type of machine and, after all the fuss that was made about it last time, I have to say I was pretty surprised to see the issue raise its head again. You can review the last incident in the March 2008 edition of Safety Spot, which is available on the web in our Engineering Section.

In short what happened the first time around was that the pilot was conducting a test flight for Permit renewal when, in a turn, the ailerons jammed solid. Naturally, the increased angle of bank was matched proportionately by the opposing force on the joystick, but to no avail. Fortunately, and I suppose a little unnaturally, the pilot decided to apply 'into roll' aileron and this had the effect of un-jamming the system. I agreed with the pilot involved in this event at the time that he'd had a 'lucky escape'.

This latest incident occurred while I was away on my holidays and I heard about it on my return via the Air Accidents Investigations Branch (AAIB) who had been alerted by the Civil Aviation Authority (CAA) as the pilot, LAA member John Gardiner, had filed a Mandatory Occurrence Report (MOR). Phew, enough of the acronyms please. I spoke to the pilot to get the full story as he came off shift. He flies an EC 225 Super Puma for a living (servicing the oil rigs) and operates a Jabiru J400 with a partner for a bit of fun at the weekends. It's a tough life, but somebody's got to do it!

John was actually demonstrating the aircraft to a perspective new syndicate member and was, therefore, putting the aircraft through its paces. Max rate turns, stalls, sideslips... I'm sure you get the drift (sorry, couldn't resist it!). Anyway, after one of the full rudder

demonstrations, actually a full left rudder application, the rudder failed to return to the neutral position. In the Jabiru aircraft, this is not quite the critical situation that would be faced by a pilot if, as in the example earlier, the aileron jams, because the aircraft can still be flown by balancing the aircraft with the ailerons.

Naturally, with full left rudder applied, the nose of the aircraft will be displaced to the left considerably and, because of the secondary effects, the aircraft will want to roll into a turn to the left. Right aileron, therefore, was applied by John, which kept the machine flying a roughly straight course.

John noted that, due to the sideslip, fuel was venting badly from the tanks and he became concerned that he would be faced with an engine failure through lack of fuel if the situation carried on for very long. On the plus side, the weather was good and he noted that he wasn't far from the now (very) disused airfield at Insch. John wisely got in touch with Aberdeen and declared a PAN (Urgency), informing ATC that he had elected to land on the disused airfield.

It's much more difficult than you might think landing an aircraft with full rudder applied; if you think about it, the Jabiru is a nosewheel type so rudder pedal application also drives the nosewheel steering, full control surface deflection means full nosewheel deflection. However, John made a successful landing – he is experienced enough to have made sure that he never allowed the aircraft to enter the 'spin-in' zone and, with a judicious application of brakes, he landed without further drama. So, a big well done to him for dealing with a very tricky situation well.

On the ground, John could see what had happened; the leading edge of the rudder had jammed against the trailing edge of the fin. He was sure that there was enough clearance there and had complied with both the Service Letter issued by the agents (S T Aviation Ltd) and the subsequent Service Bulletin issued by the factory as a result of the aforementioned aileron problem. LAA Engineering mandated the Service Letter with an Airworthiness Information Leaflet (AIL) and this had been signed off at the last Permit Renewal Inspection.

So, what had gone wrong to allow this to have happened again? Reading through the Jabiru Service Bulletin I can see that there is some room for confusion. Our AIL calls for a gap of at least 3mm between the control surface and its supporting structure and, in this case, the gap between the two parts was compliant with this requirement. What's also essential, though, is that the leading edge of the control surface must always stay within the 'socket' of the support. In other words, there must be an overlap.

While demonstrating sideslips, full rudder was applied. This had the effect of applying a very large force to the fin that distorted the structure slightly in the area of the hinge allowing the clearance to close up. There was a sufficient clearance in one sense but, because there was no overlap, the edges were able to come into contact and jam.

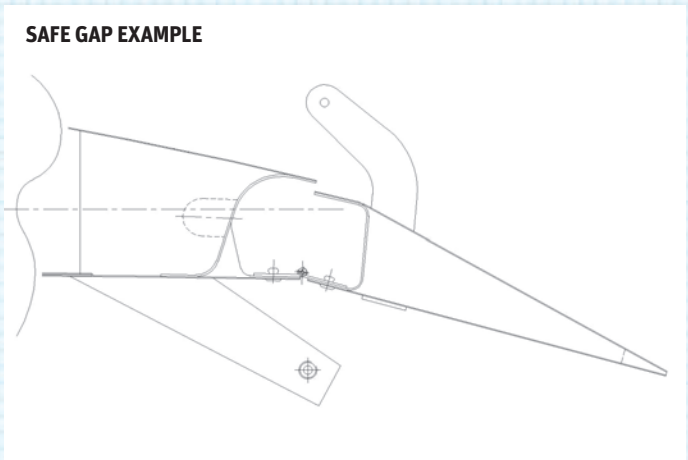
We're going to update our AIL to make the point more clearly. As I said earlier, if you have any suspicion that there is a possibility that a control surface could jam, then walk away from the aircraft and get the problem fixed before you fly it.

John never said whether the potential syndicate member 'bought in' or decided to give sport flying a miss for a while!

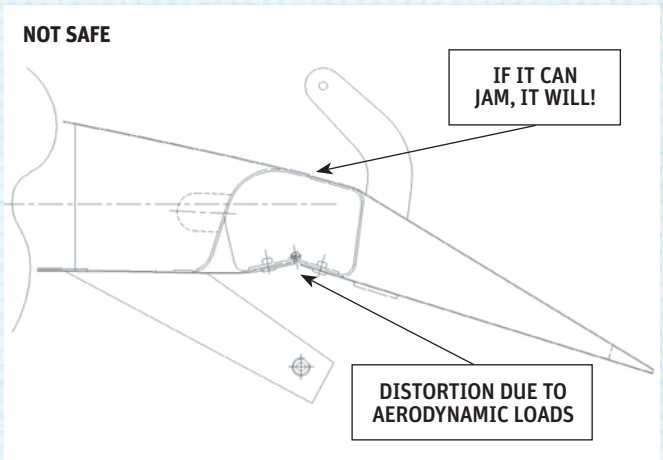
This is a photographic example that shows an acceptable rudder fit. No matter how much the fin/rudder assembly may move about, there is absolutely no way that the leading edge of the rudder can foul against the trailing edge of the fin.

Here's one that is likely to jam; note the overlap. The LAA will shortly be issuing an updated AIL offering advice to owners of Jabiru aircraft about this matter, but it is essential that pilots of all aircraft ensure that the control surfaces are free to move and that there is no possibility of a jam.

PHOTOS Jabiru Aircraft



There's confusion about what constitutes a 'safe gap' between the fin's skin and the leading edge of the rudder. It's not the faces of the adjoining components but their edges that matter. As flying surfaces take extra load they generally flex slightly, which must be taken into account during 'rigging'. While these sketches show an aileron, the rudder assembly is essentially the same.



This illustration shows an aircraft with a problem. You can see that, as the fin/rudder assembly moves about during normal operation, it is possible for the leading edge of the rudder to jam against the trailing edge of the fin. Survivable probably in the case of a rudder, but not so with a jammed deflected aileron.

SAFETYSPOT

With Malcolm McBride
Airworthiness Engineer

SportCruiser Main undercarriage cracking

LAA Inspector Graham Smith recently wrote concerning SportCruiser main gear legs. The SportCruiser has been fully LAA approved for just over two years and the very first kits delivered to customers are now having their second annual inspections. As with all aircraft types, it takes time to find out which parts are vulnerable to damage and what specific inspection procedures need to be applied. Normally, an Inspector would consult SPARS to see what areas need special attention, but the SportCruiser is still new in maintenance terms and does not yet have its own section.

That is likely to change as the 74 kits sold and build clock up the hours, and we learn more about the long-term maintenance issues.

Previous Safety Spots have dealt with the exhaust issue, and the LAA are still gathering and collating the reports coming back from owners. However, I have recently seen another problem that seems to be evading detection, despite being really easy to spot when you know what to look for.

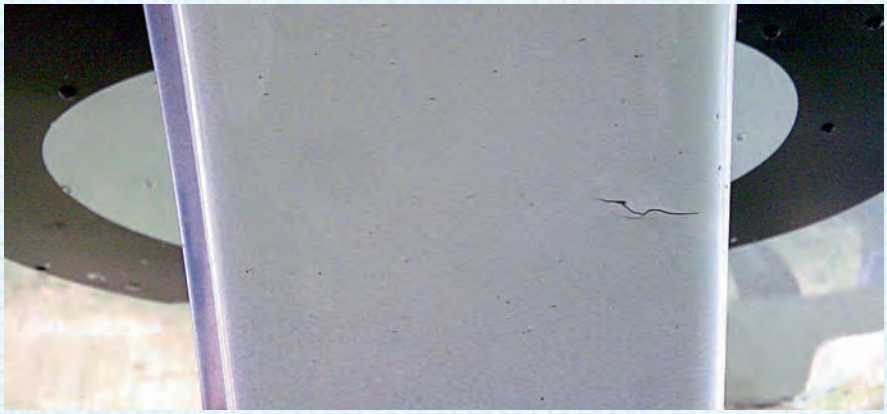
Going back now about three years, I was closely involved with the airframe static load testing that was carried out by the original manufacturer CZAW. The protocols for the tests were strictly laid down by the LAA, and one by one the tests were completed. Several important parts of the structure were redesigned as a result of the tests. It all seemed a bit of a nuisance at the time, but looking back, I can see how vital it is to get this right. The test that caused the most concern was the composite main gear drop test. Anyone that has been involved with aircraft design will tell you that undercarriage legs can be really tricky to get right.

You can make them as strong as you like, but the gear leg is just a big spring, and if you make it too stiff, it just transfers the landing loads up into the fuselage in a way that will cause damage in no time. With a wing spar, you can design in strength far beyond what is required without consequences (apart from increased weight), but the undercarriage needs to be strong enough – but no stronger.

It's important to mention that in the UK we have not seen any undercarriage failures although several aircraft have developed cracks following heavy or sideways landings. Any crack will require a replacement undercarriage leg, but the important thing is to check your aircraft regularly.

Most builders use a two-pack polyurethane paint, which is very flexible. If you can see a crack in the surface paint, it needs to be investigated. All the cracks I have seen so far have been on the inside of the leg, about two thirds of the way up and towards the front of the leg. If you find a break in the surface paint, gently rub back the surface with 320 wet and dry. The composite construction consists of a sandwich of carbon and glass. As you start to abrade the carbon, the black dust will be trapped in the crack and, where that crack runs through the white glass, any crack in the leg itself will be obvious. Take it easy because you don't want to ruin a sound leg because you got carried away with the wet and dry!

All good advice, thanks Graham. May all your storms be little ones. Fair winds.



PHOTOS Terry Smith

A small crack in the paintwork may be just that but, on an aircraft, every bit of damage needs to be thoroughly checked out. Firstly, paint cracks are gaps in a material's protective coating that will allow water ingress and may lead to corrosion. Secondly, the cause of a paint crack may be that the underlying structure is damaged. Paint on an aircraft is not just about 'looking good'.

PHOTOS Graham Smith

Here is what was found after cleaning off the damaged paintwork.

LAA ENGINEERING SCALE OF CHARGES

LAA Project Registration	
Kit Built Aircraft	£300
Plans Built Aircraft	£50
Issue of a Permit to Test Fly	
Non-LAA approved design only	£40
Initial Permit issue	
Up to 390kg	£320
391 - 499kg	£425
500kg and above	£565
Three seats and above	£630
Permit renewal	
Up to 390kg	£105
391 - 499kg	£140
500kg and above	£190
Three seats and above	£210
Modification application	
Prototype modification	£45
Repeat modification	£22.50
Transfer	
(from CofA to Permit or CAA Permit to LAA Permit)	
Up to 499kg	£135
500 kg and above	£250
Three seats and above	£350
Four-seat aircraft	
Manufacturer's/agent's type acceptance fee	£2,000
Project registration royalty	£50
Category change	
Group A to microlight	£135
Microlight to Group A	£135
Change of G-Registration fee	
Issue of Permit documents following G-Reg change	£45
Replacement Documents	
Lost, stolen etc (fee is per document)	£20

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