SAFETYSPOT

With Malcolm McBride
Airworthiness Engineer

"THE MORE YOU KNOW..."

EVEN A SIMPLE RESPRAY CAN TAKE YOU OVER MTOW... THERE'S ALWAYS MORE TO LEARN, FROM LAA INSTRUCTORS' COURSES AND OTHERS' EXPERIENCE

LAA Design Engineer Andy Draper discussing the complexities of the laminar flow wing at a recent Pioneer Aircraft instructors' course, hosted by LAA Inspector Frank Cavaciuti. Featuring, centre stage, is the port wing of the new Pioneer 400 Quattrocento, the latest machine from Pioneer Aircraft. From left to right: Bob Hallam, Roy Clarke, Frank Cavacuiti, Robb Mott, Francis Moyle, Ken Bowen and Andy Draper.
(Photo: Malcolm McBride)

Hello again and may I wish you season's greetings, I hope not too prematurely. I begin writing this month's 'Safety Spot' on a damp but surprisingly warm Saturday, mid-November. Christmas seems like a long way off but, I suppose as usual, it will come and go pretty rapidly as has, it seems, 2012. I hope that, when you have time to reflect, this last year will have been a successful one for you.

As it is December, you will notice that we've managed to strap down Ken Craigie, our Chief Inspector, for long enough to write the accident review for 2011 (see page 22). Accident Reviews make sobering reading but perhaps serve a good purpose if they remind us that aviation can be a dangerous business and to keep safe requires the best in us. I note that there are more than 60 events listed that were deemed serious enough to warrant an Air Accidents Investigation Branch report; sadly, there were four fatalities.

Most people would agree I think that a good way of improving safety is through education. Primarily, that's what 'Safety Spot' is all about, but it is easy sometimes to become complacent and stop reading some of the more demanding technical literature, thinking perhaps that one might have enough knowledge already. This last year Ken, with the generous assistance of a number LAA-oriented specialist engineering companies, has organised several type-specific inspector courses. I often come away from these events slightly humbled but, focussing on the specific for a time, they can serve as a reminder that the old rule still applies... 'the more you know, the more there is to know'.

Last week, just for example, Deltair Airmotive, the Hampshire-based engine overhaul company, hosted a training day specifically for Gipsy Major engines. I learnt to fly behind a Major 8 which, if you're a specialist, you will know is the military version of a Major 10 Mk II (a 145bhp, four-cylinder, inverted, in-line engine) and thought that I knew a fair bit about it. Well, I do, but only up to a point. I learnt, amongst many other things, that these engines were pretty much individually built and therefore it's not possible to just swap engine components from one engine to another without doing some individual 'fitting'. Deltair's Chief Engineer, Peter House, an expert on the type, described this issue specifically using the example of changing a fuel pump.

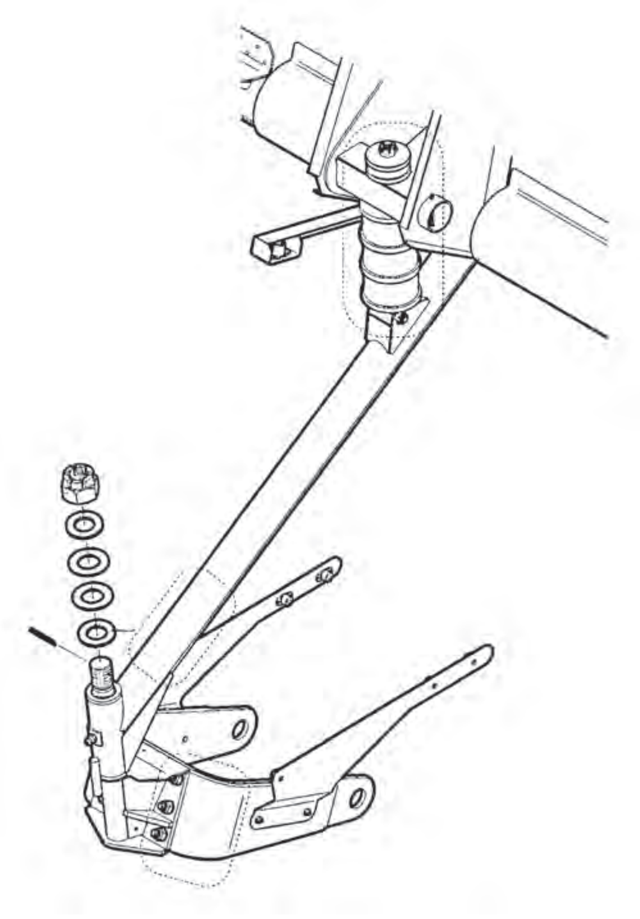
Gipsy engineers will know that there are two mechanical fuel pumps on the Gipsy Mk 8 (or 10!); they are diaphragm pumps, operating through a one-way valve. Similar, actually, to the diaphragm pumps you will see fitted to most flat-fours that we've grown very used to. Mechanically, these pumps are fairly simple as you will probably know; an arm forces against a diaphragm which, acting rather like a piston in a cylinder, reduces the volume inside a chamber, squeezing fuel out to the carburettor. The diaphragm operates a little like the bellows that are used to get a fire going in the mornings except, naturally, it is not advisable to fill the bellows with aviation fuel when used in this application as you might end up burning your toast!

The force is supplied to the diaphragm through an arm from the camshaft, so each revolution of the camshaft equates to one pumping cycle. What surprised me was that each

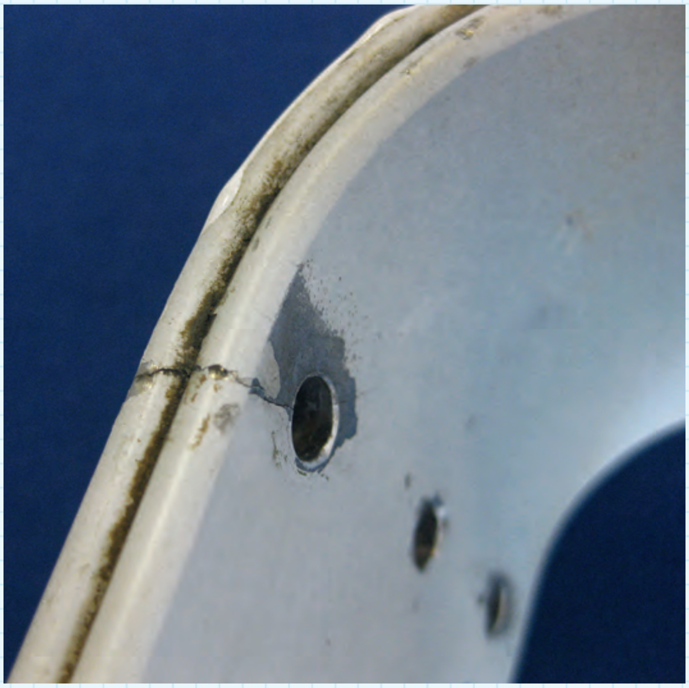
Above: LAA Inspector and Bulldog course instructor David Jones of Airspeed Aviation (Derby), explaining the importance of checking the seals on air filters to ensure that debris cannot be ingested into the engine. From left to right: Robin Johnson, David Ross (hiding), Fran Sandwell, Roy Sears, Stephen Woods, John Robertson. *(Photo: Ken Cragie)*

Left: the Chipmunk course, held in the famous main hangar at Bicester Aerodrome in July this year, was so well attended that the course had to be split into two groups, one in the classroom and one at the aircraft. The Chipmunk featuring centre stage was undergoing a major overhaul and it was extremely useful for the course attendees to take a close look deep into the complex structure of this fairly new addition to the LAA fleet. From wing-root clockwise: course instructor Alan Turney, Tim Rayner, Andy Harmer, Stuart Allen, Robin Johnson, Rudy Floate, John Giddins, Mike Thomas and, with his back to the camera, course instructor Dennis Neville. *(Photo: Malcolm McBride)*

Right: Delta Airmotive's Chris Adams and Peter House explain the timing procedure on a Gipsy Major engine that was actually undergoing a complete overhaul at their brilliant facility in Waterlooville, Hampshire. This course was so popular that it had to be held twice! From top left to right: Neil Geddes, Kevin Crumplin, LAA Director Barry Plumb, Robin Johnson, David Jones, Iain Noakes, Richard Kimberly, LAA Chief Engineer Francis Donaldson, Instructor Peter House, Keith Leyland, Chris Adams. *(Photo: Malcolm McBride)*

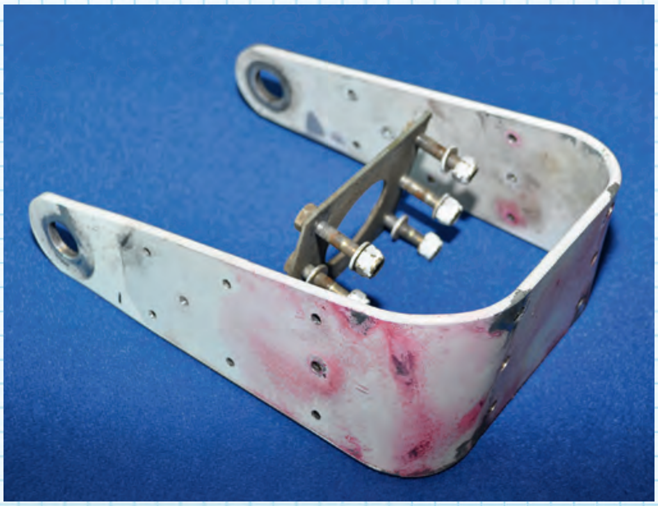


Here is an assembly drawing of the CZAW nose undercarriage assembly. To inspect the fork thoroughly it has to be completely removed from the spindle assembly by removing the six attaching bolts and the rear spreader plate (obscured). The LAA now requires that this area is strip-inspected each 50 hours of service life and that, if cracks are found, the part is replaced. *(Diagram: courtesy of CSA)*



The SportCruiser nosewheel fork is formed from two aluminium alloy components riveted together; the area shown in this picture is the point of attachment to the spindle assembly. Note that this crack has progressed from the top bolt hole right to the edge of the fork and has affected both components. *(Photo: Malcolm McBride)*

"Each aircraft, primarily the Chipmunk, was initially issued three engines – one in the aircraft, one being overhauled and, wait for it, one as a spare"



LAA Inspector, Graham Smith, of Sprite Aviation, one of the LAA's Centre of Excellence for SportCruisers, sent me this example of a badly-cracked nosewheel fork. This fork is effectively sandwiched between the spindle assembly and the load spreader plate (shown in this picture with the bolts) so cracks cannot be seen without complete disassembly. Although a failure of this attachment is likely to occur over a longer period than a catastrophic failure of the spindle, cracking in any nosewheel component is worrisome and must be taken seriously. *(Photo: Malcolm McBride)*

pump has to be individually 'fitted' and to do this properly the engineer needs to remove the crankcase top cover (which is held on by a huge number of nuts around its periphery), trial fit each pump, then get into the bowels of the engine to measure the mechanical clearance between the arm and the cam. The arm needs to be adjusted on the bench (with a file) to give optimum clearance and so achieve the proper 'throw' on the pump. Failing to do this leads to the pump 'bottoming out' and the arm snapping off in service. There's a lot more to keeping these old engines serviceable than meets the eye.

One aspect of the Gipsy course I found sobering was that, even though many of these engines were operated in the military environment where record-keeping is legendarily good, meaningful engine failure data is fairly thin on the ground. This is because each aircraft, primarily the Chipmunk, was initially issued three engines – one in the aircraft, one being overhauled and, wait for it, one as a spare. In active training service, these engines were effectively being overhauled every 300 hours (Check 4).

The manufacturer's initial life for these engines varies depending on the Mod state quite a bit, but the minimum overhaul period is 1,000 hours, while some of the ex-military units have a TBO more than twice as long (they revert back to the shorter life after their first overhaul in civvy street). I hope that you can see some of the issues that need to be tackled by LAA Engineering when it comes to the management of these slightly more complex types as they join our fleet.

SPORTCRUISER: NOSEWHEEL FORKS

Anyway, there's no such thing as simple in aviation, that's why we're all so enthralled by the subject! What else is happening

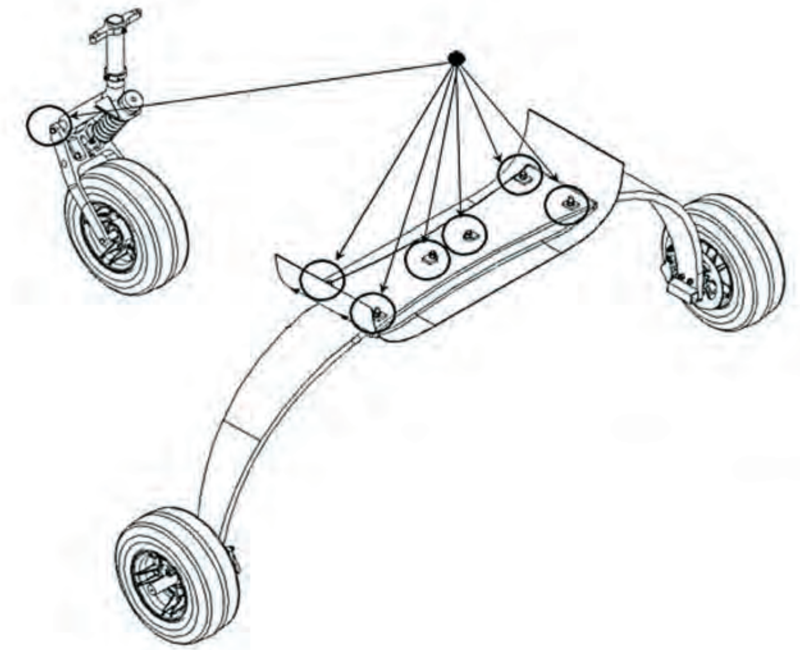
here at HQ? Well, I have to report that most of the worksheets have been returned from the mandatory inspection on the SportCruiser nose undercarriage spindles and these have flagged another problem.

Regular readers of 'Safety Spot' will know that we've been requiring owners of SportCruisers to check the nosewheel spindles on their aircraft for cracks. These checks are because of a failure a few months ago caused, we think, primarily because of cracking originating from corrosion pits in a weld-affected zone. If you haven't read this story you can review it in the October and November magazines (don't forget that 'Safety Spot' is available as a download from the LAA website – pop into the 'Briefing Room' at *www.lightaircraftassociation.co.uk*

From the returns, it is clear that there has been a developing problem with the wheel attachment forks on this aircraft type and cracking has been discovered on quite a few individual machines. When I first heard about this, I popped down to the workshop and took a look at the example that was sent to us following a spindle failure. It was pretty filthy, so I cleaned it and, sure enough, a crack could be seen at the edge of the component. Once disassembled, small cracks could be seen radiating from four of the six attachment holes but, without thorough cleaning and complete disassembly, it would be nearly impossible to see these cracks.

The LAA has issued another Airworthiness Information Leaflet (AIL) requiring checks on these nosewheel forks within five hours of the AIL's issue date, then each 50 hours and annually. We know from experience, as engineers (and tactfully, bearing in mind the fact that all LAAers do good landings), that this type of nosewheel assembly is intolerant of repeated heavy use, so this AIL, unusually, specifies that the leg needs to be disassembled and checked after a heavy landing.

One point about this that you may find interesting is that, whilst the inspection of the spindle assemblies were limited to the LAA kit-built CZAW SportCruisers, the fork is a common part between the kit-built and factory-built machines (PiperSport/CSA Manufactured). Naturally, when we first became aware of this issue I wrote to the manufacturer alerting them that they might have a developing problem and we've let the UK CAA know as they have an interest in the continuing airworthiness of EASA-approved factory-built machines.



Here is a picture of the general arrangement of the Jabiru undercarriage system, which is principally similar for all types of Jabiru. What this picture doesn't show very well is that the left and right legs are separate cantilever springs. You can see that each main undercarriage is secured by three bolts, the outer two being 5/16in (AN5) bolts fitted through a clamp that holds the leg to the fuselage structure. The inner bolt on each leg is rubber-mounted, which along with the flexible nature of the composite leg itself, affords some flex. The Jabiru main undercarriage leg is canted forward, which creates a loading asymmetry in the clamp itself; you can probably work out that the rear bolt is having to work harder than the front one.
(Diagram: Jabiru Aircraft Pty)

Here is an electron microscope picture of the remains, buried deep in the threads of the bolt, of the failed nut from the Jabiru UL430 that suffered an undercarriage failure. The reason for taking this picture was primarily to establish the material that the nut was made from. EDX analysis determined that the nut was almost certainly a Nylock nut as traces of a polymeric material were seen in the threads. No alloying elements might indicate that the nut was just made from mild steel; zinc traces are indicative of a galvanised (rather than cadmium-plated) finish. These findings suggest that the nut was of commercial quality rather than an aircraft quality part... not in itself an issue in this uncertified machine, providing that the correct part number was used.
(Photo: courtesy of AAIB)

JABIRU UL430: MAIN UNDERCARRIAGE FAILURE

Having an undercarriage fold on you during the landing is a sure-fire way to spoil the rest of your day. It's only happened to me once, and that particular incident was caused by me forgetting that the forward velocity vector needs to be a lot longer than the downward one and, I suppose, that wind gradient isn't just a theoretical concept! In the case of my particular incident, fold isn't a particularly accurate adjective, disintegrate would be a better one as the undercarriage failed catastrophically because of pure overload.

The amount of work an undercarriage system has to do during a normal landing is very dependent on the weight of the aircraft and the velocity of the impact. That's why, during initial pilot training, pilots are urged to hold the aircraft off in the flare for as long as possible before touchdown. When you get this right the main wheels drop gently to the ground from about an inch or two and, therefore, with minimal downwards velocity. 'Holding off' also has the advantage of reducing the forward velocity of the aircraft to the absolute minimum; remember that the amount of energy that has to be absorbed by the undercarriage system increases, like so many things in aviation, with the square of the speed.

During the initial certification process an aircraft has to go through before it's released to the market, the designer's theoretical stress calculations are physically tested. In the case of the aircraft's primary structure, this requires loading the airframe statically in a rig, always a tense time for the stress man. Controls are subjected to pull (and, of course, push) tests to check that they function in all circumstances and don't break the attaching structure even when maximum human effort is applied. And undercarriages go through a particularly demanding set of drop tests at maximum gross weight.

There are two basic aspects to undercarriage system design: strength and energy absorption. Strength is about whether the materials yield or break when landing and take-off loads are applied. Energy absorption is about slowing the application of that load (from impact speed to nothing over a period of time). By increasing the time that a specific amount of energy is applied to a structure, peak loads are reduced.

I use the term undercarriage 'system' because, during the testing, the whole aircraft, from the tyres up, may be involved in shock absorption as well as resisting the loads applied. Certainly, in this context, the energy absorptive quality of an undercarriage system must be considered as an equal partner with the mechanical strength of the materials used, if the undercarriage system is going to be successful in service. This is why regular maintenance checks must be introduced into the Tailored Maintenance Schedule (TMS) of your machine; tailoring can, and perhaps should, reflect average usage. For example, if an aircraft is often flown at, or close to, maximum weight, or if the aircraft is consistently flown from rough farm strips, you might consider decreasing the time between undercarriage inspections. Also, don't forget that tyre pressures will have an enormous impact on the energy absorption of the system as a whole – flattish tyres only work as good shock absorbers until the ground hits the wheel rims.

The primary purposes of an aircraft undercarriage are to support the load of the aircraft on the ground, resist and dissipate the energy generated during take-off and landing, and afford steerage. One thing, common to all these design requirements, is that you cannot check the system thoroughly without removing all the weight of the aircraft from it; this rule applies equally to the simplest of undercarriage systems to the most complex. Even the simplest cantilever spring design, like you will find on many LAA types, needs to be in its relaxed state to check it fully and this means getting it off the ground.

When checking an undercarriage with the aircraft on jacks or, as in the case of the Jabiru, by getting an assistant to lift the wingtip so that an individual leg can be lifted clear of the ground, it is important to ensure that there is as little as possible relative movement in the system; all connections and joints must be inspected, individually and as an assembly. Any sign of movement, especially along the load-bearing path, must be investigated and removed. So, what about our Jabiru UL430?

I spoke to the owner, Liverpudlian LAAer John McVey, shortly after the incident and he was still kicking himself a bit for not checking his undercarriage more often; he hadn't read the various factory bulletins which warned that the Jabiru undercarriage needs regular checking. John explained that the right undercarriage leg gave way just after landing which led to the nose-leg following suit. The damage was limited to the wing, front fuselage and propeller; naturally the engine was shock-loaded and needed a strip inspection.

The aircraft went off to the UK's Jabiru agent, Skycraft, and that's when things started to get a little difficult. Dave Almey, Skycraft's boss, gave me a call explaining that, after weighing all the parts (normal practice after an accident) this aircraft was heavier than it should be and that the insurance company was questioning whether the aircraft was legal at the time of the accident flight. We did some sums here and worked out that, during the

In this picture of the failed starboard undercarriage clamp from an LAA Jabiru UL430 that recently suffered an undercarriage failure after landing, it is clear that there has been previous movement between the leg and the clamp. Note the 'polished' surface on the right side of the clamp. This polishing indicates that the clamping force was insufficient, probably because the nuts had reached the plain shank of the bolt ('bottomed out'). Movement in this type of fixing creates two problems: 1 The movement introduces the possibility of wear, which will create still more room for movement; 2 movement changes the nature of the loading in the joint, often introducing sudden peak stresses but almost always focussing the load into a smaller area.
(Photo: courtesy of AAIB)

It was determined by the AAIB investigation team that the nut had pulled off the starboard forward attachment bolt; the rear attachment bolt was still in place. This photograph shows clearly the debris from the nut reaching right up to the shank of the bolt, indicating that it had probably 'bottomed out'. Along with the polished surface of the inner portion of the clamp, the evidence points to the fact that the attachment clamp had been loose for some time prior to the failure.
(Photo: courtesy of AAIB)

accident flight, the aircraft was operating within the maximum take-off weight permitted, that is, 430kg. We were able to convince the insurance company that this aircraft was, as far as the flying weight was concerned, legal.

When Dave questioned the aircraft's empty weight he was worried that, with a high empty weight, it would be very easy to overload the machine in normal service. To limit (as far as possible) the chances that microlight aircraft could be flown overweight, the maximum empty weight permitted for microlight aircraft is defined. John's machine was, as discussed, a fair bit over this maximum.

The maximum allowable empty weight for a microlight is calculated by deducting the pilot(s) weight (86kg per seat), plus the weight of an hour's fuel from the maximum all up weight of the aircraft, in this case, as I've mentioned, 430kg. When you do the sums, the Jabiru UL430 should have a maximum empty weight of 430kg - (172kg + 10kg) = 248kg. The parts from John's aircraft weighed in at 276kg, some 28kg too heavy.

"The amount of work an undercarriage system has to do during a normal landing is very dependent on the weight of the aircraft and the velocity of the impact"

The Jabiru UL430 has a total fuel capacity of 60lt, which is going to weigh (at 0.72kg/lt) about 43kg, so, when you take into account the empty weight, plus the pilot and full fuel (276kg + 86kg + 43kg) you get 405kg, which doesn't leave much weight for a passenger (25kg in my book). With these numbers you'd be struggling to stay legal carrying a passenger even if you were top of the class at weight-watchers and flew with minimum fuel.

You may ask why this aircraft was operating at such a high empty weight, or rather, why, when you consider that it is mandatory to weigh microlights every five years, this wasn't spotted during a weighing. The jury's out on that one but the fact that the insurance company got very close to not paying out on this incident should be taken as a shot across the bow; you may not get a payout from your insurance company if the aircraft is found to be overweight after an accident. One reason for the increased weight was that the aircraft was fitted with the big wheel kit and the aircraft had recently been resprayed.

I chatted with the owner to let him know that I would be writing about this event in 'Safety Spot' and asked him whether he minded me mentioning his name, etc. Fair play to him for agreeing that he should have been more careful, especially with regard to weight, and he pointed out that other owners might learn from his errors. John works in very dangerous environments himself as a demolition contractor and understands well the real value of flagging errors when they're made.

He mentioned a few other things he'd learnt during this event, which he felt were worth sharing. The first of these was that, like many LAAers, he's a pretty busy chap running a business and that he hadn't found the time to check through the Engineering Bulletins for the type. Had he done this he would have known that there have been a number of Bulletins, published by the manufacturer and available on its website, which require both upping the size of the attachment bolts from 5/16in to 3/8in (JSB 008-1, 2005) and limiting the life of these bolts to 500 hours (JSB 025-2, 2009). John's aircraft had clocked more than 600 hours.

One other thing that's worth mentioning, if you are an LAA aircraft owner, is that the Type Acceptance Data Sheet (TADS) for your machine will list all the relevant Mods and Bulletins applicable to the machine. One thing that is especially useful to the owner in the TADS are the Supplementary Notes. These, incidentally are particularly useful in the case of the Jabiru UL.

"Regular readers of 'Safety Spot' will know that we've been requiring owners of SportCruisers to check the nosewheel spindles on their aircraft for cracks"

Here is a picture of the AN365-524A whose threads were stripped as the main undercarriage failed on the Jabiru UL430; this nut was found in the aircraft as it was being scrapped, the damage to the airframe being so bad that it was considered unviable to effect a repair. Interestingly, an earlier EDX analysis of the remnants left in the threads of the bolt suggested that the nut was made from Mild Steel. Dave Almey, the nut's finder, has sent this nut to the AAIB for analysis and it will be interesting to see what they find. *(Photo: Skycraft)*

SAFETYSPOT

John said that, at least until the accident, he was planning to fly down to a small strip in France for his holiday. To make sure that he could get his aircraft into the "pretty tight" farm strip he had been practising his short-landing techniques. He admitted that, coming in a bit too slowly once or twice he may have, shall we say, tested the undercarriage rather harshly. If you do a landing that you would consider 'heavy' then it is necessary to complete a heavy landing check just to make sure that you haven't broken anything.

One other thing that John pointed out was that he didn't know that an aircraft needed to be weighed (and its centre of gravity established) after a repaint.

In the case of John's machine, it has been estimated that the respray has added about 8kg to the empty weight of the machine. Most microlights are built so that they just come under the maximum empty weight rule, any additional weight added (for any reason) may make it impossible to be able to issue a weight certificate at the next five-yearly weighing. Thank goodness it would take more than a simple undercarriage failure to put John off aircraft ownership. He understands now that this accident would have been completely preventable had the management of the aircraft's Maintenance Programme been better. We live and learn.

Fair Winds! ■

It is essential to remove all the access panels and cowls from an aircraft during its Annual Inspection so that every part of the structure and all the operating mechanisms can be checked. Here is an example where this looks not to have been done properly for at least two Annual Inspections. The pulley shown forms part of the aileron circuit in a Tipsy Nipper; you can see I hope that the Nylock nut securing the attaching bolt has only been put on finger tight. Remember, regardless of hours, the Annual Inspection requires that you remove all access panels and cowlings, it should be your first job; when your inspector is satisfied that all's ok then you can close the panel. *(Photo: Peter Sturgeon)*

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
Latest SPARS - April 2009	