DESIGN PROBLEMS OR REPORTING FAILURES?

As we learn more this month about the developing problems with some Pioneers, Malcolm points a finger back at us all...

I GOT in early this morning after forming a cunning plan: I'll get up early and get a couple of hours of Safety Spot writing done before anybody else arrives.

Eight eighths medium level strata-cu is completely obscuring the rising Easterly sun and a fairly stiff North North Easterly is kicking up waves on the LAA lake. These waves are measured in millimetres though rather than the three metre devils I was struggling with in the channel during an unexpected force eight off the South Coast during my holiday. Yes, I had a good time, thanks for asking!

Autumn is definitely here and, as I sit waiting for the computer to shake off it's morning cobwebs, about thirty Canadian Geese are in the downwind for the lake. Leaving everything to the last minute they, in unison, drop their starboard wings into a perfectly executed turn, get rid of their excess speed and drop their flaps. In one glorious movement the flock, looking almost like a single organism, swings round through 180º into the wind, extend their undercarriages and perform a beautiful mass landing. Who knows whether they appreciate how hard we limited creatures try to emulate them. What a fantastic start to a day.

I have a lot to discuss this month so, without further ado, let's get going. Oh, whilst I think about it, Francis Donaldson, the Chief Engineer, asked me to mention the fact that there are now four Zenairs flying again after their grounding. Regular readers will know this story well from Light Aviation's coverage last month so I won't go on about it here, but it's great to see these very fine machines back in the air again. I can imagine the frustration felt by owners when an engineering problem surfaces within their aircraft and they are unable to fly.

Pioneer 300 and Pioneer Hawk – Main spar update and undercarriage issues

I HOPE that all the members reading this will understand that the last place we want aircraft to be is in their hangar. We work hard to keep all your flying machines airborne but, as a membership organisation, we all have a responsibility to keep our activity as safe as it is possible to be. In other words, if you see anything that you're not happy with with regard to air safety then you are duty bound, as a fellow aviator, to report the facts to us. This is a subject that, because of recent incidents, I am to explore more fully in this month's Spot and I shall use a couple of recent problems faced by members as examples of what can happen when something breaks and repairs are conducted with a certain clandestinity.

We all understand the complications brought about by conflicting interests, the 'should I tell the LAA about this or not' thoughts that pass through all our brains are sometimes magnified by vested interest. Hiding problems though, for whatever reason, helps nobody either in the short or the long term. A good example of this reticence to come clean about problems are the recent events suffered by owners of the Pioneer its close relative, the Pioneer Hawk. I have flown these machines and taken the time to have a good poke around the aircraft, and in my book they are impressive aircraft in every department.

Pioneers are becoming a popular type with forty six machines on our books, thirty five aircraft of which are flying. These machines are shaping up well as the hours start to mount but, just like every aircraft ever designed, in-service problems occur. In last month's Safety Spot I showed a picture of a bodged main spar connecting plate that was found on a 300 that was disassembled because the nose landing gear had collapsed. If you haven't read this worrying story please, in the interests of air safety, take the time to do so.

'We all have a responsibility to keep our activity as safe as it is possible to be'

The LAA has now issued an Airworthiness Information Leaflet (AIL) requiring owners to check these plates and this is a check that requires an LAA inspector sign off. These checks are ongoing within the Pioneer fleet and, so far, this inspection has uncovered four other aircraft with mis-drilled main spar connecting plates; one spar has been so badly damaged that there is a very good chance that the wings will have to be written off. I cannot believe that whilst this mis-assembly was going on, nobody's hackles were rising.

I am the last person to throw stones and can accept that anybody can make an error of judgement. Whilst it may seem obvious to me that you don't mess with main spars, others may have a different view. But why didn't anybody pick up the telephone or send us an email when they saw this butchering going on?

So, what about the problem that required the wing to be taken off in the first place; the nose gear collapse? The facts behind this story are now emerging and I am having trouble believing what I am hearing. Let me say from the outset that I am in no way criticising the design. It is what it is and has been designed around 'light touch' certification requirements. There are lessons to be learnt in all departments here, which is why I am going on about it a bit. First things first, as you probably don't know how this undercarriage works, let me offer a brief description.

The Pioneer aircraft are kit built, side by side, low wing monoplanes. The kits are manufactured in Italy by Alpi Aviation and distributed in the UK by Pioneer Aviation (UK). The aircraft are essentially wood and, looking around the aircraft, are manufactured to a very high standard. In fact, some of the joinery is, in the mind of the writer who loves such things, eye wateringly beautiful. The undercarriage is fairly conventional, consisting of a hinged leg locked into the down position using a hinged brace which, when the leg is fully down, over-centres. Undercarriage retraction and deployment is accomplished by the use of a mechanical linkage to a central retraction motor, this linkage is basically a threaded shaft which operates like a screw jack.

There is provision to operate the retraction mechanism by hand in the event of an electrical motor failure, using a hand operated crank. During normal operation landing and taxiing loads are contained within the leg/brace mechanism but, should the brace fail to go over-centre much of this load will be taken by the

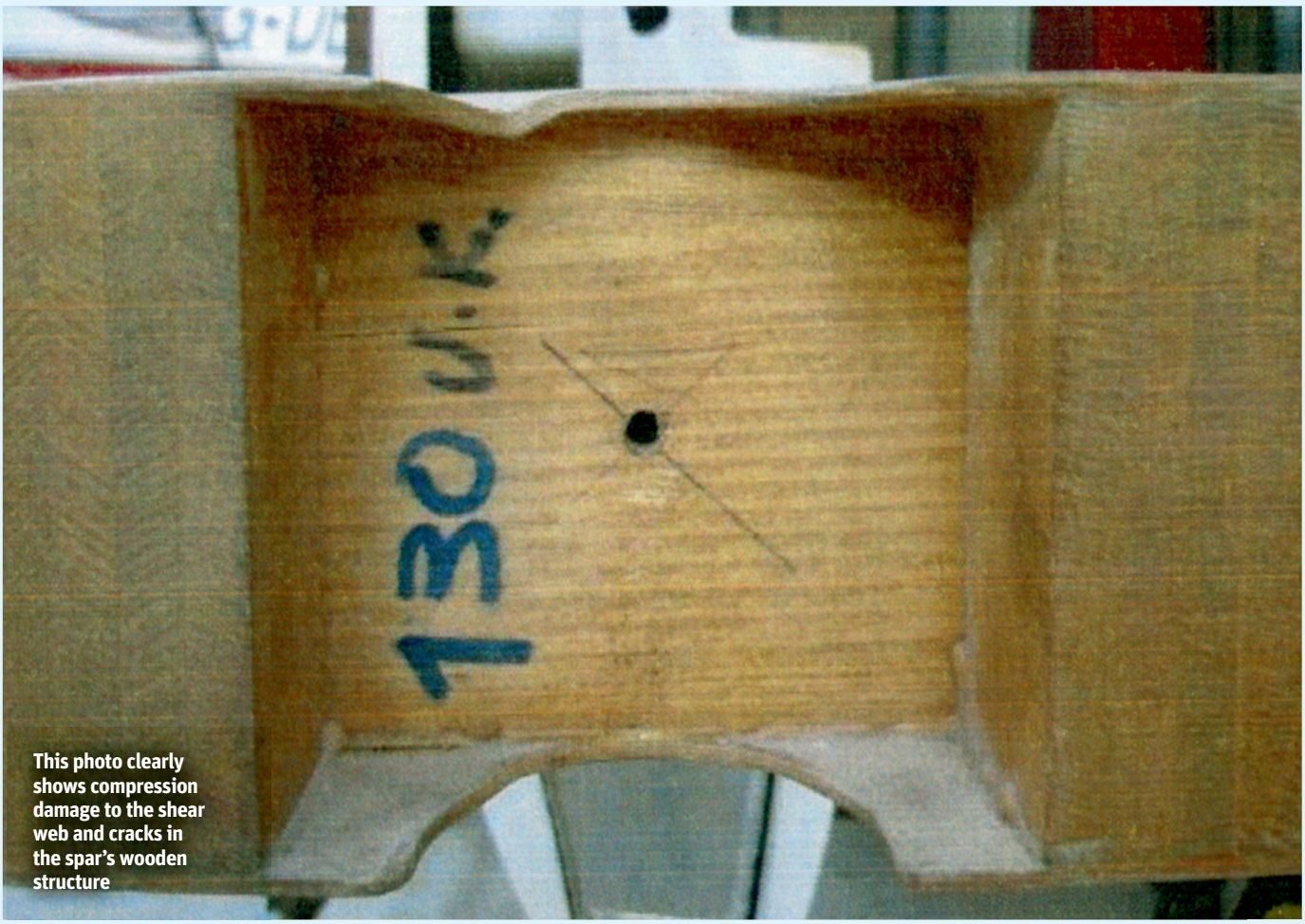

PHOTO Tim Skinner

This photo clearly shows compression damage to the shear web and cracks in the spar's wooden structure

affected screw jack.

The jack is not designed to take these loads and will, under such circumstances bend, which in turn puts the undercarriage further out of alignment, further increasing jack loads. The result of this misalignment of load path will eventually lead to failure of the screw jack and either retraction problems or undercarriage collapse. To let the pilot know that the gear is down a micro-switch has been fitted to the retraction motor which, in addition to operating a light in the cockpit, isolates the motor electrically so the pilot will have no warning if the undercarriage legs are not fully down.

Since the first reported failure, which we only heard about because of the bodging in the main spar found by the repairer when he took the wings off to transport the aircraft, the LAA has received evidence that there have been many undercarriage failures that had previously gone unreported. In other words, there seems to be a problem developing with something in this system and the LAA weren't aware of this growing situation.

By the way, when I use the word system, I am not just referring to the undercarriage itself. Let's have a look at the rest of the components in my broader definition of system. First, and as far as the LAA are concerned, foremost, is the owner/member. Then there is the repair/maintenance organisation/inspector involved with the aircraft. We have to include the product's design back-up here and naturally, I include myself. We could go on to include any of the (possibly) many witnesses to a failure

'There is very little adjustment in the operating jacks. This is another design issue'

event but this might stretch a point a bit (but only might). Let me explain what has been going wrong with this undercarriage mechanism.

The problem starts as I have described, when one of the braces fails to go over centre; we have now had reports of this happening to both main and nose gear mechanisms. The first systemic problem that's evident is that there is no direct information to the pilot indicating that an undercarriage is fully down; pilot information is only received about the position of the motor drive. This is a design issue. Another feature of this design is that the brace doesn't go over-centre by very much, the operating jack only needs to be slightly out of adjustment for the mechanism to fail. This is also a design issue. There is very little adjustment in the operating jacks. This is yet another design issue.

As is the way of all things, it is very unlikely that this 'out of adjustment' is a one off event, it is more likely to happen over the course of time. This is especially true when you remember that we are dealing with a wooden aircraft here; it is notoriously difficult to attach anything to wooden (and for that matter, composite) structures. The fact that movement in the system wasn't picked up by the pilot is a pre-flight inspection issue. The reason why so many aircraft, and their owners, have been negatively affected by this is that the previous incidents weren't reported, in fact in some cases, actively suppressed.

I say again, the Pioneer is a fantastic aircraft; it would be a miracle of design for a new machine not to exhibit teething problems. But, if the error feedback system that has been developed over many years fails anywhere – and I hope I've explained the multiple feedback loops operating in this incident well enough for you to get the gist at least – the whole system of Continuing airworthiness is at risk. It is vital that early design issues are dealt with in an 'on the top of the table' manner. Continuing airworthiness is about identifying and solving problems before they get to the system failure point.

You, dear reader, are a component in this system. The LAA is discussing the possibility of fitting independent 'down and locked' lights to the Pioneer undercarriage system which should offer immediate indication of a change to the adjustment of the operating jacks, and the design side of the Pioneer project are issuing modification advice to increase the amount of 'over centre' in the undercarriage braces. The LAA has also asked the agent to review advice regarding pre-flight inspections for this type and Pioneer Aviation (UK) Ltd. has rearranged the management structure within its Inspection Department and is instituting an incident reporting system.

We'll continue to keep all LAA members up to date on this important issue...

PHOTO Malcolme Ducker

A propeller makes a bit of a mess when its hits a fuselage. The blade in this incident narrowly missed the pilot's foot on its journey through the aircraft

The worrying incident of the Speedtwin ST2 propeller failure

INCIDENT reporting is nothing new and, while smaller events can be evaluated at a local level, anything more serious needs to be reported to the authorities. If the incident or failure leads to an accident then there is a well established accident reporting scheme operated by the UK Air Accident Investigation Branch (AAIB), a section within UK Government's Department for Transport. Their job is to get to the bottom of an incident or event and establish the root causes of a failure. There are specific definitions about what constitutes a reportable accident but, as in all things, there are arguments about what should and shouldn't be reported. LAA's advice about accident/incident reporting is given in our Technical Leaflet TL2.16.

Sometimes of course, there is no doubt about it, you need to pick up the telephone and talk to somebody at the AAIB. Such was the case with LAA'er Malcolm Ducker when, during a test flight, the starboard engine threw a propeller blade. There's bad luck and good luck and this event had its fair share of both of these ethereal and mischievous forces.

The LAA and the Speedtwin have a fairly long and involved history and, as an unusual machine, it deserves a short description. The aircraft was originally conceived by the Britten-Norman Chief Test Pilot Peter Phillips, who felt there was a place in the world for a two seat, high performance, aerobatic twin that could be kit-built by the amateur builder. The first machine was constructed using Victor Airtourer wings and a DH Chipmunk undercarriage. The fuselage was essentially a fabric covered steel tube cage, although the tail surfaces were made of plywood. This aircraft was powered by two Continental O-200 engines which, when they are brand new and working in tip top order, produce about 100 HP. The first prototype, G-GPST, flew in 1991 and soon became a regular visitor to aviation events around the UK, and the aircraft actually demonstrated at Farnborough in the early 90s. Sadly, both this aircraft and it's designer have now passed into history.

'There was an almighty bang followed by severe vibration. There was a smell of hot oil'

In 2000 ex-RAF man Malcolm Ducker decided this aircraft design was too good not to be resurrected. Malcolm had just retired as a Cathay Pacific 747 pilot and got to work completely rebuilding the project. The aircraft that evolved was scratch built and became the Speedtwin ST2. It first flew in 2007. As a prototype this machine has had various engine/propeller combinations but Malcolm eventually settled on the LOM M332B piston engines as the power source, driving GT variable pitch propellers. The LOM engine is really a modern derivative of the Walter Mikron engine, an inverted inline air-cooled engine developing about 140hp. The power can be increased to about 160hp when the supercharger is engaged. These engines develop full power at about 3000rpm. Readers with some engine knowledge will note this is a rapid rotational rate for this type of engine.

At the time of the incident a CAA test pilot (who also happens to be a Speedtwin enthusiast) was flying the aircraft from the front seat with Malcolm acting as an observer in the rear. The object of the flight was to establish the full power (supercharger engaged) level flight maximum speed; the aircraft was at 4000 feet and accelerating when, to use Malcolm's words: "There was an almighty bang followed by severe vibration. There was a smell of hot oil and lots of noise." The pilot attempted to shut down the offending starboard engine and selected the

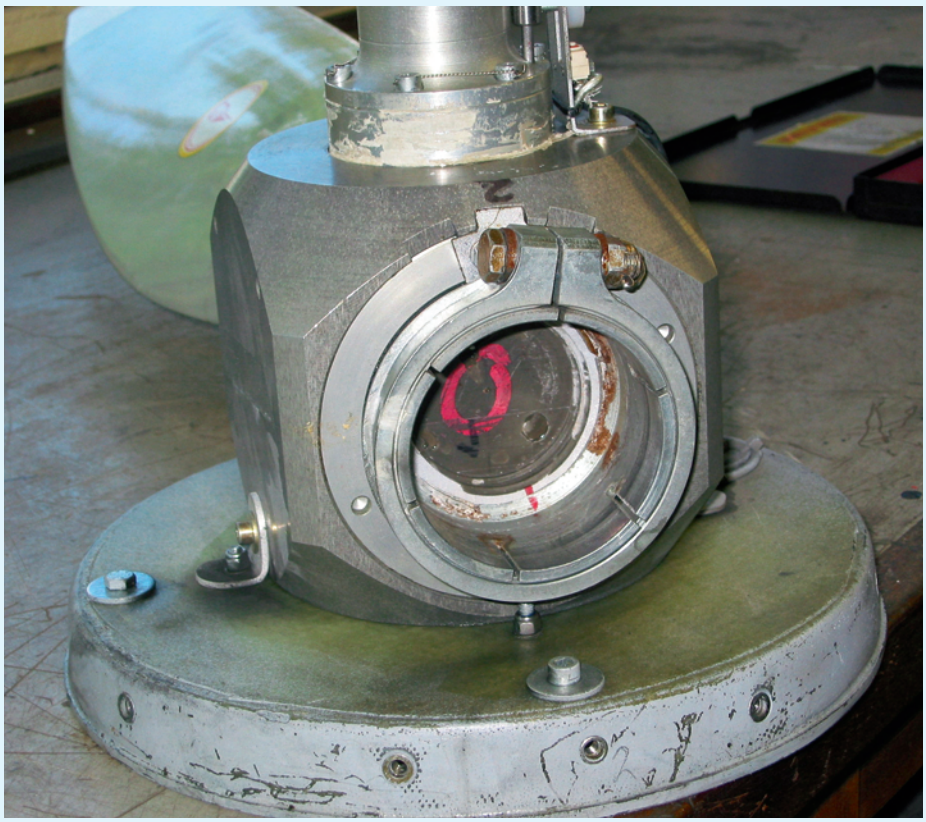
PHOTO AAIB

Corrosion can clearly be seen inside the hub of this GT propeller


PHOTO AAIB

The crack on the blade can clearly be seen emanating from these cut threads. Residual stress and corrosion leads to stress corrosion cracking even in a low stress environment

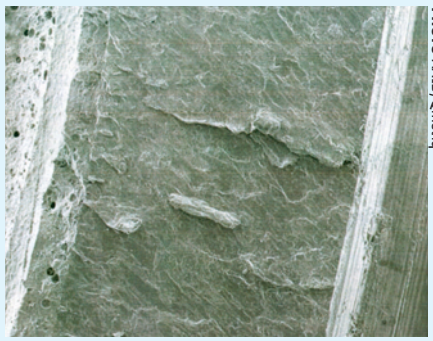
PHOTO AAIB/Qinetiq

Micrograph showing delamination of the fracture surface

electrical feathering switch. The engine failed to stop and the feathering system didn't appear to be working. It was also noted the port engine also appeared to be vibrating badly but was still producing power. The pilot transmitted a MAYDAY on the Wattisham frequency but, due to the very high cockpit noise, didn't hear a reply.

Twin pilots will know that this is not a good position to be in. An unfeathered propeller causes an enormous amount of drag and add large thrust forces from the other engine into the equation and you can soon run out of rudder. The pilot elected to make an immediate forced landing and with luck the ex-USAF base at Woodbridge was within reach. The pilot made an uneventful landing, so well done to him.

In this case the crew did everything right but the aircraft systems let them down. First, let's look at what happened to cause all the fuss. Examination on the ground revealed that one of the starboard propeller blades had left the hub. The out-of-balance forces at this point must have been phenomenal and it is a credit to the aircraft's design that the engine stayed with the airframe. In any event, the failed blade hit, and passed through the fuselage from right to left, just missing the pilot's feet on the rudder pedals. The unrestrained blade struck the port propeller which, although damaged, held together. I will discuss the cause of the propeller failure, which has now been established, later in this article. For now I would like to look at the other aspects surrounding this event. There are a few lessons to be learned and a few that were learned years ago which were adopted during the design, meaning the pilot is still walking around.

Last lesson first. When the aircraft was designed a stainless steel plate was added to protect the pilot's feet in the 'unlikely' event of a propeller blade failure. It did its job. Well done

'The failed blade hit, and passed through the fuselage just missing the pilot's feet'

to the designer for incorporating this safety feature into the aircraft.

The reason for the pilot's inability to shut down the engine was due to the fact that the magnetos' P leads had been ripped out of the back of the mags. As I am sure you will remember from previous Safety Spots, the P leads earth the mags, basically stopping the spark... No earth = no stop. I can almost feel the cogs going around in your cranium: "why didn't he operate the idle mixture cut?" Answer: simply this – there isn't one! The LOM engine has an automatic mixture system, reminiscent of the BFCUs found on much larger engines. It is possible to enrich the mixture but not to lean it out. One further operational problem was that nobody heard the MAYDAY. The radio transceiver had ripped itself out of it's mounting because of the vibration.

So, why did the propeller blade leave the hub? Basically, old lessons not learnt (or remembered). This GT propeller was a one off, specially put together for the LOM engine. It was operating at powers above the normal 100/110hp but it is unlikely that engine power in itself played much of a part in this failure. The failed blade was not recovered, although a portion of its root section remained within the hub. The hub, and the complete left hand propeller, were sent to the AAIB for investigation. It can be seen from the photographs that there was some severe corrosion on the inside of the hub, especially on the blade-securing screw threads. There was no evidence of jointing compound being used in the assembly either. In fact in this design there was no way to keep moisture out at all. Cracks are evident in the failed blade root section and an examination of the threads showed that they were cut by a tool rather than rolled.

A closer look by using a scanning electron microscope (set at very low power) revealed fracture surface delamination; this is a crack feature we've seen before and is a characteristic feature of stress corrosion. Readers will remember the MCR-01 tailplane bracket that failed last year due to a similar process although, in this later incident, there is no doubt about where the stress component originated from – the cut threads. There are always residual internal stresses which, unless relieved, will remain in machined surfaces.

Cut threads also leave an end grain which makes materials susceptible to stress corrosion cracking. Incidentally, aircraft bolts are always rolled for this very reason (and a few other applications too, which time and space prevent me from discussing).

I had a chat with Malcolm Ducker to check my facts out before writing this. He tells me that the Speedtwin project is alive and well. The LOM engines were virtually destroyed during the event and are going to be replaced by two Lycoming IO-360s. Weight considerations prevent the use of Variable Pitch propellers so he's opting for fixed pitch blades (hmmm, I suspect weight wasn't his only consideration!). He's still aiming to exceed the 200mph barrier and reckons he might reach closer to 220mph eventually. He's promised to turn me upside down in the aeroplane when it is finally fixed. I can't wait!

With Malcolm McBride
Airworthiness Engineer

Woodcomp SR3000 Propeller failure

AS REGULAR readers will know I bash on a bit about the need to get everybody into the loop when problems are discovered within a system and, as I have explained earlier, a system will include both mechanical and human factors. There is no place in the aviation world for people who hide their mistakes. In the previous two examples of system failure there were no injuries, though in both cases this was quite a close call. In the Pioneer wing spar case nobody took one of the affected aircraft up to limit load and the wings held together. And the Speedtwin was crewed by very experienced people who where able to cope with the problems the aircraft was throwing at them. But even in this case, luck played it's hand in the crew's favour in that they were within gliding range of a huge runway. The builder and owner of SportCruiser G-CRUI, John Massey is also counting his chickens after a scary incident that occurred over Goodwood. If the incident had happened half an hour later then the story would have been very different.

Let's start at the beginning. John started off his career in engineering but soon moved over into the rather more lucrative financial sector. He's been flying a fair time, having started with gliders and moved to rented PA28s and the like. John decided enough was enough with renting and part shares and built himself a SportCruiser, which he keeps at Baynard's Park, the estate of the late Alan Bristow near Dunsfold Aerodrome. Apparently, so Ken Craigie the Chief Inspector tells me, the ghost of Sir Thomas Moore roams the park after dark and that his pickled head still exists somewhere in a jar within the grounds. I digress...

John had arranged with his flying partner to fly from Baynard's Park to an airfield near La Rochelle in South West France. Their route took them south to Goodwood, West(ish) to the Isle of Wight, across the Channel and on to their destination. In a SportCruiser this means about forty minutes over the water, so both John and his passenger donned full immersion suits before leaving. John's aircraft was completed in 2008 and had about 90 hours on the clock, in effect a new aircraft. All was well until the waypoint turn west just before Goodwood when, without warning, a severe vibration started. John was working London info at the time and put out a PAN call and eased back the power. London info asked John to change frequencies but – and where have I heard this before – he couldn't do this because the buttons on the radio were too small to be operated with gloves (remember the immersion suit!). There was a short panic about the aircraft's position until John realised that the "little aircraft on the GPS obscured the Goodwood symbol on the screen". He was right over the airfield.

John did a great job of getting the aircraft back on the ground safely.. When on the ground, the cowlings were removed, but nothing seemed out of place. In fact, apart from the transponder leaving it's tray due to the vibration, all appeared well. John picked up the telephone and called the SportCruiser Guru, Graham Smith. Graham's other hats include an LAA inspectorship and as such, he runs the LAA Gold Star service centre for Woodcomp propellers. Graham advised John to get the propeller off and measure the blade tracking and blade angles. John did this and "with a bit of trig" worked out that there was a six degree difference between the two blades and had therefore discovered the reason for the vibration – naturally, one blade was producing far more thrust than the other.

Graham travelled down to John's workshop and together they stripped the propeller, the results of what was found can be seen in the accompanying photographs. The text explains what I think is going on here; it seems that the components were under-strength. This failure appears to be an early fatigue brought about by the increased load applied by the larger blades of the two bladed propeller – the assembly is the same as in the three bladed propeller which, so far at least, hasn't had problems.

We're quite early in this investigation and I expect there to be more to talk about later, but it seems that the Woodcomp designers realised early that this assembly was not man enough for the job because they uprated these two cogs in two bladed propellers made after about 2008. The only problem with this is that they decided not to tell anybody about it. Now, where have I heard that before? Fair Winds.

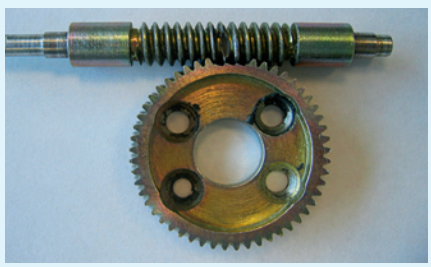

PHOTO Malcolm McBride

John Massey's propeller pitch change mechanism showing failure point

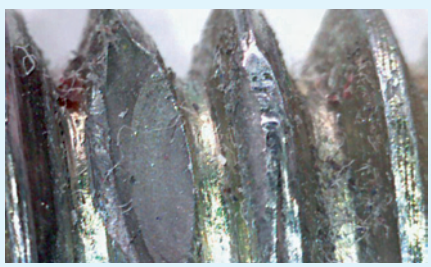

PHOTO Malcolm McBride

Close up of a failed section of worm from the SR 3000 pitch change gears. Beach marks can be clearly seen in this photograph which indicate a sequential fatigue failure

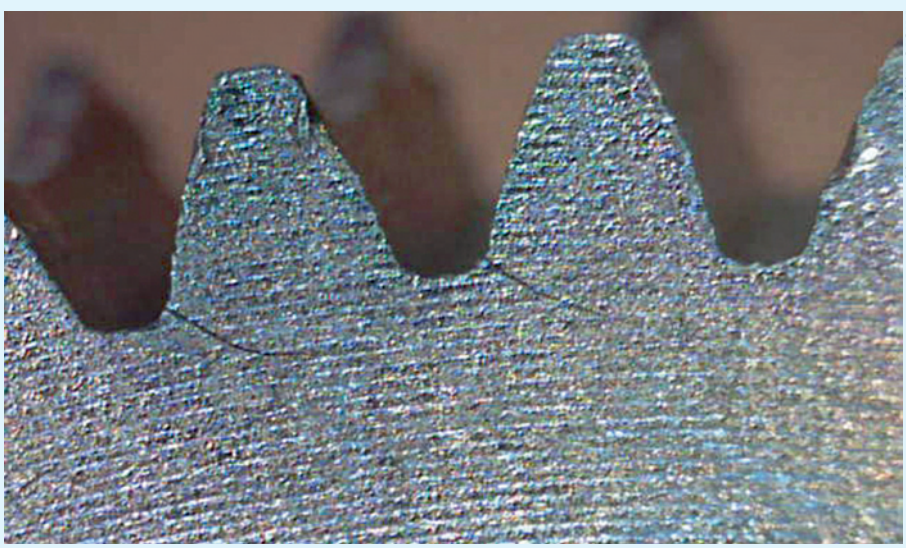

PHOTO Malcolm McBride

Close up of another SR3000 drive cog supplied by Graham Smith of the UK Woodcomp Service Centre. Note poor machining and check out the cracking which is not visible to the naked eye. These two teeth were not far away from failing

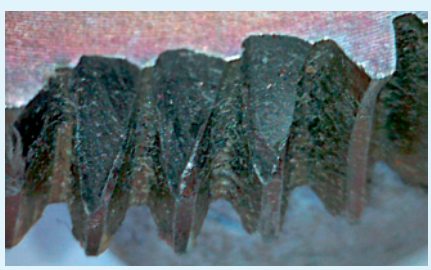

PHOTO Malcolm McBride

Closer view of failed section of operating cog

PHOTO Woodcomp

The SR 3000 blade at the root end disassembled from it's hub