DEADLY CORROSION
How your aircraft can avoid the chop

FLYING FOR AN AIRLINE
How to get the career you want

Buying an aircraft overseas
Tips & traps

FLIGHT TESTS
• Sportstar SL
• King Air B200GT

DIY aircraft maintenance
What you need to know

Vineyard destination Canowindra
Contents

Features

NATFLY REPORT 10
More developments in recreational sector.

A STRIP AMONG THE GRAPE VINES 18
Shelley Ross gets into the spirit at Canowindra NSW.

SPORTSTAR SL FLIGHT TEST 22
Advanced avionics and “automatic” CS prop enhance a popular trainer.

UPDATED CLASSIC: KING AIR 28
Modern avionics keep a classic more than competitive.

CATCH THE CAREER WAVE NOW 34
Airlines and flying schools provide their advice for those intent on an airline career.

DO YOUR OWN MAINTENANCE 52
Shelley Ross learns the basics from helpful LAMEs.

FATIGUE AND CORROSION 60
Steve Hitchen examines the latest thinking on contending with fatigue and corrosion.

BUYING AN AIRCRAFT OVERSEAS 65
The dollar may not be great but good deals are out there.

PILOT PROFILE – JOCK FOLAN 68
Aviating by any and all means.

Regulars

EDITORIAL 4
AIRMAIL 6
CALENDAR 16
BOOKS 70
ROTORS 72
WHAT CAN WE LEARN 74
FLIGHT SIMS 76
MY STORY 78
MEDICAL MATTERS 80
BACKLASH 82

Cover: New Sportster SL. See flight test page 22.
Fatigue and corrosion

The age of the general aviation fleet in Australia has been a hot issue for some time, and is often bandied about as a safety issue. **Steve Hitchen** waded through a sea of information available and presents his conclusions in this special report.

The spectre of aged aircraft falling out of the sky has become aviation’s world-wide bogey man. Visions of airframes separating in the air are a lot safer than it was ever designed to be. The average age of powered GA aircraft has reached 30 years, a service life likely to be a lot longer than the manufacturers ever intended. This places both regulators and owners in the grey unknown; no-one knows what is going to happen, and worse, when it is going to happen.

In isolation, the calendar year age of an aeroplane is not as relevant to its service life as the flying hours, maintenance history and types of operation. There are aircraft labeled “antique” flying all around Australia and many of them are in far better condition that some of their younger counterparts. The reason is that they are well-maintained and looked after, and no longer have the work loads of the average GA equivalent.

And largely it is the service loads over time that determine how much life is left in an airframe. As most of the fleet is made of metal, structural components subject to cyclic loading will inevitably be exposed to fatigue and the risk of consequent fracture. The constant loading and unloading of a component ultimately leads to a crack on the surface, which grows further through the metal with each load/unload cycle until the remaining metal is not enough to carry the design load, and the part fractures into two pieces.

At 8500 feet that is catastrophic.

Compounding the problem is corrosion, where chemical attack destroys the metal to such an extent that, again, there is not enough metal left to resist loads trying to separate the component. In aeroplanes, this is worrying everyone the most.

Thomas Turner, CFI of Mastery Flight Training in the USA and Manager—Technical Services for the American Bonanza Society, has worked long and hard on the issue with the FAA’s Small Aircraft Directorate and AOPA USA.

"Corrosion degrades the capability of the metal to the point when some single event will cause a crack," he said during a recent visit to Australia. "A crack that comes from corrosion would more typically be a catastrophic single event. It wouldn’t be a period where there would be a smaller crack then a larger crack. You’d have the metal that corrodes to the point where it suddenly can no longer handle the stress that it undertakes and the whole thing goes at once.

"It is the biggest single issue we have with our aeroplanes. The challenge is to find the corrosion and address it, whether it is to replace the skin or part, or repair the part before it becomes an issue, and there are certainty portions of the aircraft that are far more difficult to inspect for corrosion than others."

The kicker in the whole issue is in Turner’s last sentence: some areas of aircraft cannot be inspected for corrosion and cracking economically. If it can be seen, something can be done about it, which will give owners a measure of confidence that the airframe is safe. But when problems cannot be seen the level of safety needs to be addressed in another way.

Exactly how is what the entire industry is struggling with right now.

How Old is Old?

A significant amount of energy has been expended pondering this one question, and in truth the answer is still eluding the regulators. The most common figure you will find in writing is 30 years, which seems to have been derived from the average age of the GA fleet. Initially the FAA advocated setting a
calendar year definition, but according to Turner, it has stepped back from this.

"At a conference on ageing aircraft in Kansas City, Missouri a few years ago the FAA and other organizations spent two days discussing the issues that face the continued airworthiness of ageing aircraft. One of the work groups was tasked with defining what we mean by ‘ageing aircraft’.

"In the end, the FAA’s stance was that an aircraft’s age is not a function necessarily of calendar years, but more what we might consider to be fatigue exposure - was the aircraft operated in a rough environment, was it operated in the dual flight instruction role, was it operated a lot at the high end of its maximum gross weight allowance? Very critical issues were - has it been stored in a maritime environment? Corrosion was the number one issue in aircraft ageing, and you can of course get corrosion in a virtually new aircraft if you park it outside in a maritime environment and it sits for a long time.”

The issue in Australia was recently clouded by the federal government when they included this unhelpful statement in their National Aviation Policy Green Paper, p138: “Well-maintained aircraft can operate safely for at least 20 years, but eventually will need to be replaced.”

Two separate sources at CASA were quick to point out that the figure of 20 years did not come from them. We can only presume that it was extracted from some murky corner of another government department or cross-applied from the life limits manufacturers set on transport category aircraft.

Turner has a more practical idea for measuring fatigue condition: "I think it would be better if we could arrive at some sort of inspection process or some sort of sliding scale of fatigue or some point value that you could assign to various fatigue events in an aircraft’s life and track an aircraft based upon its own experience.

"Compare a 1947 Bonanza that has been completely restored to pristine condition with modern safety devices added, to a 1983 33 Bonanza that has been stored out in the rain in a salty environment, and the pilot has been flying unauthorized aerobatics. When we’re talking about aged aircraft issues, we’re not really talking about age at all, we’ve just never figured out a better way of saying ‘old aeroplane’. ‘Old’ is more a matter of fatigue than calendar age.”

Mass Grounding Hysteria
Attempts by regulators - in particular the FAA and CASA - to address the problem have put the frighteners on a lot of people. Poorly-worded or confusing documents have aircraft owners believing that over half the GA fleet is about to be grounded because of fears age has wearied critical components to the point of being dangerous.

"The GA industry in the USA is frankly frightened by some of the terminology," says Turner. "When they talk about ‘safety by retirement’ it sounds like wholesale grounding of the GA fleet. If they decide that 30 years is the cut-off point, we’re going to ground an aircraft when it’s 30 years old. Well, we take away all those aeroplanes and we take away some huge percentage of the fleet, and that fleet must exist to support the infrastructure that’s going to give us the airports and the maintenance facilities and
the fuelling facilities for the remaining aeroplanes."

The situation is little different in Australia, where the paper Rough Diamond, published on the CASA website, was interpreted by many as advocating compulsory retirement after only 15 years service. It takes a few passes through the text to understand that is not the case.

Instead, the paper promotes the concept of scientific life limits—as distinct from arbitrary life limits—and then a plan to either inspect or reinspect once the limit is exceeded. CASA’s Steve Swift, who co-wrote the paper with the FAA’s Bob Eastin, is quick to dispel the myths of mass groundings.

"CASA is not going to set an arbitrary limit to retire air frames or components. We would prefer to manage each aircraft on its merits, as we do now. Admittedly, keeping the structural management program current can be hard, especially if the manufacturer is no longer actively supporting the type.

"Life limits were the first way we tried to manage fatigue. Since then, ways of inspecting are increasingly being used to manage fatigue. Instead of throwing parts away before they crack, they can stay in place until they crack - provided we know it has cracked and can manage the issue.

"If you can’t inspect them regularly, you may have to replace. Retirement is the default situation for when you can no longer inspect. If someone comes up with a justification for going past the life limit on a part, say with a workable inspection program, then we are open to consider it."

After you distill Rough Diamond to get rid of the tech talk, there is a simple concept left: measuring the extent of the crack is the secret to knowing if the part is still safe. Swift and Eastin note the three stages of crack assessment as detection, duration and dangerous. Basically, once you discover the crack, you need to work out how long it will take before the crack grows to a
dangerous size. The duration is effectively how long the crack will take to grow to the dangerous stage, after which it has to go.

What quells such a simple concept is that the duration will vary depending upon the type of duty the aircraft is performing, and some cracks cannot be detected before they reach the dangerous stage. That’s where life limits enter the argument. Once the limit has been exceeded, an aircraft operator will need to show the regulator that they can evaluate the integrity of the part; show they can detect a crack and measure the duration to dangerous.

If CASA doesn’t accept the management plan, it is unlikely there will be an extension of the life limit. In some instances, this may mean retirement of the airframe and the loss of a valuable asset. Saying that the component must be considered unsafe because there is no way of knowing for sure is a bit like “guilty until proven innocent” and the concept is not popular with aircraft owners who have to wear the cost burden.

Regulatory Moves
In the US there are two existing regulations under which an aircraft has been certified: CAR3 and FAR23. CAR3 has been around since 1945 and has applied to most GA aircraft, but not commuter aircraft. FAR23 contains the more stringent testing required for commuter aircraft as well as other categories. When it comes to the issue of ageing, there is one big difference between the two, as Thomas Turner explained:

“With CAR3 aeroplanes there was never a requirement for determining the fatigue life on the aeroplanes, no requirement to produce any documentation on how long they would operate or what the useful lives were. It is my opinion that they were never intended to last as long as they have, which is a testament to how soundly they have been built. But the FAA is now releasing advisory circulars that are moving in the direction of requiring retroactive FAR23 standards for CAR3 aeroplanes.

“Take, for example, a Baron 58, which is a CAR3 aeroplane and a Baron 58P, which is pressurized Baron and is a FAR23 aeroplane. They are essentially the same aeroplane. There are differences in the engine and the pressurization, but the basic design is the same. Beechcraft was required to establish some form of life limit on critical components on the 58P, in this case the wing structure, the carry-through structure and the pressure vessel.

“They had the option to do some very stringent testing to arrive at some mean time between failure for these components and then take some percentage of that and establish that as a life limit. Or, they could simply put some arbitrary life limit on the aeroplane, for instance, 10,000 hours and that’s it. I think it was done on the arbitrary life limit on the assumption that no-one was ever going to fly one of these things for 10,000 hours. What we’re seeing now is aircraft that are approaching that limit, but are still flying perfectly well. But, they’re facing a day when their re-sale value is going to be very low and they have to be salvaged.”

“To adhere to the same airworthiness standards as an FAR23 aeroplane pretty much solely for the purpose of assigning a fatigue life to them instead of taking a more data-driven approach – finding out what fatigue issues really exist and do we really need to do something – I think is a little excessive.”

If you are cringing at the thought of a perfectly good B58 Baron being grounded, you are not on your own. Owners can take some heart from CASA’s emphatic statements that they don’t advocate arbitrary life limits, which should keep our Barons—and just about any other GA aeroplane—safe from similar fates.

CASA, however, does advocate life limits arrived at by engineering research. Although there is a strong argument for the integrity of limits reached in this manner, it would still be a cold cup of tea for aircraft owners who have to go through the expense of replacing the part just because no-one has invented a method of checking for cracks.

What are the Options?
Ken Cannane is the Executive Director of the Aviation Maintenance Repair and Overhaul Business Association (AMROBA). After 50 years in aviation as a LAME, CASA administrator and Head of Maintenance Standards, it
would seem he has been battling with airworthiness issues most of his life. His experience has shown him that the best way to tackle an ageing aircraft is to keep it young.

"Many past fatigue failures and major structure failures due to corrosion have been due to what is now known as ineffective maintenance programs and/or design standards. The lessons learnt by manufacturers and safety dedicated operators have been the catalyst for the safe designs of today.

"Because of the advances made by manufacturers and NAAs [National Airworthiness Authorities] in addressing ageing aircraft issues, most aged aircraft are safe, but not as safe as newer designs of more modern aircraft. At some stage all materials used in aircraft will have a finite life - it is the maintenance program and inspection techniques used by competent and qualified inspection staff that will maintain safety."

Sounds simple, doesn't it? But of course it's not that easy. CASA has to approve your inspection program, and a weekly walk around with a torch is unlikely to impress them greatly. Steve Swift provides some idea of what will be needed.

"First you need to know what the cracking or corrosion issue is you're looking for. Second, you need to know what size you could miss and what the duration will be until it becomes dangerous. It will take trials and engineering to come up with a method of knowing this."

"We consider other options put to us all the time. We are not entrenched on anything. Whether or not the system you devise is cost-effective is immaterial to us. We only want to see that it is safe."

By the time you have developed your very own inspection program, with the engineering data to support your methods, you may find your bank account is lower than if you had bought a new part. The good news for aircraft owners is that they are not on their own - aircraft manufacturers, aviation groups and type clubs have been working on maintenance programs for some time.

Perhaps the most well-publicised instance of "inspect or replace" is the Cessna 400 series saga, where testing by the manufacturer showed that the wing main spar lower cap and upper and lower attachment fittings had a finite life, and that many of these popular commuter aircraft were either approaching that age or already past it. CASA Airworthiness Directive (AD) AD/Cessna/400/40 required the components to be retired when they reached a certain number of hours or flights.

Many operators faced the immediate loss of their asset as the repair bills to comply with the AD were crippling. However, aircraft were exempted from the AD or some part of the AD if they were on a maintenance program, such as those devised by Hawker de Havilland, Aircraft Engineers Australia (AEA) and, eventually, Cessna's own Supplementary Inspection Data (SID).
"Type clubs typically have much expertise regarding the maintenance of a particular model and keep up-to-date on service difficulties. They usually have data pertaining to the best inspection and maintenance techniques. They also have data regarding field approvals for modifications and alterations ... the collective knowledge within a type club could easily be used to develop special inspection guidelines for a model type.

"When type clubs provide easy access to all available data on a particular model to its members, the probability that an owner or their mechanic will use it increases."

Clearly the type clubs have a pivotal role to play in the ongoing maintenance of aircraft, particularly if the type is no longer supported by the manufacturer. It is one of those quirks of the industry that LAMEs are more likely to supply data on maintenance problems to the manufacturer and type clubs than they are to the FAA or CASA, making the official feedback systems close to being ineffective.

Thomas Turner: "The best thing we can do is use whatever data we have currently to share information about what issues have actually been found in aeroplanes and incorporate those into advanced inspections. If we have for instance information about corrosion around the window frames inside Brand X aeroplane, then we modify the annual inspection checks so that we are looking specifically for that issue."

*The World of the Future*

In years to come, inspection techniques such as magnetic particle and eddy current may advance to the point where they can be relied upon to detect even the smallest defects, but for now they are limited.

"The National Institute of Aviation Research did a lot of the Cessna 402 work," says Turner. "They're looking at some advanced eddy-current techniques for detecting cracks before they become visible. The hope is that one day you might have the aeroplane equivalent of an MRI. We could see the whole make-up of what's going on inside the aircraft and be able to say 'OK, this structure is going to crack inside X number of hours.' Whether that's achievable or not, I don't know."

With the ability to wave a magic wand that show up all the defects still some years away, the industry's best option at the moment is to band together and use shared information to develop advanced inspection programs.

But even with that in place, it is likely there will be instances where the aircraft has simply expired. This is a worse-case scenario, and let's hope that commonsense, good engineering and cooperation with regulators keep those instances to a minimum.

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Operators had to weigh up the economics of replacing, retiring or going onto a maintenance program, neither of which was a cheap option. With aircraft age very much in the regulators' focus at the moment, it is fair to expect that more owners will be facing similar decisions in the near future.

In 2003, a working group consisting of AOPA USA, the Antique Aircraft Association (AAA), the Experimental Aircraft Association (EAA) and the FAA developed a booklet called the Best Practices Guide for Maintaining Aging General Aviation Airplanes. A copy is available from the AAA at http://www.antiqueairfield.com/bestpractices/aceagingbestpractices.pdf. It needs to be noted that this is a guide and not a regulation, and in itself does not constitute an inspection program.

It is, however, an excellent starting point, especially for buyers who want to know the fatigue state of the aircraft they are looking at. It is customary for buyers to check the hours left on the engine and prop, but aviation is now at the stage where airframe life needs to be taken into account also. This guide—although American—lays out what records need to be searched and where the big problems lie. With a bit of translation into Australian, it can be a valuable resource.

It also exposes ones of this country's least-tapped resources: the type clubs such as the Australian Bonanza Society, the Cessna Pilots Association and Australian Piper Society. The guide says: