TAAATS contenders sign contracts

Specification development to precede evaluation

The process of providing Australia with its first fully-integrated air traffic services system took another step forward recently when the Civil Aviation Authority signed contracts with the two prospective suppliers.

The contracts marked the start of the competitive Specification Development Phase and were signed by Acting Chief Executive Doug Roser, for the CAA, and representatives of Thomson Radar Australia and Hughes Aircraft Corporation.

Selection of the TAAATS contractor will be based on an evaluation of the competing offers developed during this phase.

Doug Roser said discussions between the two companies and the CAA leading up to the signing had been professional and amicable.

“We have agreed a process which gives both companies an equal opportunity to be the successful contractor for The Australian Advanced Air Traffic System (TAAATS),” he said.

“I am confident we now have a process which will lead to Australia having a fully integrated air traffic services system for the first time and we hope to sign a contract with the successful bidder by the end of the year.”

Doug Roser said 14 weeks after the signing the companies would deliver draft specification.

Continued page 4

- Experienced project manager appointed to TAAATS — Page 5

CAA approves All-Australian aircraft

An Australian aircraft, the Seabird Seeker, designed for patrol, surveillance and inspection work, was granted certification by the Civil Aviation Authority (CAA) on Friday, 12 March.

The Seeker is only the fourth Australian-designed and built aircraft, and the only one of its particular type, to gain certification which puts it in the same certification standard as imported aircraft such as Beech, Cessna and Piper.

The other three Australian aircraft certificated were the GAF [Government Aircraft Factory] Nomad, Transavia Skyfarmer and Gippsland Aeronautics CA-200.

The Certificate of Type Approval, in accordance with CAA Regulation 22, was presented by Ron Cooper, General Manager, Safety Regulation and Standards, to Seabird Aviation Managing Director, Don Adams, in an informal ceremony at the CAA’s Canberra head office.

The Seabird Seeker was designed, developed and built by Seabird Aviation, of Hervey Bay, Queensland, after extensive study of the international market by Mr Adams.

His decision to develop the aircraft to the United States’ Federal Aviation

Continued page 15
Old commuter aeroplanes: Consumable treasure

Presented by STEVE SWIFT, Principal Engineer, Fatigue Evaluation, Civil Aviation Authority, at the ‘Aging Commuter Airplane Conference’ Canberra, 4 August 1992.

D o not lay up for yourselves treasure on earth, where moth and rust consume — Matthew 6:19

To moth and rust add fatigue. Even with careful piloting and conscientious maintenance the insidious process of fatigue is unstoppable. Dozens of Australian air travellers have been killed by fatigue, and hundreds more have been very lucky.

I sometimes hear people say this about their aeroplane:

‘There’s been thousands like her flying for yonks. I know every inch of her like the back of my hand. She’s a beauty, and she’s gonna last forever’

I can sympathise with them - I’m sometimes tempted to feel this way about my faithful old car - but it’s false confidence, and if it leads to complacency, it’s out of place in the aviation business.

Jesus is right. Old commuter aeroplanes, like everything material, are consumable treasure. They wear out, especially by fatigue.

THE ACCIDENT RECORD

There have been several fatal accidents involving fatigue in commuter aircraft (including helicopters) in the Australian region. They include

1945 Stinson A2W Australia
1952 de Havilland Dove Australia
1953 Bristol 170 Australia
1957 Bristol 170 New Zealand
1957 Twin Pioneer Papua New Guinea
1961 Aero Commander 680 New Zealand
1963 DHC-2 Beaver Australia
1964 DHC-2 Beaver Australia
1973 Douglas DC-3 New Zealand
1987 Aerospatiale Puma Australia
1990 GAF Nomad Australia

By all rights there should be added to this list several that were very lucky: a Beech Queen Air, several Partenavia P68, an Aero Commander 500S, another Puma and a Bell 214ST.

The point I am trying to make here is that fatigue is not just a problem for big Boeings in Hawaii.

THE PROCESS

Well, what is this process called fatigue that causes so much tragedy?

If you’ve ever removed a time-expired part from an aircraft, you’ve probably wondered why it needed changing. But though it might look as good as new, it’s not. If we had access to the most powerful microscopes available, this is the sort of thing we’d see.

Figure 1: Slip (left) leading to surface micro-cracks (right)

We’d see that there’s been a lot of slipping and sliding going on within the metal grains, and microscopic discontinuities in the crystal structure of the metal have clustered together and are starting to form micro-cracks.

This process began on the aircraft’s first flight. It’s real damage, but we can’t see it with the naked eye. Left in service, micro-cracks grow to form visible cracks, which we’ve all seen. What happens once a crack starts?

Stresses in a part flow just like a river: they like smooth, gradual changes in direction. They don’t like detouring sharply around a crack, or any other discontinuity for that matter.

Near a crack tip, stresses may “bunch-up” to be several times higher than average. Every time the aircraft pulls a manoeuvre or hits a bit of turbulence, the crack will grow by a tiny amount, until eventually the part will break.

Each time the crack grows it leaves a line on the fracture surface. These lines are called striations, and we can see them with an electron microscope, like the one at the CAA’s laboratory in Canberra. Sometimes we can even
see individual flights and count them, a bit the same as growth rings on a tree. Some metallurgists imagine that they can even see where the pilot coughed!

Figure 2: Striations

Striations are not to be confused with the much broader bands called “beach marks”, that give fatigue away at the accident site because they’re easily visible to the naked eye. Beach marks are groups of similar striations, marking longer periods of constant crack growth. Remember, each broad band in Figure 3 represents hundreds of striations.

Figure 3: Beach marks on an Aero Commander spar cap

COMMON PROBLEM AREAS

Some of the things that aggravate fatigue are joints, other structural discontinuities (abrupt section changes, holes, windows), repairs (especially those that markedly alter stiffness), engines and propellers, helicopters (a fatigue engineer’s nightmare!), and corrosion (corrosion pits are stress concentrators that can easily initiate fatigue cracks).

SCATTER

The real fly in the fatigue ointment is scatter. A set of identical parts, subject to the same loads, won’t all break at the same time. In fact they’ll be all over the place.

Figure 4: Test 1000 Cessna wing spars to destruction

If we were to fatigue-test 1000 identical wing spars, from a Cessna 402 say, until they broke, we would get a distribution something like this.

One would break before 8200 hours, the Australian mandatory retirement life (AD/Cessna 400/40); 65 would last somewhere between 8200 and 16400 hours; etc. One would even last 130000 hours! It’s a shame we can’t tell beforehand which one’s which.

Keep this business of scatter in mind when the Maintenance Manual or an Airworthiness Directive asks you to inspect for cracks, and you don’t find anything. Remember that not all aeroplanes will crack at the same time. The chance of finding a crack on the first inspection is lowest, but increases as time goes on. Be wary of anyone who says to you, “Boss, I’ve carried out this same inspection three times and haven’t found a thing, I’m in a bit of a hurry. Can I skip it this time?”

Keep scatter in mind too, when you find a major defect. Just because your mate in the next hangar hasn’t heard of it before, doesn’t necessarily mean that it’s a “one off”. Yours may be the one that failed early, over on the left hand side of Figure 4, and sooner or later the rest will follow. Report the defect so that the CAA can take action to protect the rest of the fleet.

Many factors contribute to scatter and lower lives. Here’re just a few.

Figure 5: Factors that affect fatigue
CONTROLLING THE EFFECTS OF FATIGUE

Clearly fatigue can be a killer. We can’t stop the process, but we should try to control its dangerous effects. How?

Broadly, we have two methods: Inspection, or Retirement. In other words either inspect regularly for cracks, or retire fatigued parts from service before cracks have a chance to start. (I have avoided using fatigue jargon here like safe life, fail-safe and damage tolerance. Some attach their own special meanings to these terms and it can get a bit confusing.)

Inspection appears more attractive than retirement, at least superficially. For example spar replacement is a major cost that most would like to avoid. But it’s not that simple. Inspections can be expensive. And the absence of a mandatory retirement life does not mean that a part will last forever. If an inspection does find a crack, a high premium may have to be paid for part replacement or major repair, because it’s urgent and unscheduled.*

These are the hoops you have to go through to demonstrate that you can maintain safety by inspection.

For each critical part you have to ask: ‘WHERE will it crack?’; ‘WHEN will it crack?’; and very importantly, ‘Can we find these cracks early enough?’

If we don’t know the answers to all of these questions, or the answer to the last one is ‘No’, then we have to set a retirement life.

For each critical part:
- Where will it crack?
  - When will it crack?
  - Can we find these cracks early enough?
    - Yes
      - detectable size
      - growth rate
      - critical size
      - INSPECT Cessna 404 wing spar
    - No
      - RETIRE before cracks start

Figure 6: Controlling the effects of fatigue - two options

* Alan Emmerson discussed the fundamentals of inspection versus retirement in his paper, ‘Airworthiness control in the face of structural fatigue’ presented at the same conference.

EXAMPLES

It may be helpful to illustrate some of the principles with two examples. I’ve chosen Cessna 402 and 404 wings, but not because they are better or worse than any of the others. I could have just as easily chosen Pipers or Beechcrafts.

Let’s start by looking at a wing where safety CAN be maintained by inspection: the Cessna 404.

We know WHERE it will crack from a fatigue test conducted by Cessna. A test is expensive but it’s usually too late — fatally late — to wait for service data, although sometimes we’re very lucky and get away with it.

We know WHEN it will crack from the same test.

We can find the cracks early enough because it has good internal access for inspection. Note also the dual main spar. We don’t have to go chasing tiny little cracks. Even if one spar develops a big crack, the other one can carry the load until the crack is found.

Crack growth is slow because stress levels are only a third of those in a 402, and the spar material has been deliberately chosen for slow crack growth. See how the crack spends a nice long time in the detectable zone. It gives us a good chance of finding it before it’s too late.

The end result is that we can keep things safe with inspections every 1200 hours, and there’s no retirement life. You won’t find the 404 listed in AD/CESSNA 400/40. That’s the good news. Now for the not-so-good.

The Cessna 402 was designed a lot earlier than the 404, back in the days when light weight, to give top performance, drove the designers and before durability became a selling point.

Figure 9 shows some of the critical bits. Again, consider the wing spar. We have some idea of WHERE the spar will crack and WHEN it will crack: Cessna conducted a
fatigue test and there’ve been at least three spar failures since.

The next step is to ask ourselves: ‘Can we find these cracks early enough?’ For example, what if we get a crack growing in the lower cap of the spar, inside the nacelle? You can’t get at it, and in at least two cases in the past the cracks remained hidden and were not discovered until they had grown so large that the pilots noticed the wing flexing in flight! Had these aircraft been fully loaded, or seen a moderate gust, they would have been lost.

What if we could cut a hole in the nacelle to improve the access for inspection?

Here’s how a crack might grow. Notice that there’s no detectable zone in the middle as there was for the 404. Because of the high stress levels, the notch-sensitive alloy that’s used, and the difficulty of inspecting the spar

![Figure 9: Cessna 402B](image)

**Figure 10: Inspectable? Crack in Cessna 402 wing spar**

cap through the skin and rivets even with eddy currents, by the time you can find the crack it’s already too big!

The only safe thing we can do is set a retirement life for the spar. How? Do you recall the scatter mentioned earlier?

Figure 11 is a smoothed out version of Figure 4 (If we’d plotted time in service on a log scale, we’d have the familiar bell-shaped normal distribution, but let’s not get too complicated.)

First, we estimate what the mean, or average, life is. We can do this by analysis, but a test is much better.

Second, we estimate how much scatter to expect — the ‘fatness’ of the hump. We can base this on the hundreds of tests that have been carried out on similar structures.

Third, we have to decide what risk we are prepared to

![Figure 11: Fatigue life distribution](image)

run. For a given time, t, the dark area under the curve is a measure of the risk. If we set the mean as the retirement life, half the spars would break before reaching it. Can we afford to lose half the fleet?

Clearly not. What we do is follow standard international practice, which is to come down three standard deviations from the mean, where the risk of failure turns out to be about 1 in 740. For the Cessna 402 this life is 8200 hours. What this means is that with two wings on your Cessna 402, the chance of one of them cracking severely before reaching 8200 hours is 2 in 740, or 1 in 370.

Retiring structural components like this seems wasteful, since most of the parts would last at least as long again. Again though, the problem is that we don’t know beforehand which will and which won’t! For uninspectable structure there is no safe alternative.

Why not make the structure inspectable? We could improve the access for inspection; or reduce the stress levels to slow crack growth and increase the critical crack size; or we could provide another load path.

Hawker de Havilland already has such a modification for most of the Cessna 400 models. Gippsland Aeronautics has one for Piper Navajos and Chieftains. These mods, especially the inspection programs that go with them, are not child’s play to design. Most of the current round of Aero Commander wing problems are the consequences of this sort of modification poorly done.

**CONCLUSIONS**

Fatigue is a wear-out process. It is not a matter of bad luck as in most aircraft accidents. If not attended to it WILL cause an accident.

Remember

1. Inspect the parts that are inspectable;
2. Retire those that aren’t and
3. Keep your eyes open — cracks have a nasty habit of turning up in the most unexpected places, even after the most thorough fatigue evaluation.