The Human Element in Ageing Aircraft Safety

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Steve Swift, Director, Steve Swift Pty Ltd, Canberra, Australia

Abstract
Now that the engineering is mature, the main challenge for ageing aircraft safety is the human element. This paper discusses clarity, simplicity and trickery.

Introduction
Safety experts talk about the human element and ageing aircraft, but not often together. Should we?

In 1977, two Boeing 747s collided at Tenerife airport, killing 583. Causal was a human element: communication [1,2]. From crashes like this, we teach it for the cockpit and tower.

In 2003, a Beech 1900D crashed soon after takeoff in the USA, killing two. Again, one cause was the human element of communication [3]. From crashes like this, we teach it for maintenance.

Communication and other human elements are important for safety. Are there special issues for ageing aircraft? Let us look under three headings:
• clarity
• simplicity
• trickery.
Clarity

I learned the importance of clarity early in my engineering career, while at university. I was designing a wing for my thesis. Another student was stressing it. He told me how long to make part of the main spar. He told me the semi-span. I thought he meant the full span. So my part was too short by half. When we tested it for strength, it broke early and dramatically...

Fortunately I had an understanding professor.

I learned more about the importance of clarity in 2000, when Ansett had to ground several 767s because they had overlooked new inspections Boeing added to the maintenance manual. Boeing described the revision as a “reassessment of the ’50-series’ inspections”. Ansett thought ’50-series’ meant 50,000 flights, which none of their 767s were near. So, they put the revision aside. But ’50-series’ meant something else to Boeing. They wanted some of the new inspections to start at 25,000 flights, which several of Ansett’s 767s had passed.

When Ansett realised, not until three years later, they had to inspect and repair the overdue 767s immediately. It stranded passengers and ruined the airline. You can read the full story in [4].

’50 series’: innocent jargon that was unsafe because it was unclear.

In a paper for ICAF 2011, I discuss other ‘ageing aircraft’ words that could be unsafe because they are unclear [5]. One is the word ‘ageing’ itself. The first problem is definition. For the FAA, ‘ageing’ starts from 15 years. For the Civil Aviation Safety Authority (CASA), it starts from ‘the day they leave the factory’ [6]. Supporting CASA is Airbus finding fatigue cracks in the A380 during flight test (see EASA AD 2008-0216). Even the newest and best are ‘ageing’. As CASA says, ‘every aircraft therefore is an ageing aircraft’.
If so, the word is only useful politically. If it gets more government attention because it is newer and catchier than 'continuing airworthiness', the traditional name for the same discipline, then it could be an example of engineers understanding and exploiting the human element for good. Could there be risks? There could if we think it really is new. And, if we think it really is a continuum.

First, false newness. ‘Ageing aircraft’ programs are mainly only retrospective application of new rules, such as those for Instructions for Continued Airworthiness (ICA), to old aircraft. (I mean the ICA in the FARs, which includes a safety standard, not the one in the CASRs, which does not. It would help clarity and safety if CASA could fix this anomaly.) We just need more retrospective application, so all old aircraft have ICAs, not just large airliners. The engineering is mature and ready. We just need to work on the economics and the politics (the human elements).

Second, false continuum. If you were a doctor, you would want to know where a woman was with respect to puberty, pregnancy and menopause. If you were a dentist, you would want to know if you are dealing with a baby tooth, an adult tooth or a false tooth. If you were a financial planner, you would want to know if your client is a student, a worker or a retiree.

But what if you are maintenance planner? Are there milestones for maintenance? An important one is the Limit of Validity (LOV) for the ICA. See FARs 23, 25 and 26.

When aircraft designers predict risks, they don’t predict them forever. For example, for metal fatigue, they only run the test for a finite time. So, really, ICAs are only good for a finite time, which the FAA calls the Limit of Validity (LOV). The FAA’s Bob Eastin thinks of it as the ‘knowledge horizon’ [7]. Past the LOV, the ICA can no longer assure safety because we don’t know the risks. It is when CASA says the aircraft has ‘outlasted the maintenance system’ [6], and the FAA warns there could be ‘widespread fatigue damage’ (WFD).

A320s are approaching their LOV. So Airbus is running a new and longer fatigue test. In Australia a few years ago, several Cessna 441 Conquests passed their LOV. CASA had to ground them.

In Australia, some aircraft have no ICA. Others have an ICA but no LOV. Neither group’s maintenance can assure safety. If CASA were to fix that, as previously suggested, operators would know when, where and how to ‘take a closer look’ [6]. And, where no ‘look’ could ever be good enough to find deterioration before it is dangerous [8].

If you are an operator looking for assurance, ask your aircraft’s Type Certificate Holder if the maintenance program meets the standard for ICAs (or similar), and has an LOV.

I am not the only one who sees problems with ‘ageing’. For example, the former Ageing Aircraft conferences in the US and Australia now have new names.

Other unclear names are these two:
They are the same maintenance to the same standard. Both are essential for safety. But, while operators revere Airworthiness Limitations, they often ignore Supplemental Inspections because they think ‘supplemental’ means ‘optional’. Non-compliance has been a particular problem for the Supplemental Inspections for Cessna’s piston twins. If they are the same, why don’t we call them the same?

Another term is ‘failsafe’. For years, it deceived us into thinking we no longer needed inspections. It took a crash (707, Lusaka, 1977) and a courageous authority (British CAA, Airworthiness Notice No. 89, 1978) to convince us that even failsafe aircraft need ICAs. Unfortunately, the FAA still allows failsafe for FAR 23 aircraft.

We replaced failsafe with ‘damage tolerance’. Two early ‘damage tolerant’ aircraft were the Airbus A320 and Boeing 757. ‘Damage tolerance’ is a good concept with a bad name. Civil and military meanings differ. It confuses ex-military engineers designing civil aircraft, so they ignore inspectability. And, it confuses FAA regulatory policy. Bob Eastin, its Chief Scientific and Technical Adviser on Fatigue and Damage Tolerance, wrote that ‘the use of the same words for different things can lead to confusion and needless debate’ [9].

Also, like fail-safe, damage tolerance fosters complacency. Some think damage tolerant aircraft do not need inspection, or even repair. Some, like DSTO and our Air Force, prefer the term ‘safety by inspection’ (SBI). But, MSG-3 recommends something simpler: just ‘inspection’ [10].

For other unclear words, please refer [5].

Clarity is part of ergonomics. It is cognitive ergonomics instead of physical ergonomics. It is part of ICAO’s SHELL model [11]:

![](image)

It is important for writing (liveware-software) and speech (liveware-liveware).

Clarity is why the Australian government has a guide on plain English [12]. And, Michèle Asprey a book for lawyers [13]. In 2011, the Commonwealth Ombudsman estimated plain English would reduce complaints about the tax office by two-thirds.

Clarity is why US President Clinton wanted plain English for his government [14] and the FAA has a guide [15]. And why the Europeans wrote ASD-STE-100 for Simplified Technical English [16]. But, a search on CASA’s web site could not find any general policy on plain English.
Simplicity

A help for clarity is simplicity.

Do you remember when complexity in the cockpit was impressive? Like this early DC9 on the left:

But we matured. We learned that complexity increases error. So we now strive for simplicity, like the later DC9 (717) on the right. How much do we strive for simplicity with maintenance documents? Where are their ergonomic standards? Don’t maintainers also have to absorb a lot of information quickly, for safety?

Sadly, maintenance documents are still like an old cluttered cockpit, especially for old aircraft types. The maintainer must scan too many ‘instruments’ to see everything they have to do. Even in the US Air Force, more standardised than civil aviation, a recent report concluded that the ‘root causes’ for ‘inspection misses’ include ‘confusing...documents and instructions’ [17]. ICAO warns that ‘delays and errors may occur while seeking vital information from confusing, misleading or excessively cluttered documentation and charts’ [11].

It is still too easy to miss or misread an instruction, just as Ansett did ten years ago with the 767. It could happen again with others, like Australian operators of the Beech Queen Air 65-B80. If you want to know the maintenance for fatigue and corrosion in the wing, and you are in the USA, where the Queen Air was designed and built, it is easy. There is an FAA Airworthiness Directive (AD 89-25-08) that says to maintain the wing to the Beech manual (called the Structural Inspection and Repair Manual). Simple.

Other countries, including Europe, refer to the same FAA AD. Again, it is simple.
In Australia, it is not so simple:

There are rules that say you ‘must have regard to ... the manufacturer’s maintenance schedule’ (CAR 42M)—the Beech manual. There are four overriding CASA Airworthiness Directives (AD/BEECH 65/22 Amdt 4, AD/BEECH 65/34 Amdt 5, AD/BEECH 65/57 Amdt 4 and AD/BEECH 65/64 Amdt 1) which add to and subtract from the Beech manual.

And then you still have to check the FAA AD. CASR 39 says to do FAA ADs for American aircraft. Except you only have to do FAA ADs issued after 1 October 2009. So, you have to get the FAA AD and check its date. It is 4 January 1990, so it does not affect you. If the FAA were to revise the AD, then it would affect you, but you would wonder how because of conflict with CASA’s ADs.

If you wanted to change the maintenance, the Type Acceptance Certificate (A118 Issue 5) would tell you that CASA accepted the FAA’s airworthiness standard (mainly CAR 3) unconditionally. But then you would find that one of the ADs (AD/BEECH 65/64) has added a condition (FAR 23.573, which no other country requires). The result is confusion and more risk of error. Why does CASA not collaborate more with other major authorities, especially the FAA?

**Trickery**

Finally, trickery. Maintenance can play tricks on maintainers just as flying can play tricks on pilots. There are illusions. They are not just for magicians. An illusion is any ‘false or unreal perception or belief’.

We know a lot about illusions for pilots. There are warnings, like the Pilot Safety Brochures from the FAA:
We know how runway widths and slopes can trick us into approaching too high or too low. We know how accelerations can trick us so we don’t know what’s up and what’s down. Illusions are serious. The FAA blames them for 10% of all general aviation crashes. 90% are fatal.

But what about illusions for maintainers? Are there any? Where are the warnings? At the FAA’s Symposium on Human Factors for Maintenance and Ramp Safety, in San Diego, in 2009, I warned about three illusions [18]. Here is a story about one:

In 1993 a propeller blade broke off a Nord 298 Mohawk airliner soon after take-off from Sydney. It was lucky the blade flew away from the fuselage and not into it. The blade broke because the airline, with CASA’s approval, had extended the time between inspections because they were not finding cracks. Extensions for this reason are common because the ‘nil findings’ argument sounds so plausible. But it is wrong. It is trickery. It is an illusion.

Unfortunately, there are no warnings about it in any of the maintenance publications. Some even encourage it.

The problem is lack of knowledge, one of Gordon Dupont’s ‘Dirty Dozen’. The knowledge lacking is the maintenance theory for inspection intervals. Maintainers lack it because it is in the design rules, not the maintenance rules. You have to know how the designer set the interval to know how to safely extend it. I talk more about this in another paper [19]. But, briefly, here is how it is done:

1. The curve shows how a crack grows with time. First, it is ‘missable’ (too small to find with the inspection method). Last, it is ‘critical’ (too big for the part to carry enough load). So, to find it safely in between, the time between inspections must be no longer than the ‘interval’.

What does ‘nil findings’ tell us about any of these variables? Do we know any more about crack growth? Do we know any more about what is missable? Or what is critical? No! We have no more information than the designer. ‘Nil findings’ is not evidence to extend an interval. I warn about this and other illusions for maintainers of old aircraft in my training courses.
Conclusion

In 1986, the FAA Administrator, the late Don Engen, said:

'We spent over fifty years on the hardware, which is now pretty reliable. Now it's time to work with people.'

Likewise, for ageing aircraft, we’ve spent over fifty years on the engineering, which is now pretty reliable. Now it’s time to work with people—to convince them to apply the engineering to all aircraft, not just the new; to strive for clarity and simplicity as we do; and to warn maintainers about trickery, about illusions. It is all part of the human element in ageing aircraft safety, an area in which I hope to see ‘future growth’ to meet the ‘future challenges’ (the Safeskies 2011 theme).

References


[12] Eagleson, R., Writing in Plain English, AGPS, Canberra, Australia (1990)


