Fall 2001

AWAKENINGS

TSB WIRE RECOMMENDATIONS

TRUTH & RECONCILIATION

SAFETY DATA FOR ALL – FACT OR FICTION?

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LIMITING FACTORS FOR GLASS COCKPIT IMPLEMENTATION

THE MAGAZINE OF THE INTERNATIONAL AVIATION SAFETY ASSOCIATION

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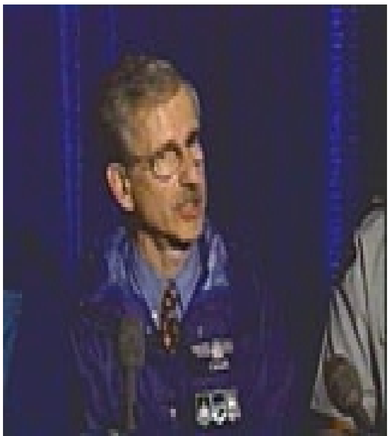
TRANSPORTATION SAFETY BOARD OF CANADA

WIRE RECOMMENDATIONS

BY JOHN SAMPSON IASA AUSTRALIA

AUGUST 28, 2001: ``A specific spark, whatever the location, should not bring down an airplane with 229 people on board,'' Daniel Verreault, the board's director of air investigations, told a news conference releasing the report.

``There should be defenses in place to prevent this, and that is an objective that we have and that is the way that we believe we can contribute to advancing aviation safety.'' Of the 2 million pieces of aircraft recovered from the Atlantic seabed in their efforts to determine the cause of the crash, some 65,000 pieces showed evidence of fire damage, the TSB said. Vic Gerden, the safety board official in charge of the Swissair investigation, said the probe was looking at all possible safety issues. ``If there were no combustible materials in an airplane there could not be a sustained fire. If we can break the links then we could stop the next accident,'' he said.



Vic Gerden

``We are looking at all the links, the ignition sources, the combustible materials, the oxygen contributors and other safety deficiencies that we find en route that are links in the chain to other accidents that might occur. It is time to raise the bar on the type of material that is put in airplanes,'' said Gerden.

Stringent flammability regulations are applied to materials in the passenger compartments of aircraft, but Gerden said there are fewer restrictions on materials used in inaccessible areas of planes. The board is particularly concerned about the qualification testing of aviation wiring that examines only individual wires, not live wire bundles, and inexplicably does not look at how wires carrying an electrical current can ignite a fire. Some types of aromatic polyimide wiring (such as Kapton) are known to arc-track. Arc tracking is a process whereby the wiring's insulation itself becomes a current-carrying conductive carbon char. Once a wiring bundle arc-tracks, heat of the order of thousands of degrees Celsius can quickly incendiarise anything adjacent to it - and fatally cripple vital aircraft systems.

TSB investigators speculate that a short-circuit or arcing wire aboard Flight 111 may have ignited a fire fed by flammable thermal/acoustic blanket hidden from sight above the cockpit ceiling's lining. Frighteningly, one of the life-support systems intended to help the pilots get the plane down to a safe landing may have contributed to the fire. The MD-11's emergency oxygen supply, intended to feed 100% oxygen to the cockpit crew's masks during a fire, may have instead fed the fire like a blowtorch. Investigators found the stainless-steel oxygen lines had aluminium fittings, which could leak during a fire and feed enough oxygen to turn a small blaze into an inferno.

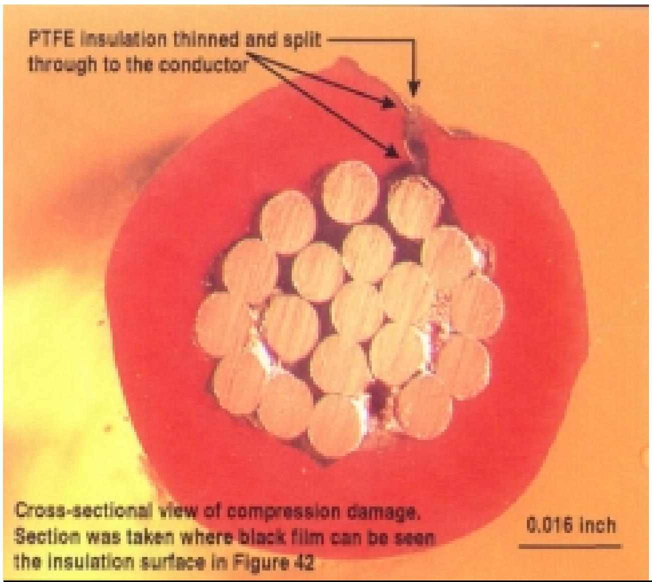
CONCLUSION

The TSB is concerned that there remain safety deficiencies in the material flammability standards, and that these pose an *unacceptable* risk to the flying public.

First, in a series of aviation safety recommendations issued in December 2000 and entitled *In-Flight Firefighting,* the Board stated that material flammability standards for aeronautical products are an integral component of any in-flight firefighting "system". The Board is concerned that the flammability standards for certain materials used in the pressurized portion of aircraft are inadequate.

Second, despite many ongoing initiatives to mitigate electrical wire discrepancies, the Board believes that the certification test criteria for aircraft wires do not adequately address the potential for wire failures to ignite or propagate fires.

Third, indications that the failure of certain aircraft systems, such as crew oxygen, could exacerbate a fire in progress suggest that current requirements for conducting system safety failure analysis may be inadequate.



Cross-sectional view of compression damage. Section was taken where black film can be seen the insulation surface in Figure 42

PREVIOUS RECOMMENDATIONS

January 1999: FAA is asked to inspect cockpit wiring on all MD-11s.

March 1999: The Canadian board recommends flight recorders have independent power sources and be able to record up to two hours rather than 30 minutes.

August 1999: Advisory issued that Mylar use be reduced or eliminated. FAA orders metallized Mylar blanket insulation be replaced after it is found to be flammable.

September 1999: FAA bans the in-flight entertainment system used on Flight 111, calling it "not compatible with the design concept of the MD-11."

April 2000: FAA orders map-reading lights on MD-11s inspected or shut off. In inspections of about 12 aircraft, flammable Mylar blanket insulation was found pressed against many of the lights and showed signs of heat damage.

April 2000: The Federal Aviation Administration issues eight safety orders concerning MD-11 electrical systems, bringing to over 30 the number of airworthiness directives released since the crash.

December 2000: The Canadian board issues five safety recommendations aimed at detecting and suppressing in-flight fires. Also recommends revising cockpit crew's emergency checklist to save time in event of fire

THE FUTILITY OF COLLATION IN THE ABSENCE OF COORDINATION

BY ADAM SMYTH IASA UK

The formation of the Wire System Safety Interagency Working Group (WSSIWG) should see an end to the era of "organisation specific data". Now, those scrutinising the problems associated with electrical systems in aircraft should have at their disposal data acquired by other government agencies not specifically concerned in aviation. One of those agencies is the Nuclear Regulatory Commission (NRC).

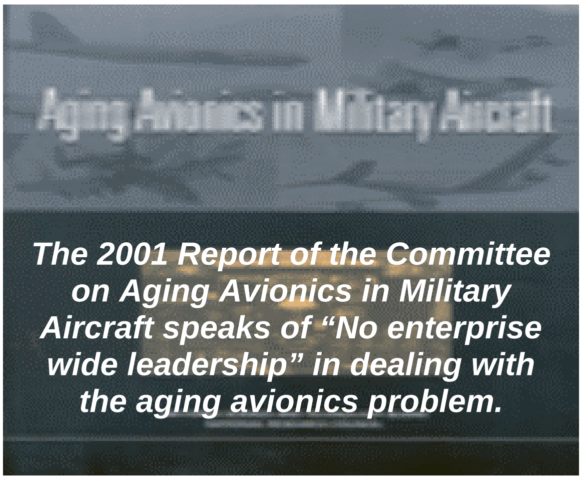
The NRC experience of problems associated with electrical systems provides us with a wealth of information that directly impact aviation. Not only that, it raises important questions regarding data sharing among government agencies and how lack thereof can lead to duplication of efforts & resources and ultimately impact safety. This is one of the problems cited in a Report by the Committee on Aging Avionics in Military Aircraft titled "*Aging Avionics in Military Aircraft*".

One of the Committee's Findings was: "A large number of organizations within DoD, the military services, and industry are attempting to address various aspects of the aging avionics problem. However, these efforts are poorly coordinated and often duplicative." The Report goes on to say: "The Committee identified more than two dozen organizations… that collectively spend tens of millions of dollars each year… to address the aging avionics problem… Although many of these programs are making substantial progress, they are poorly integrated. No enterprise wide leadership is being provided."

So when the FAA's Associate Director, Tom McSweeny, stated in evidence to a congressional hearing on aircraft wiring held in September 1999 that the FAA did not have "serious concerns about Kapton® wiring" based on in-service data one wonders if their stated position might have been different had they seen documents from the NRC archive uncovered by IASA.

One of the documents IASA uncovered is NRC Information Notice No. 88-89 titled "Degradation of Kapton Electrical Insulation". Dated November 21, 1988, this substantial report details what the NRC defined as a "generic safety problem" involving Kapton aromatic polyimide electrical insulation.

The report refers to a "complex hydrolytic Kapton degradation process" that "is almost fully reversible provided that actual cracking has not occurred…" and "the generic lesson is that the performance of numerous Kapton-insulated wires degraded considerably after only one year in a quite mild environment"



The 2001 Report of the Committee on Aging Avionics in Military Aircraft speaks of "No enterprise wide leadership" in dealing with the aging avionics problem.

Although nearly 13 years have passed since it was published its importance to the wider debate is perhaps finally being given the credit it deserves. How? One of the non-governmental projects for wire system safety cited in the WSSIWG's Final Report is being undertaken by EPRI who "Evaluated the polyimide (Kapton®) problems identified in naval aircraft with respect to nuclear plant applications". Their report, titled "Review of Polyimide Insulated Wire in Nuclear Power Plants", was published on February 1, 1991. In the abstract to the report reference is made to the "Problems due to handling damage of Kapton wire recently led the NRC to issue an Information Notice (No. 88-89)".

Whilst the military's damning experience of Kapton aromatic polyimide electrical insulation was often discounted by reference to a perceived more "hostile environment" than the average commercial plane, the "quite mild environment" referenced in this NRC document could not have been so easily discounted.

So when Tom McSweeny said in evidence that he had "looked at all the research" did that include NRC Information Notice No. 88-89?

® Kapton is the registered trademark of DuPont

Useful Links:

Please note that the International Aviation Safety Association (IASA) is not responsible for the material and/or content of the sites to which it provides Internet links.

NRC Information Notice No. 88-89:
Link 1

EPRI Report "Review of Polyimide Insulated Wire in Nuclear Power Plants": **Link 2**

WSSIWG Final Report: **Link 3**

Committee on Aging Avionics in Military Aircraft Report: **Link 4**

LINKS

1 http://www.nrc.gov/NRC/GENACT/GC/IN/1988/in88089.txt
2 http://www.epri.com/OrderableitemDesc.asp?product_id=NP-7189
3 http://scitech.dot.gov/polplan/wirerpt/index.html
4 http://books.nap.edu/books/0309074495/html/R11.html

AUSTRALIAN SENATE INQUIRY CONSIDER HEALTH IMPLICATIONS OF EXPOSURE TO SMOKE & FUMES

CONTRIBUTED BY AOPIS.ORG

With incidents of smoke and or fumes entering into aircraft cabins due to leakage by oils & hydraulic fluids ongoing for at least 20 years, a recent Australian Senate Inquiry revealed the problem is a major concern for the safe operation of aircraft and health of crews.

While the focus was on the BAe146, other aircraft including B757, A320 & MD80 have experienced incidents of crew exposure, around the world, with varying levels of incapacitation.

Crews inhaling bleed air contaminants at altitude are exposed to a range of substances including organophosphates, hydrocarbons, C0 & C02. Mobil Jet Oil II containing Tricresyl phosphate (TCP) at 3% was always known to include a low level of the neurotoxic ortho isomer TOCP but Mobil revealed to the Senate Inquiry that it included higher quantities of the isomers MOCP & DOCP having a significantly higher toxicity than TOCP. Industry reliance that the oil contains low levels of TOCP underestimates the toxicity by a factor of at least 30,000. The oil can label states “Prolonged or repeated breathing of oil mist, or prolonged or repeated skin contact can cause nervous system effects”

New oils being introduced (MJO291) are not phosphate free.

Along with strong evidence of under-reporting, the Inquiry recognised the presence of fumes and associated crew effects conflicted with the Regulations and recommended that when fumes occurred the aircraft should be immediately withdrawn from service until fully rectified.

A range of health effects experienced by crew and linked to aircraft fumes are sufficiently consistent to indicate the possibility of a discrete occupational health condition termed aerotoxic syndrome with numerous flight crew having lost their flight medicals and no longer able to fly.

The growing list of incidents demonstrates there is a significant risk of a serious incident occurring. Many feel the long term welfare of crews and the safety aspects of potential crew contamination must be taken more seriously and that a crew testing procedure be introduced to assess what crews are being exposed to, whilst a full and independent investigation takes place into the toxic nature of hydraulic fluids and oils such as MJOII.

You can learn more about AOPIS.ORG by visiting http://www.aopis.org

ARE WE INVESTING IN PREVENTION TO THE DETRIMENT OF CURE

There was a time when the mere mention of flaws in aircraft wiring would be greeted with derision and disbelief. However, now that there is a widespread acceptance that aircraft wiring deserves its place under the proverbial microscope, attention has now shifted to methods of inspection and technological aids in detection of wiring flaws. But do these apparent advances in acceptance of the central problem herald a more sinister problem? Are we investing so heavily in Prevention that we have abandoned Cure?

The Office of the Inspector General Audit Report, Observations On Efforts to Address Concerns About Aircraft Wiring (Report No. AV-2001-004 Issued October 27, 2000), echoes our concerns. The report stresses the "need for action by various parties" and identifies three specific areas where improvements are needed:

1. Improved Maintenance Practices
2. Better Training for Maintenance Personnel & FAA Inspectors
3. New Technologies for Detecting & Preventing Problems

But the Report also asks, "when improvements in these areas can be made" and equally critical, has the FAA allocated resources appropriately in addressing this complex issue?

The FAA requested $22 million for fiscal year 2001 for aging aircraft research, the bulk of which it spends on methods to predict and detect fatigue cracking and corrosion of aircraft structures. According to the Office of the Inspector General the FAA "needs to rethink its planned investments in aircraft safety research to determine the correct mix of structural and non-structural research"

The FAA has often been criticised for concentrating too much of its efforts on data collation to the detriment of a concerted effort in the form of "action". Even this is now further eroded, by the recognition that even the all-important data is incomplete and unreliable. The Office of the Inspector General found that "meaningful analysis could not be performed because coding to specifically identify wiring problems is not available".

The acceptance of the central problem has exposed the fundamental flaws in the infrastructure that is now charged with the task of solving it. An industry that can be prone not to report a problem, a system that cannot as yet properly record an event for trend analysis, a regulator that does not allocate resources adequately and that makes decisions on incomplete and misleading data.

Is the flying public justified in its concerns that aircraft wiring is as much a compromise to their safety as those whose mandate it is to make flying safer?

INTOLERABLE DAMAGE

BY MARTIN AUBURY

In April, when overdue inspections found cracks in Ansett aircraft and their 767 fleet was grounded spin doctors wrangled that the planes were designed to tolerate damage, that the cracks were "hairline" and were "only seven centimeters long".

In reality "Damage Tolerance" is a specific way of managing metal fatigue that relies on knowing when and where to look for cracks. Without timely inspections, damage tolerance is a meaningless platitude.

Also, hairline cracks are more dangerous than gaping ones because they are harder to find. And tiny cracks can be just as lethal as long ones.

So it is worth understanding how damage tolerance evolved and its limitations.

Metals fail at a definite stress. They also fail at lower stress if the stress is applied repeatedly; this is fatigue. But because the number of repetitive loads before failure varies enormously, it is impossible to accurately predict the fatigue life of an aircraft.

The simplest solution uses analyses and tests to estimate an approximate life; then cuts it by a safety factor. After that the structure is discarded.

The safety factor is set so that not more than one aircraft in a thousand should fail. Passengers may fear flying on that one aircraft whereas operators hate discarding 999 prematurely!

Although this "safe life" approach is risky and wasteful it is still used for small aircraft and helicopters. It was abandoned for airliners soon after two De Havilland Comet jets crashed in 1954.

Aviation mythology has it that the Comets crashed because fatigue was overlooked. Not true; an airframe had been tested to 18,000 flights but the test was faulty and the planes burst apart after around 1000 real flights.

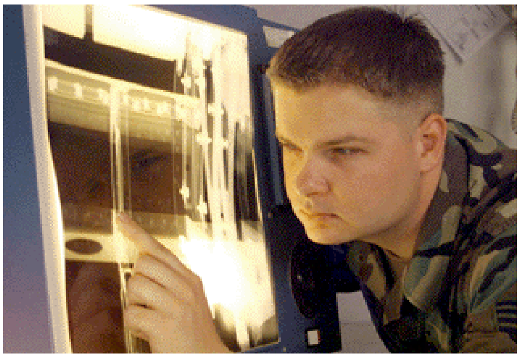
A better approach was to duplicate all critical structure, so that if one member fatigued prematurely there was alternative structure available to carry the load. This is "fail safety". It was the methodology used to design aircraft throughout the 1960's, up to and including the Boeing 747.

Implicitly fail safety depended on detecting the first failure before the back-up structure also failed. That did not always happen. In 1977 a 14-year-old Boeing 707 crashed in Zambia when its tailplane broke off, because failure of the main structure had gone unnoticed.

By then new technology made it possible to estimate how quickly a crack would grow and how long a crack could be before the structure failed. Damage tolerance was achievable by scientifically scheduling inspections.

Sometimes the critical crack length is very short and sophisticated inspection techniques are needed. Elsewhere cracks can be a meter long and visual inspections suffice.

The difficulty is knowing where to look for cracks. Clues are drawn from the aircraft design and an airframe is tested to simulate several lifetimes and see where cracks start.



But the best aid is reports from routine inspections on hundreds of aircraft around the world. Findings are reported back to the manufacturer then notified to all operators. And that is why Ansett was remiss in not acting quickly enough on Boeing advice about the likelihood of cracks on the 767 tailplane and engine attachments.

Although it is possible to predict crack growth and critical length for a single crack, a major deficiency with damage tolerance is the risk of many tiny cracks suddenly joining together. That is what happened to an Aloha Airlines Boeing 737 in 1988 when six meters of fuselage ripped away, most passengers were injured and a flight attendant died.

The Aloha accident dramatically triggered an unprecedented review of aircraft structural maintenance. Defects and complacency were rife. Since then manufacturers, regulators and airlines have cooperated to cut the risk of aging aircraft. Congress has enacted specific legislation, hundreds of service bulletins have been made mandatory, and inspections are backed up with structural reinforcement.

Multi-site damage remains a danger. Old airframes are stripped in a hunt for structure susceptible to it and new inspection techniques are being developed.

Meanwhile aging aircraft need meticulously maintenance. This becomes increasingly expensive and eventually uneconomic. Unfortunately, airlines that cannot afford new planes sometimes cannot afford to properly maintain those they already own.

Abridged by the author from his article published in Canberra Times 18 April 2001. Martin Aubury is a Fellow of the Royal Aeronautical Society and teaches at Australian Defence Force Academy

Limiting Factors for Glass Cockpit Implementation

More automatic, pilot-friendly Avionics features mean more computing power is required.

Computer "power" depends largely on the clock speeds at which the CPU cycles are timed. Also a factor is the level of voltages used for the data bus operations. Years ago +28 Volts Direct Current (VDC) was and is still used today. Being a digital circuit, the +28 VDC logic line was either "true" (+28VDC) or "false (0VDC). The voltage tolerances were very forgiving, often "true" was considered anything greater than +24VDC, "false" was considered anything less than +5VDC.

Early Avionics Test systems of the 1970's used 18VDC for logic operations, with correspondingly reduced thresholds. Any voltage in-between the "false" and "true" realm was a "no-operation", i.e., disregarded. The higher voltage data systems offered good and not so good benefits. A good benefit was the noise immunity. It was very difficult for a random electrical noise pulse to "false trigger" a "true" response. The not so good was that the higher voltages and accompanying higher power levels made miniaturization difficult if not impossible. A second issue was the speed restriction imposed by the higher logic levels. Digital switching is not instantaneous, it takes a finite amount of time for a transistor to slew between

a "0" and a +28VDC level. This limitation served to restrict the system clock speeds and thus throughput.

Modern logic levels are much lower, some systems use +5VDC and even +2.2VDC for extremely high-speed parallel processors.

The available noise margin is essentially gone.

Also developed during the early years were the power distribution systems we see on both Military and Commercial aircraft. Evolving gradually from years of flight, the systems began as battery systems using Direct Current (DC). DC aircraft systems generally used a single wire to provide power to a load. The airframe was used as a return current path back to the battery.

The maturing need for more sophisticated Avionics drove the need for an Alternating Current system. Today, aircraft AC systems use a grounded WYE, 200 volt three phase 400 Hertz generator and distribution system as specified by MIL-STD-704. Aircraft AC systems today are allowed to use the airframe for the return of AC currents to the generator, thus eliminating the weight and volume required for a Neutral conductor. MIL-STD-761 authorizes the use of the airframe for AC and DC return currents.

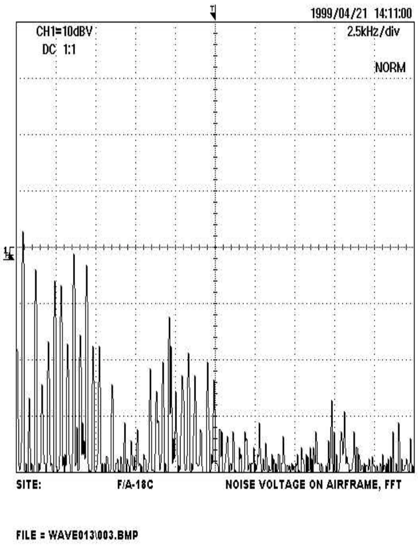
Logic system noise margin requirements and aircraft power system practices meet head-on at the airframe.

As stated, the airframe carries power system return currents. These are characterized by wide band noise current and voltage transients below 20 kHz. The logic system is electrically bonded to the Avionics module chassis and thus to the airframe. The airframe is intended to serve as a “0” volt reference for the many on-board logic processors in the Avionics system. Yet the airframe is not a “0” volt reference – it is one of the power system electrical conductors.

Random noise pulses on the airframe from normal power system operations can upset computer operations by forcing false calculation or even destruction of logic chips causing system failure.

Successful Implementation of the “glass cockpit” concept will require elimination of power system return currents on the airframe.

The first successful airplane was built not by degreed aviation professionals, but bicycle mechanics in a wooden shed. Let’s take this problem back to the shop and apply common sense.



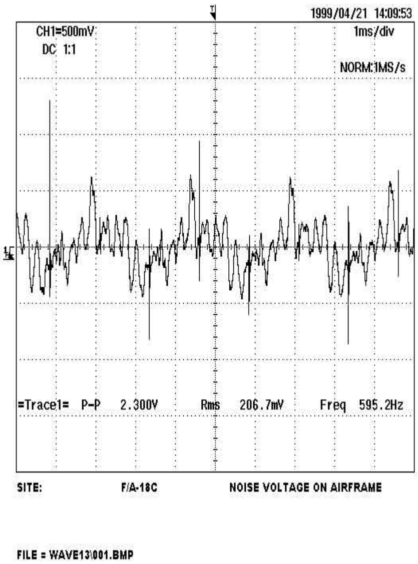


Fig 1: Fourier Transform showing the of the major noise elements on the same airframe. This data was taken with only around 20% of the aircraft loads energized. Most cannot be fired up with "weight on nosewheel". Primarily concentrated below 5 kHz, they are capable of creating all sorts of mischief.

Of course, MIL-STD-461 REQUIREMENTS FOR THE CONTROL OF EMI CHARACTERISTICS OF SUBSYSTEMS AND EQUIPMENT testing does not address this area for the F/A-18. Per CE101, page 28, Conducted Emissions, 30 Hz to 10 kHz, this only applies to ASW aircraft. Finally, real world measurements are not necessary, all qualification tests can be done in a lab.

Fig 2: Airframe noise measured on a Digital Sampling Oscilloscope, using shielded test leads, referenced to the hangar static ground. The narrow positive and negative voltage spikes are capable of "forcing" a logic low, with all the possible interesting results.

It is believed that this is one of the most common causes of the "no fault found" gremlin.

A false signal forced in flight may cause a very real system BITE error. But on the ground, after a full system reset, the fault does not appear.

FEATURE ARTICLE By John Sampson, IASA Australia

TRUTH & RECONCILIATION

One of the aviation safety benefits of the Internet is that research can give fresh insights into the past, enable new perspectives on old accidents and disclose underlying trends against the backdrop of more recent events. Ever since the 27 Nov 87 crash of an SAA 747 Combi off Mauritius, rumour and speculation about the cause of its onboard fire has been rife. Last year the South African Truth and Reconciliation Commission decided to address this festering sore with a view to laying it all to rest. Those good intentions backfired. On the IASA web site there are 18 pages packed with the various facts and potential fictions about "the Helderberg", including "fresh evidence" as to its real cargo (from a May 2000 scientifically enhanced CVR tape). It's recommended reading because there is an underlying lesson, one that has emerged repeatedly in accidents such as TWA800, Valujet 592 and AI182 (to name but three). In the aftermath of those accidents, certain conclusions could be drawn from particular facts, but always the proof positive was lacking. VJ592 had a cargo of flammable (but not inflammatory) oxygen canisters in its hold but it also had defective electrics and a type of wiring (PVC) that is no longer approved - and for good reason. TWA800 theorists have run the full gamut of criminal, terrorist and conspiracy /cover-up scenarios yet the top contender is once again not one of the preferred "usual suspects"; it is proven defective wiring. June 85 and Air India 182 suffered a sudden explosive decompression at altitude, the prime suspects automatically becoming Sikh Terrorists - simply because of the politics of the time, and because Canadian Sikhs could be woven into the pre-flight chain of events. Although they are two very distinctly different forensic events (see later), the "explosive" decompression gradually found its definitive development into "there needing therefore to have been a bomb". The RCMP doggedly pursued this line of inquiry for decades and two individuals (Sikhs of course) will soon face trial. It is human nature to assume that there is a culprit and that blame must be laid. Foul play is always suspected if there's any lack of evidence to the contrary (such as was fortunately available in the Swissair Flt111 accident). It's a natural cynical legacy of the numerous terrorist hijackings of the 60's and 70's. The influence of the players in an accident investigation and their preconceived notions, perceptions and even agendas can give a particular line of inquiry a life of its own. If you do read into any of these accidents looking for logical conclusions, then there is a further premise that you must entertain. Simply stated, it is that airliner manufacturers are necessarily part of the "party" system of investigation but will always tend to support alternative theories - and the more of them the better. It is in their interests that there should not be any definitive conclusion about an accident's cause - particularly if it was to mean that costly intrinsic design flaws would be unearthed (e.g. 737 rudder), or the spectre of culpability in class-action litigation be raised. Remember that a modern airliner is a very costly vehicle to keep parked, hangared for maintenance or modification or, perish the thought, grounded. Utilisation is the name of the game and running fixes on turnaround is the modus operandi. Insurers are also wont to believe their own actuaries, that all the risks are already factored into their premiums. Evidence of non-impartial activity in investigations came out in the GAO's 1999 inquiry into allegations of improper conduct and unsatisfactory aspects of the 737 rudder-caused accidents. But before we get to the extracted lesson, let us look at the Helderberg and AI182 accidents in a little more detail.

Because the Helderberg's 30 minute CVR was in two parts, an earlier 20 minute meal-time and the last ten minutes of the flight, the conclusion was that a fire had broken out earlier (just about two hours out of Taipei on their nine hour flight to Mauritius). It was postulated that, because of the sensitivity about the cargo, Captain Uys had strict orders not to divert. Understandably, it was feared that if it was found, at some divot airfield, that SAA 747 Combi Freighters had contraband Armscor gunrunning munitions on board, then SAA's routes might thereafter be denied to them (or be subjected to UN Inspections or Sanctions). Yet, Armscor's embargo-busting activities were vital to the continued security of SA, which was embroiled in internal dissidence and regional wars. In particular the lightly armed SADF was up against 50,000 Soviet supported Cuban mercenaries in Angola and they needed an equaliser that would stimulate Western intervention. With Israeli help, SA had developed seven tactical nuclear super-weapons in order to level the playing field (pun intended). Helderberg was widely rumoured to be carrying at least the air-delivery barometrically-actuated fission trigger of one such fusion weapon but it was also conceded to be carrying much more dangerous oxidizers, such as ammonium perchlorate rocket fuels. Shades of the convenient oxy-generator theories of VJ592, no? However, these would have been well containerised and quite inert (i.e. quite inconsequential, short of an accident or fire occurring - which would then have been another story). Armscor had been granted secret dispensations because it was a matter of national security and the SA military needed weapons - any way it could get them. Armscor, and not SAA, had the last word on what was to be carried. Armscor was a law unto itself. Defence Chief Magnus Malan needed the armaments and that was the basis of their 007 licence - which in the culture of the day is not merely a play on idiom. Proponents of the "two fires theory" claim that the crew had Armscor Standing Orders not to divert but the Pilots Federation pooh pooh's this, saying that no sane captain would press on into a long oceanic transit with a fire onboard (whether or not it had gone out). But why then was that CVR in two parts? Perhaps there is a middle-ground explanation that the CVR had been disabled because the crew had partially powered down the aircraft due to earlier smoke or smell being detected (i.e. not an actual fire). If it had later flared up when power was reapplied (for a navigational check) just prior to descent into Mauritius, then that would explain the later re-initiated CVR recording and the logic being used throughout by the captain. There would have been no need to disable the CVR because of it recording their sensitive discussions with SAA Operations - simply because the CVR was a 30 minute endless loop. So, is it *likely* that any munitions could have smouldered for that length of time and then been rekindled over seven hours later - coincident with the power being reapplied to the electrical busses? Not really. Would the rocket fuel have played any part? Of course - but before hopping on the conspiracy bandwagon, first apply the chicken and egg part of Ockham's Razor. The Razor says that in the absence of evidence to the contrary the most rational and probable explanation for a train of events is likely to approximate reality. i.e. the wire started the fire. In particular, this might be so because there was another tape, one that recorded aircrew enroute conversations with their SAA ops controller in Johannesburg. That tape was neatly disappeared after the crash, the man who took it conveniently died and one end of that vital missing conversation became rapidly promoted into heading up the Miami Office of SAA. At the time, the Margo Inquiry neatly circumscribed any mention of these difficult-to-explain areas and concentrated on what the deep-sea dives had managed to dredge up. Boeing sided with the popular fomentation of conspiracy theories various. Against the violence, intrigue and pre-eminent security considerations of that apartheid era, the vague outcome seems to have been inevitable. One reasonable interpretation of what the crew said (and clearly avoided saying) on the CVR tends to support the above scenario. But a reasonably dispassionate observer might simply say: "OK, but all that plot and counter-plot aside, it looks to me like it might have been a wiring fault that later developed into a wiring fire. They restored power in order to get a tracking check before top of descent into Mauritius. That is obvious from the CVR. But we would never restore power to the wiring nowadays - not knowing what we know now." It's not been confirmed but it's suspected that the Combi's were Kapton-wired, just like the follow-on 747-400 models. They had very large cargo holds full of wiring that would have been subject to lots of wear and tear. Inbound cargo capacity was important to the SA of the 80's, although they were restricted to about 150 odd pax. As the Captain says, in the enhanced tape, shortly before the onboard fire: "Guess what guys, we've got Boy George[1] aboard". And, as borne out by the heated discussion that ensued, he wasn't talking about the entertainer. So why was the Margo Inquiry only now revealed as having been a cover-up? The simple answer is because they stood to lose 400M rand on the hull loss if the insurers could prove that there had been munitions on board.

In comparison with the Helderberg's onboard fire, the Air India Flt182 emergency (Jun 85) was (according to its CVR) a sudden loud sound of about 5.4 seconds duration in which a scream or cry could be heard. "AIB analysis indicates that there were distinct similarities between the sound of the explosive decompression on the DC-10 and the sound recorded on the AI 182 CVR. The AIB report concluded that the analysis of the CVR and ATC recordings showed no evidence of a high-explosive device having been detonated on AI 182. It further states there is strong evidence to suggest a sudden explosive decompression of undetermined origin occurred. Although there is no evidence of a high-explosive device, the possibility cannot be ruled out that

[1] Hiroshima: Little Boy; Nagasaki: Big Boy; George relates to Operation Greenhouse, the "George" test (Cylinder device) showed that a thermonuclear fusion bomb by fusion reactions of ^{2}H (deuterium) and ^{3}H (tritium) would be possible to make.(and fusion boosting for atomic bombs was thusly proved possible).

a detonation occurred in a location remote from the flight deck and was not detected on the microphone. However, the AIB report is of the opinion that the device would have to be small not to be detected as it is considered that a large high-explosive device could not fail to be detected on the CVR." Of course the report doesn't liken the sound to the much later [28 Dec 97] United 811 747's loss of a cargo-door over the Pacific - but a comparison of the two reports makes the similarity apparent. In fact, there were two AI182 reports (see links on IASA site). The Indian and Canadian reports describe "an explosion" in the forward cargo area - however no trace was ever found of explosives. So here we can possibly suspect that UA811's survival of a cargo door loss on climb might indicate how lucky they were - in comparison with Air India 182's possible loss in cruise flight at Flight Level 310 (i.e. at a much higher speed and pressure differential). Why do cargo doors open in flight? Cargo doors are outward opening, not inward opening plug-doors like the personnel entrance doors. Plug-doors are held closed by pressurisation but if a cargo-door's latches fail, pressurisation tears it open, the fuselage is weakened and the cargo door is sucked into an engine (#3) and can also damage the tail. It's loss will not necessarily be a straightforward "opening", the fuselage skin surrounds may be torn away also…. and its violent separation can so weaken the fuselage integrity that, as per TWA800, the nose may separate. The cargo door-locking mechanisms are electrical and although they are powered by the ground buss (which is deactivated once airborne), the fault mechanism could be similar to the way in which a stray electrical high voltage current found its way into the TWA800 centre-wing tank's fuel quantity indication system. It had been believed that UA811's door had been improperly latched - until they much later recovered the actual door from the Pacific and found that its latching mechanism had been electrically driven open in flight.

It has long been known that faulty wiring can cause intermittencies, false indications, uncommanded actuation and strange symptoms in electrical (and electronic) systems. Arc tracking and shorting can cause fires that can then propagate courtesy of aircon airflows and, beneath the cabin linings, ably assisted by the flammable thermal/acoustic blankets with which wiring bundles are entwined. You might well say that that is simply a hazard that comes with the territory - the hundreds of kilometres of wire that go to make up the sinews of a modern airliner. Many wire-faults must exist and so, sooner or later, a failure is bound to occur, just as in any other aircraft system. However wiring faults can manifest themselves in many different ways. In the Helderberg, there was a known fire. CVR evidence (and recorded crew conversations) seems to point to an early problem that much later recurred when power was restored - and it then spread rapidly. The only logical explanation for that is a wiring-initiated fire. There is much video evidence of the explosive response of aromatic polyimide wire (Kapton) to a circuit-breaker being reset after an arc-tracking event has caused it to trip. In the 1985 AI182 accident, Sikh skulduggery was presumed, so it wasn't until after other DC-10 and 747 cargo-doors had opened explosively, that any viable alternative explanations could be offered up. The RCMP are putting a brave face upon their Oct 2000 arrest of three SIKH individuals. Upon the release of one Sikh from jail for the 1985 Narita airport bombing, he was promptly re-arrested and simultaneously two other Canadian long-term Sikh "suspects" were also arrested and charged with "bombing" AI182. It may yet turn out to be a face-saving RCMP "fishing expedition". But admittedly: " Although luggage made it on board both the aircraft, in both cases, these Sikh travellers did not fly." As their web-site says in explanation of the dearth of real proof:

http://www.airindia.istar.ca/

" The RCMP is not prepared to release any information regarding the individual involvement of each accused in this case. That information will be presented to the courts at the appropriate time. We are also not prepared to discuss any direct evidence in this case as this may affect the integrity of the investigation. Although arrests have been made, this does not mark the conclusion of the police investigation. We are continuing to receive information which is being followed up and which we consider beneficial to our case. The Air India Task Force investigators believe there are some people who will come forward with information now that arrests have been made. If your information leads to an arrest in this investigation you will qualify for the One million dollar reward. If your information is already known to the RCMP, you will be so notified."

Well I guess that we shall see about all that - in due course.

But as 18 Sikhs were amongst the victims of AI182 and the Sikh's grievances were wholly sectarian issues, you have to wonder why they would be killing those of their own beliefs. And "Pathological examination of 131 recovered bodies failed to reveal any injuries indicative of a fire or explosive residue". Which all brings me to the point of this long journey through burnt and twisted metal. When aircraft wiring causes a crash you can be sure that there will not be much evidence of its infidelity once everything has burnt out. Even in the case of Swissair 111, the ocean floor has failed to yield up any golden nuggets in spite of there being no post-crash fire. On 28 August 2001 the Canadian TSB will be offering up more of what they have come up with - and certainly to date there has been much said about onboard fires, fighting them and even preventing them. And quietly, almost surreptitiously in the background, there has been an ongoing welter of MD-11 electrical service bulletins and Airworthiness Directives, mostly to do with wiring. Boeing refused to endorse (even as non-mandatory service bulletins) Swissair's suggested MD-11 electrical improvements for the World-wide MD-11 fleet although Swissair has gone ahead anyway - after considerable pressure from its crews. I guess you would cynically have to opine that Boeing could not accept the SR modifications because it would have been a tacit admission that there was something faulty about their MD-11's original design. The Boeing stand has always been that it's wiring installation (and not insulation) that is the real concern. However, the forthcoming report of the ongoing NTSB investigation into the FAA's airworthiness standards and type certification might express other opinions.

The great unspoken has always been the issue of that chicken and egg gestation of any onboard fire. Boeing will always insist that even though (perhaps) the wiring was the cause of fire and smoke - that it could have been something else that first damaged that wiring insulation and cooked it off. Portraying the insulation of a particular wire-type as being the culprit has been simply "not on" - despite a wealth of military and other in-service knowledge of the failings and failure-modes of certain types of wiring insulation. The limited concession has lately been that the age of wire is a part of the consideration in the overall concern about geriatric airliners. Meanwhile there are multiple daily instances of aircrews landing prematurely with smoke in the cockpit or cabin. There is no great crescendo of concern simply because findings in the VJ592 and TWA800 cases were quite inconclusive, alternative theories abounded - and the SR111 investigation will soon enter its fourth year. The length and cost of these puzzling crash investigations seem to be as inconsequential as the fact that their conclusions are usually indeterminate and inconclusive. There has to be a better way to keep track of (or later determine) an airliner's fate - and there is…. but what's stopping developments in this vital area?

The FAA has grudgingly agreed to swap out the flammable Mylar blankets on a five-year deadline and concedes that CVR and DFDR technology should be enhanced. But these improvements are quite demonstrably far short of what's technologically feasible. Firstly the cheapest and easiest solution would be CCTV, simply because CVR analysis, no matter how clever, can only tell you so much. There are other methods of keeping an eye on an aircraft's in-flight progress. It can be done in real time. Go to the IASA site[1] and use the site-search engines to look for IRIDIAN, ROADSHOW and RAFT. These will tell the story of satellite uplink real-time data-monitoring of an aircraft's systems whilst enroute. Today's technology is quite deterministic and can tell you as early as this afternoon exactly why an aircraft went down this morning. Under their respective FOQA programs (Flight Ops Quality Assurance) airlines are already similarly keeping an eye on the performance of both aircrews and airplanes via post-flight QAR/DFDR[2] analysis. Data-flow upload of that same data via satellite uplink is technically unchallenging and may well save millions in protracted crash investigations[3]. It may seem quite cynical but in my opinion, the entity with most to lose would always be the airliner manufacturers. They are content that accident causes should remain as probable causes…. simply because litigation under that regime is non-punitive and permits them wide scope in out-of-court settlement bargaining. If this was not the way things were, and accident causes were to be easily nailed down, well that would be a whole new litigation ball-game, would it not?

So here we have reviewed some old, some not so old and some more recent accidents. Why is it all topical? Well the Truth and Reconciliation Commission turned up so much "stuff" that Trevor Abrahams, chief executive officer of the Civil Aviation Authority, a man from a somewhat chequered background himself, will soon be advising the Transport Minister whether to hold a further Helderberg Inquiry. Air India 182 trials are soon to begin (unless charges are dropped for lack of evidence of course) and the Canadian TSB is about to surface further SR111 revelations. The FAA and NTSB are also embroiled in TWA800 aftermath - the decision whether double-checking the wiring is enough… or should inerting of fuel-tanks be mandatory.

But why is it that I strongly suspect that aircraft wiring will figure in none of these high profile events? Well if you cannot answer that for yourself at this point, I suggest you go back to the beginning and re-read - and then look at the IASA web site.

[2] Quick Access Recorder/Digital Flight Data Recorder